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Managing Water in the West

Central Yavapai Highlands Water Resources Management Study Appraisal Report

U.S. Department of the Interior
Bureau of Reclamation
Program Development Division
Phoenix Area Office, Glendale Arizona

September 2016

Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Cover photo: Courtesy of Doug Von Gausig, 2016, Verde River Box Canyon

Central Yavapai Highlands Water Resources Management Study Appraisal Report

Prepared By:

Bureau of Reclamation, Phoenix Area Office
Yavapai County Water Advisory Committee
Arizona Department of Water Resources

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Program Development Division
Phoenix Area Office, Glendale Arizona

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Central Yavapai Highlands Water Resources Management Study (CYHWRMS)

Acronyms

Acronym	Phrase
4FRI	Four Forest Restoration Initiative
AAWS	Assured and Adequate Water Supply
ACC	Arizona Corporation Commission
ADEQ	Arizona Department of Environmental Quality
ADRE	Arizona Department of Real Estate
ADWR	Arizona Department of Water Resources
AF	Acre Feet
AFY	Acre Feet per Year
AMA	Active Management Area
APP	Aquifer Protection Permit
AZPDES	Arizona Pollutant Discharge Elimination System
CCD	Census County Division
CDP	Census Designated Place
CPWAC	Coconino Plateau Water Advisory Council
CYHWRMS	Central Yavapai Highlands Water Resources Management Study
DES	Department of Economic Security
EC	Electrical Conductivity
GFR	Grandfathered Groundwater Rights
GPPD	Gallons Per Person Per Day
NACOG	Northern Arizona Council of Governments
NCAWSS	North Central Arizona Water Supply Study

NEPA	National Environmental Policy Act
NOI	Notice of Intent
NDVI	Normalized Difference Vegetation Index
POS	Plan of Study
PrAMA	Prescott Active Management Area
SDWA	Safe Drinking Water Act
SOC	Statement of Claimant
SRP	Salt River Project
TWG	Technical Working Group
USGS	United States Geological Survey
WAC	Yavapai County Water Advisory Committee
WIFA	Water Infrastructure Finance Authority
WPA	Water Planning Area

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I. Executive Summary

Study Purpose
The Central Yavapai Highlands Water Resources Management Study (CYHWRMS) is an appraisal level regional planning study initiated by local communities in Yavapai County to assess current and future water supply and demand, and evaluate alternatives to meet future demand.

CYHWRMS followed the Reclamation appraisal-level planning process and addressed three over-arching water resource related questions:

1. Is there a problem? (i.e., determine if water demand in the study area is unmet (projected to the year 2050)).
2. If the demand is unmet, is there at least one potential alternative to meet future demands?
3. Is there a Federal interest?

Study Location
The study area is located in central Arizona in a part of Yavapai County that includes the Prescott Active Management Area (PrAMA), and parts of the Big Chino and Verde Valley sub-basins (Figure 1). These areas represent regions of high potential growth and commensurate water demands which are complicated by water supply challenges and environmental and legal issues.

Figure 1. - CYHWRMS Study Area and Water Planning Areas (WPAs)

The Study Team
The study was performed under a federal cost share agreement between the study partners: the U.S. Bureau of Reclamation (Reclamation), Yavapai County Water Advisory Committee (WAC) and Arizona Department of Water Resources (ADWR).

The study was led by a Reclamation Project Manager and a Project Management Team composed of one representative from each study partner. A Technical Working Group (TWG) was assembled to support the study through technical assistance and review. The TWG consisted of representatives and technical experts in various disciplines from the many entities and organizations that participated in the stakeholder process. TWG members provided key expertise in many areas as well as insightful local knowledge.

Study Components and Findings
The study was divided into three major phases: Demand Analysis (Phase I); Water Resource Inventory (potential new supply analysis; Phase II); and Alternative Formulation and Evaluation (Phase III).

The first phase of the study addressed the first over-arching question (Is there a problem?) and quantified the future unmet demand to be approximately 45,000 or approximately 80,000 acre feet per year (AFY) depending on the method of calculation. The Phase I results are summarized in the "Demand Analysis Summary Tables".

In Phase I, the study area was defined and divided into designated Water Planning Areas (WPAs; Figure 1). Then the present (2006) population and present water demands were determined for each WPA. Future population and supply was then estimated for the year 2050 for each WPA. The difference between the estimated available 2050 water supply and the estimated 2050 demand is "the problem" and is referred to as future "unmet demand".

Using values provided for this study by WPA representatives, the increase in population for the entire study area is estimated to be over 390,000 people, from approximately 200,000 people in 2006 to nearly 595,000 in the year 2050. Based on study assumptions and future water use values provided by WPA representatives, and two different methods of estimating available water supply, the total 2050 additional water ("unmet") demand for the study area is estimated to range from as little as 45,000 AFY to as much as 80,000 AFY. For the development of alternatives, a maximum of 45,000 AFY was used.

The second phase of the Study inventoried potential sources of water to satisfy the unmet demands identified in Phase I. Potential supplies include surface water,

groundwater, storm water, reuse, conservation and other waters both within and outside of the study area.

The Phase II analyses concluded that due to the amount of water right claims, surface water is not available within the study area except for some potentially available unappropriated flood flows. However, surface water may be available from outside of the study area (e.g., Colorado River). Groundwater is available from within the study area and potentially from a few areas outside of the study area. There is potential to obtain and utilize more effluent, convert septic tanks, and conduct macro-rainwater harvesting. Conservation, watershed management, and weather modification could be additional sources of water.

The third phase answered the second over-arching question posed by the study (Is there at least one potential alternative to meet the future unmet demands?) by developing and evaluating alternatives to meet the future unmet water demand. The alternatives were developed to connect potential water supplies identified in Phase II to the demands identified in Phase I. As shown on Table 1, thirteen potential water supply alternatives were developed and ten were fully evaluated at an appraisal level.

Table 1. - Water Supply Alternatives

Water Supply	Alternative	Alternative Description
Groundwater	**1**	Local Groundwater Development within the WPA (Inside and outside PrAMA)
	2	Regional Groundwater Development – Big Chino Pipelines (PrAMA and Verde Valley)
	3	Regional Groundwater Development Outside Study Area - Bill Williams Sub-basin and Big Sandy Sub-basin
Effluent	**4**	Conversion of Existing Systems – Urban
	5	Conversion of Existing Systems – Rural
	6	Additional Effluent from Increased Population
Flood Water	**7**	Capture and Store Unappropriated Verde River or tributary water
Storm Water	**8**	Rainwater Harvesting – Aquifer Storage
Conservation	**9***	Implement Conservation (e.g. low flow toilets, turf restrictions, educational programs, etc.)
Surface Water	**10**	Alamo Lake
	11	Colorado River via (a) Alamo Lake, (b) Diamond Creek, (c) Lake Mead, (d) Lake Havasu, (e) Lake Mohave, and (f) Lake Powell
Other	**12***	Weather Modification – Cloud Seeding
	13*	Watershed Management

*Alternatives 9, 12 & 13 were not evaluated.

Each of the ten fully evaluated alternatives was analyzed relative to environmental, cost, public perception and legal and institutional issues. Then the alternatives were evaluated against four tests of viability, "acceptability, effectiveness, efficiency and completeness". Three of the alternatives were not fully evaluated because they did not have a component for collecting the water supply (i.e., watershed management and weather modification) or it was already somewhat accounted for in the Phase I assumptions of future water use (i.e., conservation). Two of the ten alternatives that were evaluated were not considered viable (rural septic conversion and local groundwater development in the Prescott Active Management Area (PrAMA)). Eight alternatives were deemed viable. These alternatives are recommended by the stakeholders for further study.

The alternative evaluation concluded that each alternative has significant, but not necessarily insurmountable, environmental, legal and perception issues that would need to be addressed in a feasibility investigation or prior to implementation. The cost estimates are generated at an appraisal level, represent a range and are useful for relative comparisons between alternatives.

No single alternative fully meets the 2050 total unmet demand for the study area. However, imported surface water meets nearly all of the demand, except for some outlying areas where distribution is not practical. Therefore, any complete solution will likely involve more than one alternative.

The third over-arching question of the study addresses justification of future federal involvement (Federal interest). The study partners conclude that there are Federal interests vital to regional plans that justify Reclamation's future involvement in a feasibility study of one or more of the viable alternatives. The study area is located within the Verde River Watershed which contains Reclamation projects and an alternative that proposes improvements to Reclamation facilities. Federal lands are within the study area and include the Bureau of Land Management, the Forest Service and the National Park Service. Additionally, there are Trust Responsibilities to Yavapai Apache and Yavapai Prescott Indian Nations.

Reclamation will continue to collaborate with ADWR, the communities and other stakeholders to plan for and manage water resources in the central highlands of Arizona. The next step for the communities is to determine if they are interested in further pursuing any of the alternatives. Reclamation involvement may be appropriate for some of the viable water supply alternatives.

II. Introduction

A. Background

The Yavapai County Water Advisory Committee (WAC), Arizona Department of Water Resources (ADWR) and the US Bureau of Reclamation (Reclamation) have an interest in promoting and planning for water security in Yavapai County. They have a common goal of secure, resilient long-term water supplies. In 2008, regional planning efforts were furthered by initiating the Central Yavapai Highlands Water Resource Management Study (CYHWRMS).

Calculating future water needs, the development of water supply alternatives to meet those needs, and determining if there is a federal interest were the primary objectives of this study. The study participants' motivation stems from knowledge that a reliable water supply is necessary for a robust economy and environment. Water reliability concerns in central Arizona arise from population growth, drought, climate change, water quality, legal rights, land management and groundwater utilization.

The communities in the Central Highlands of Yavapai County and the state have long recognized their responsibility to plan for water security. The WAC, ADWR, and others have conducted several studies relevant to water supplies and demands in the Central Yavapai Highlands. As a result, key information about water resources of this region has informed community leaders that while current water demands are mostly satisfied, the current supply is not inexhaustible, and water demand will increase in the future.

This study represents a step forward in planning for future water needs. It is a jointly funded appraisal level study that conforms to the Reclamation planning process by assessing and applying existing information and local expertise to questions of identifying and satisfying future water supply and demand needs.

B. Project Location and Hydrogeological Conditions

The study area is located in central Arizona (Figure 1 and Figure 2) where a large amount of growth in water demand is expected to occur over the next 50 years. The study area is approximately 2,300 square miles in central Yavapai County that includes the Prescott Active Management Area (PrAMA) (i.e., Chino Valley, Dewey-Humboldt, Prescott, Prescott Valley, and county lands), part of the Big Chino subbasin (e.g., Williamson Valley area, Paulden area, and potential ranch developments) and part of the Verde Valley subbasin (i.e., Camp Verde, Clarkdale, Cottonwood, Jerome, Sedona, and unincorporated areas)

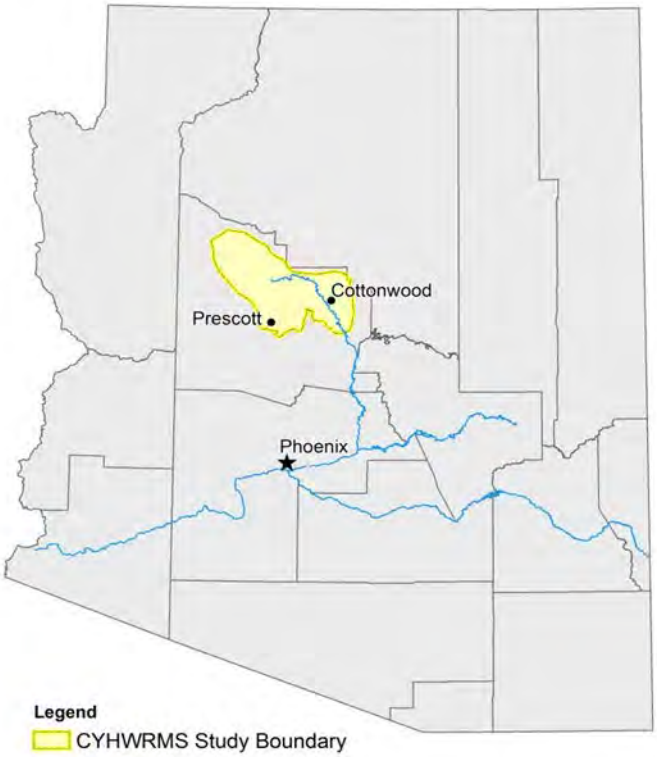

Figure 2. - CYHWRMS Study Area

The study area is within the transition zone between the Colorado Plateau and the Basin and Range physiographic provinces (Arizona Department of Water Resources, 2009). It consists of northwest- to north-trending valleys and mountains typical of basin and range topography (Blasch and others, 2006). The region contains "gently rolling or undulating topography with broad sloping alluvial fans which were formed at the base of the surrounding hills or mountains", (ADWR, 2009). Land surface elevations in the study area range from 7,854 feet above mean sea level (ft, amsl) in the Juniper Mountains to 2,942 ft, amsl on the Verde River downstream from Camp Verde.

The study area is located primarily within the Verde River Watershed but also contains a portion of the Agua Fria Watershed (ADWR, 2009). Major perennial streams in the study area are the Verde River, Oak Creek, Wet Beaver Creek, and West Clear Creek.

Primary groundwater aquifers in the study area are alluvial basins comprised of sedimentary basin fill, typically with the coarsest material deposited on the basin boundaries and the finest material located in the deepest part of the basin (Blasch and others, 2006). Volcanic (e.g., basalt) deposits are found within the basin fill. The basin-fill aquifers are typically unconfined along the basin margins and confined in the basin centers. Thin stringers of geologically recent surficial flood-plain alluvium and terrace deposits are located along major streams, are rarely

saturated and provide permeable zones for stream flow to infiltrate into underlying aquifers (Blasch and others, 2006). Groundwater flow direction in the alluvial aquifers is typically from the basin margins and tributaries toward the basin center and along the major axes of the valleys (Blasch and others, 2006). The alluvial basins are underlain by bedrock consisting of Precambrian igneous and metamorphic rocks that generally do not store significant amounts of water, and Paleozoic rock units that may yield water to wells. The Paleozoic rocks are not ubiquitous throughout the study area (Blasch and others, 2006).

Native vegetation within the study area ranges from high desert grasslands in the low elevation areas to coniferous forests in the mountainous areas. Annual precipitation varies from about 12 inches per year at the Town of Chino Valley, to about 19 inches per year at Prescott (ADWR, 2009). Average daily temperatures range from about 22°F to 57°F in January and from about 50°F to 89°F in July (ADWR, 2009).

Study Purpose

The purpose of this study is to identify water resources and water management strategies that include a range of alternatives designed to meet future water supply needs of communities in the Central Yavapai Highlands, Arizona.

The study was scoped consistent with Reclamation's appraisal-level planning process to accomplish the following:

- Summarize and clarify needs, objectives, constraints and opportunities.
- Identify stakeholders in the development of this study to the extent appropriate for an appraisal level analysis.
- Use science and engineering analyses to report a comprehensive range of water-supply alternatives and demand management practices, which will take full advantage of identified opportunities within constraints.
- Evaluate environmental, legal, social and cost issues associated with water-supply alternatives to alleviate identified problem(s).
- Determine if there is a Federal interest.

Three over-arching questions were addressed by this study and answered in the affirmative:

1. Is there a problem? (i.e., determine if there is future water demand in the study area that can't be met with current supplies (projected to the year 2050))
2. Is there a solution? (i.e., if the future demand is unmet, is there at least one potential alternative to meet future demands?)
3. Is there a Federal interest? (i.e., determine if there is a Federal objective in which there exists at least one regional plan that can be recommended to be carried forward into a Feasibility Study)

C. Study Authority

Reclamation is authorized to enter into this Agreement pursuant to the authority granted by the Act of Congress approved June 17, 1902 (32 Stat. 388), as amended, commonly known and referred to as Reclamation Law, the Act of March 4, 1921, referred to as the Contributed Funds Act; and Public Law 102-575 that authorizes the expenditure of funds for general investigations. ADWR is authorized to enter into this Agreement pursuant to authority granted by A.R.S. §45-105.

D. Public Involvement/Scoping

An initial objective was to identify stakeholders and other entities that have not only an interest in the development of reliable supplies but have land and resource management responsibilities. The appraisal study commenced with a Plan of Study (POS) that identified a partial list of stakeholders organized by government sponsored water organizations, citizen's water groups, groups that address water as part of their mission, water providers, Tribal, Federal and State Agencies involved with water, other out-of-area water groups/organization, non-water focused groups/organization, and universities and colleges. The aforementioned grouped stakeholders provide a robust cross-section for the development of this report. Not all parties were able to participate nor expected at all meetings; however, many parties participated in some or all phases of the study.

The study was led by a Reclamation project manager and a project management team composed of one representative from each of the three study partner organizations. A Technical Working Group (TWG) was assembled to support the study through technical assistance and product reviews. The TWG met on a regular basis throughout the study and consisted of representatives and technical experts in various disciplines from the entities and organizations that participated in the stakeholder process. The TWG provided key expertise in many subject areas as well as insightful local knowledge. Several TWG members served as a liaison to WPA entities for accumulating entity-derived information such as future population and water use values. TWG members comprised sub-groups for completing various specific tasks such as accumulating population estimates, performing the legal and institutional analysis and the environmental analysis. TWG members along with Reclamation staff were vital in developing and evaluating alternatives. The study could not have been completed without TWG member participation.

III. Need for the Study

The ability to provide reliable long-term water supplies is a long-standing challenge for central Yavapai County due to the projected increase in demands and the issues associated with the physical and legal availability of water supplies. Questions related to these issues have been asked repeatedly in the population centers of central Yavapai County, however, this is the first study to assess and evaluate the demands, supplies and future supply alternatives for the entire region. As evidenced by historical events, regulations and hydrologic data, the areas included in this study are linked through water resource issues making a regional solution an ideal choice for securing long-term water supplies. With the concerns over maintaining sustainable long-term water supplies, these communities realize it is impractical to develop water supply solutions independent of each other and recognize the opportunity and benefits of combining their resources to meet their individual needs.

Issues that led the parties to conclude that an appraisal level study was appropriate and applicable at this time include the following:

- Water shortages resulting from the increased usage of currently available supplies
- Potential environmental impacts from the continuation of groundwater mining
- Compliance with groundwater regulations within the PrAMA
- Projected population growth trends
- Ongoing adjudication of water rights
- Long-term economic viability
- A desire to maintain local control and input into the identification and pursuit of long-term water supply alternatives

The study gathered, organized, analyzed and evaluated the current and projected water supplies and demands of the region to determine whether or not an unmet water demand is projected to occur for the region by 2050; and involved local stakeholders to develop and evaluate future water supply alternatives.

A. Resources, Opportunities and Constraints

By examining currently available data related to hydrologic conditions, weather patterns, endangered species, and population growth trends, the region of central Yavapai County was identified by Reclamation as an area that is “highly likely” to experience potential water related conflicts by the year 2025 (United States Bureau of Reclamation, 2003). Additionally, local governments and planners have recognized multiple issues facing the region that create the need for proactive

planning in order to avoid and/or resolve water-resource-related conflicts before they occur.

Studies in the area are generally completed based on population centers and groundwater sub-basins or watersheds. The areas of focus for this study generally fall into three distinct locations: Prescott AMA, Big Chino and Verde Valley sub-basins (Refer to Figure 1). Although many commonalities exist, each focus area has its own unique set of challenges and opportunities. There are opportunities for a regional solution, but any regional solution will have to overcome challenges; both locally and from one focus area to another.

Many resources and potential opportunities are available, as well as obstacles or constraints, to take into consideration while working in and adjacent to the study area. The following is a synopsis of the many issues, regulations and activities that were contemplated while developing alternatives.

1. *Demand*

Demand is currently being met with locally available water supplies consisting of mostly groundwater with a portion from surface water supplied by small reservoirs, the Verde River, and its tributaries. All existing surface water is currently being utilized and the number of water rights claims for surface water far exceeds the available supply. Therefore, with the possible exception of an infrequent major flood event, unappropriated surface water is not available within the study area. Increased pumping of groundwater to meet future demand may result in declining groundwater levels and the inability of the PrAMA to meet its goal of safe-yield. For areas outside the PrAMA where there are limited groundwater use restrictions, increasing the use of groundwater may result in unfavorable consequences such as water table declines, reduced aquifer storage, surface water impacts and water quality issues.

2. *Available Water Supply*

This appraisal study used existing data in its analysis. Much of the desired data related to the quantification of available water supplies for all WPAs doesn't exist. Based on this fact, the TWG assumed the current Estimated Available Water Supply was sufficient to meet the Total 2006 Water Demands (Table 3). This assumption resulted in what is referred to in this study as the Status Quo Method for estimating future demand. The Status Quo Method assumes that existing developed supplies would always be available to meet existing demands and no new supplies would be needed to meet existing 2006 demand. Any future water demands greater than the total existing 2006 water demands would result in an unmet future water demand that would have to be provided for by a new supply in order to prevent a deficit. Based on a preliminary analysis of available

information, current locally-available sources of water supplies are either at or very nearly at their limits.

The Estimated Available Water Supply for the PrAMA is equal to the Total 2006 Demand minus 782 AFY due to the extinguishment of rights for agricultural use for the Chino Valley Irrigation District based on ADWR records and assumptions by PrAMA staff for the assessment.

In addition to the Status Quo Method, the TWG prepared the Water Balance Method for determining available water supplies for the PrAMA, Big Chino and Verde Valley sub-basins. The Water Balance method assumes the basin's net natural recharge is the amount of groundwater available. The Water Balance Method compares the annual inflows to the average long-term annual outflows to determine net natural recharge. Groundwater pumping in excess of net natural recharge indicates an annual groundwater overdraft and a supply deficit (Tables 4, 5 & 6).

3. *Legal*

The Assured and Adequate Water Supply Programs, overseen by ADWR were created to address the problem of limited groundwater supplies in Arizona. Both programs are based on the demonstration of a 100-year water supply that includes current and committed demand in addition to future demand. A.R.S. §45-576 through 580 and Arizona Administrative Code Rules R12-15-701 through R12-15-729 govern the Assured and Adequate Water Supply programs.

The Assured Water Supply program was created as part of the 1980 Groundwater Management Act and sets forth rules within Arizona's five Active Management Areas of which the PrAMA is one. Developers of proposed subdivisions in the PrAMA are required to demonstrate an assured water supply that will be physically, legally, and continuously available for the next 100 years before the developer can record plats or sell parcels. The Arizona Department of Real Estate (ADRE) will not issue a public report, which allows the developer to sell the lots within a subdivision, without a demonstration of an assured water supply. The developer can prove a 100 year supply by satisfying the requirements to obtain a Certificate of Assured Water Supply or by a written commitment of service from a provider with a Designation of Assured Water Supply. In order to obtain a determination of Assured Water Supply, the following seven criteria must be met (ADWR, 2014):

1. The water supply must be physically available for 100 years.
2. The water supply must be legally available for 100 years.
3. The proposed supply must be continuously available for 100 years.
4. The water must be of sufficient quality for the proposed use.
5. The proposed water use must be consistent with the management goal of the AMA.

6. The proposed water use must be consistent with the current management plan of the AMA.
7. The applicant must demonstrate the financial capability to construct any necessary water storage, treatment, and delivery systems.

The City of Prescott is the only Designated Assured Water Provider within the PrAMA. This means they possess a certificate that indicates they have sufficient water of suitable quality that will be continuously available to meet the anticipated water needs for at least one hundred years for their entire service area. A developer can prove a 100 year supply by a written commitment of service from a provider with a Designation of Assured Water Supply, without the need of a separate study (ADWR, 2014).

The Adequate Water Supply program operates outside of Active Management Areas and was originally intended to serve as a consumer protection program. Developers of a subdivision are required to obtain a determination of the quantity and quality of the proposed source of water from the ADWR before the ADRE will allow the sale of any lots. Any developer that applies for a Water Adequacy Report and successfully demonstrates that water of sufficient quality will be physically, legally, and continuously available for the next 100 years, will be deemed by ADWR to have an adequate water supply. If ADWR determines the water supply to be inadequate, the developer may still sell lots, but the inadequate determination must be disclosed to the first buyer of each lot in the public report approved by ADRE and in all promotional materials. If the proposed subdivision will be served water from a designated water provider, the developer only has to provide a written commitment of service from the designated provider.

In 2007 the legislature passed SB 1575, which provided authority for cities, towns and counties to adopt an ordinance requiring new subdivisions to obtain from ADWR a determination of 100-year adequate water supply in order to obtain final plat approval from the local platting authority. Thus far, the Town of Clarkdale is the only city or town within the study area that has passed an ordinance requiring a mandatory demonstration of water adequacy for proposed subdivisions. Within the study area the City of Cottonwood, Town of Clarkdale and Camp Verde Water are the only Designated Adequate Water Providers.

Despite the existing regulations, development can proceed in rural Arizona through the process of lot splits that can lead to "wildcat subdivisions". “Wildcat subdivisions” are not subdivisions as defined by ADRE and as the term subdivision is used in ADWR Assured and Adequate Water Supply rules. They are instead tracts of land divided by a succession of owners in a way that leaves them exempt from basic county building requirements, such as putting in roads, sewers and sidewalks, or the requirements of SB 1575.

Prescott AMA

The 1980 Arizona Groundwater Code recognized the need to aggressively manage the state's groundwater resources to support the growing economy. Areas with heavy reliance on mined groundwater were identified and designated as Active Management Areas (AMAs). The area encompassing the City of Prescott, Prescott Valley, Chino Valley and the Yavapai Prescott Indian Tribe Reservation was one of the areas identified and resulted in the designation of the PrAMA.

The PrAMA covers 485 square miles in central Yavapai County and consists of two sub-basins, the Little Chino and the Upper Agua Fria. Granite Creek, Big Draw, and Little Chino Creek drain the Little Chino sub-basin into the Verde River. Lynx Creek and other smaller ephemeral streams drain the Upper Agua Fria sub-basin into the Agua Fria River.

Within the PrAMA, the Code established a groundwater rights system, which strictly limits groundwater withdrawals; prohibits the development of new irrigated farmland; requires new subdivisions to have long-term, dependable water supplies; and requires measuring and reporting of groundwater withdrawals. The PrAMA has a statutory goal of achieving safe-yield by 2025. Safe-yield is a groundwater management goal designed to achieve a long-term balance between the amount of groundwater withdrawn and the annual amount of natural and artificial recharge that is occurring within the designated area § 45-561(12). A series of management plans that are updated every 10 years contain mandatory conservation requirements for industrial, municipal, and agricultural water users (ADWR, 2014).

In January 1999, ADWR formally declared the PrAMA to no longer be in safe-yield (ADWR, 1999). ADWR states that "ongoing groundwater level declines and that existing groundwater pumping greatly exceeded the AMA's safe-yield goal" and "Data demonstrated that the Prescott AMA had been out of safe-yield since at least 1990" (ADWR, September 2014).

General Adjudication of Water Rights

A general stream adjudication is a judicial proceeding to determine or establish the extent and priority of water rights. Two general stream adjudications are currently underway in the State of Arizona, the Gila River System and Source (Gila Adjudication) and the Little Colorado River System and Source. The study area is located within the Gila Adjudication.

The Gila Adjudication came about as a result of numerous petitions being filed in the 1970's to determine the water rights for a number of streams within the Gila River System and Source. The Salt River Valley Water Users (SRP) filed the first petitions on the Salt and Verde Rivers. Large mining companies filed on the Gila System and Source, including the Verde River. The Buckeye Irrigation Company filed to expand the previous filings to include the Agua Fria River. In November of 1981, the Arizona Supreme Court consolidated all of these adjudications into

one proceeding assigned to the Maricopa County Superior Court (Gila Adjudication).

Any person or entity who uses water or who has made a claim to use water from the Gila River System and Source may be subject to the jurisdiction of the Superior Court. The legislature has charged the Arizona Superior Court with quantifying and prioritizing existing water rights claimed in the watershed. The final court decree will establish the existence and ownership of claimed water rights, as well as important characteristics of the water rights, including location of water uses, quantity of water used, and date of priority of the water. A final court decree will also establish a delineation of what is considered to be groundwater and appropriable groundwater (sub-flow).

More than 83,500 Statement of Claimants filed by more than 28,000 parties are currently joined in these proceedings. Parties to this proceeding include irrigators, cities, business and numerous Indian Tribes. As a part of the adjudication effort, the Gila Adjudication Court has recognized the interconnectivity between surface water and groundwater and directed ADWR to develop a methodology for determining which wells may be potentially pumping appropriable groundwater (sub-flow) of the river system rather than groundwater. The report submitted to the Gila Adjudication Court by ADWR in 2002 recommended that all wells located within the geologic zone known as the Holocene Alluvium be considered as potentially pumping appropriable sub-flow if water was historically in the river (ADWR, 2002).

The ramifications of a final Decision and Order from the court pertaining to the sub-flow decision are not fully known, but it is anticipated that one of the impacts will be the potential limitation on the development of new wells within the Holocene Alluvium and wells that draw water away from the alluvium. A final decree issued by the court will also clarify the quantity of surface water that is available

SRP, shareholders in the Salt River Valley Water Users Association and other senior downstream appropriators to the Verde River are resolute in protecting the flows in the Verde River and exercising their rights to the use of the water.

4. *Environmental*

The Verde River and surrounding riparian corridor support nearly 20 threatened or endangered species including razorback sucker, Colorado pike minnow, spike dace, southwestern willow flycatcher, yellow-billed cuckoo, river otter, southwestern bald eagles, and others. The Verde River has also been identified by American Rivers as one of America's Most Endangered Rivers (American Rivers, 2006).

The increasing use of groundwater may potentially impact the base flows of the Verde River, which is a concern to all communities within the study area as well as to downstream water users. With a projected unmet water demand of more than 45,000 AFY, the challenge is to identify alternative solutions that meet the projected water needs of the communities while maintaining the base flows of the Verde River.

5. *Studies Used in Alternative Formulation*

Big Chino Pipeline

ADWR's declaration in 1999 that the PrAMA was no longer in safe-yield triggered the full implementation of the Assured Water Supply Rules, which required only renewable or imported water supplies from outside the PrAMA be utilized for new subdivisions within the AMA. This resulted in the City of Prescott, in partnership with the Town of Prescott Valley, to purchase lands north of the PrAMA in the Big Chino sub-basin for the purpose of importing water into the PrAMA.

Arizona statute generally prohibits inter-basin transfers of groundwater, however, A.R.S §45-555(E) authorizes the City of Prescott to withdraw and transport up to 8,068 acre-feet of groundwater annually from the Big Chino sub-basin into the PrAMA. Despite the legal authority to exercise the development and transfer of groundwater from the Big Chino, attempts to access this supply have led to disputes over the cost of the project and potential impacts from pumping that may occur to the headwater springs of the upper Verde River.

Black & Veatch, under contract with the City of Prescott, has already completed a pipeline conceptual design report for the Big Chino Water Ranch project. Included in the report are preliminary design work and design and construction cost estimates. The Bureau of Reclamation has re-evaluated this alternative, including the development of a cost estimate, using the same methodology employed for the other alternatives to maintain consistency in the development and presentation of each alternative.

North Central Arizona Water Supply Feasibility Study

Reclamation is currently conducting a feasibility study for the Coconino Plateau Water Advisory Council (CPWAC) in northern Arizona (BOR, 2006). The study has concluded that by 2050 there will be an annual unmet water demand of 28,100 acre-feet in the study area. The Coconino Plateau encompasses an area that includes more than 12 Navajo Nation chapters, all of the Hopi Tribe villages, 12 non-tribal communities, and Grand Canyon National Park. In October 2006, the CPWAC voted unanimously to seek Feasibility authority to study the four viable alternatives identified in the Appraisal Study (NCAWSS POS).

One of the water supply alternatives being studied is the North Central Pipeline, which if constructed would deliver water from Lake Powell to Flagstaff. There is

an opportunity to connect to an existing water supply alternative that is currently being studied, which could deliver Colorado River to the study area. Reclamation has developed a cost estimate for a water supply alternative that upsizes the proposed pipeline from Lake Powell to Flagstaff to accommodate the projected demands presented in the CYHWRMS and extends the pipeline into the study area.

6. *Social*

Citizens are concerned about meeting the future needs for people and sustaining the economic well-being while preserving their natural and cultural resources. They are interested in renewable and sustainable water supplies at an affordable price. While some of the alternatives presented in this study may contribute, this study does not attempt to balance or restore the aquifer to safe-yield standards.

IV. 2006-2050 Demand Analysis (Phase I)

The Phase 1 Demand Analysis is the foundation of this study. It addresses the general planning question of "is there a problem?" by calculating the difference between the estimated supply and projected demand (for the year 2050). A "problem" exists if the future demand is larger than the estimated supply. Where negative, the difference is referred to as the 2050 unmet demand.

To begin Phase I, Water Planning Areas (WPAs) were defined so that 2006 demand could be calculated and 2050 demand could be estimated using area-specific population growth projections and data sets. Available water supply was estimated using a status quo method and a water balance method (further defined in Section D below).

For the study area, the results of the Demand Analysis (Phase I) indicate an overall unmet demand of 45,000 – 80,000 AFY depending on the method of analysis. Phase I results are summarized in Tables 3, 4, 5, and 6. Supporting documentation is also included in Appendix A.

A. Water Planning Areas

The study area was divided into 20 Water Planning Areas that were defined by municipal, water provider or Census areas (Figure 3). The WPAs make it possible to use existing area-specific data sets, separately quantify current demand and project future demand for each area. WPAs allow modification of demand and supply assumptions independent of each other.

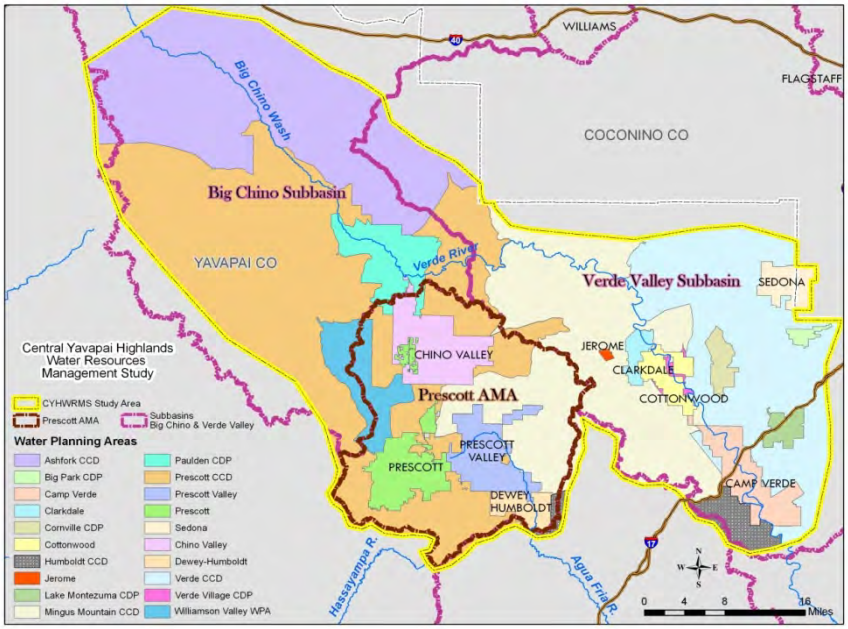

Figure 3. - CYHWRMS Study Area and Water Planning Areas (WPAs)

WPAs defined by the municipal boundary and any portion of the water service area that originates inside the municipal boundary and extends outside of it were used for Camp Verde, Dewey-Humboldt, Clarkdale, Cottonwood, Jerome, Prescott Valley, Chino Valley, Prescott and Sedona.

WPAs defined by Census Designated Places (CDPs) as identified by the United States Census Bureau and used in the Yavapai County Water Advisory Committee's *Long-term Development Scenarios – Scenario #1* (H3J Consulting, 2008), were used for Paulden, Big Park, Cornville, Lake Montezuma, Verde Villages and Williamson.

WPAs defined by the larger Census County Divisions (CCDs) to include only those portions of the CCD that are within the CYHWRMS study area were used for Verde, Prescott, Mingus Mountain, Humboldt, and Ashfork.

Figure 3 shows the WPAs and the study area boundary. Individual maps for each WPA are included in Appendix D.

B. 2006 Population

Population was developed based on previous studies and assessments, past trends, and/or GIS analysis. All population values were finalized in consultation with technical and political representatives from each WPA.

The population estimated for 2006 for most of the WPAs used Department of Economic Security (DES) numbers; modified DES estimates based on town/water provider input, or modified DES based on the difference between water service area boundaries and city/town boundaries. Present population (2006) for CCDs is based on 2006 Yavapai County Parcel Data (i.e. single and multi-family) multiplied by the average DES persons per household by census designated areas.

Future population (2050) in most WPAs referenced 2008 H3J Consulting report with slight modifications. The CCDs were not whole due to the study area boundary excluding some portions. 2050 populations in the CCDs were developed with a 2.25% compounded growth rate. The 2.25% rate for CCDs was based on analysis of past trends (e.g. last 10 years) and discussions with the County Supervisors. The Ashfork CCD had an additional 35,000 people added to the 2050 total in order to represent a planning population that includes residential growth in the Yavapai and CVCF ranches. (Note: this was reduced from the 65,000 value used in the H3J report because 65,000 was thought to be too high due to lack of any current development and discussions with County Supervisor Carol Springer which indicate knowledge that Yavapai Ranch may not develop as quickly, or densely as previously assumed).

The total estimated population for the study area is 201,035 for 2006 and 594,392 for 2050, which represents an increase of 393,357.

Table 2 below compares the different population data sources for current 2006 population and projected 2050 population estimates, annual growth rates and population changes for the WPAs.

Table 2. - Comparison of Different Population Sources for Current and Projected Population

Water Planning Area[1]	2006 DES Population (not WPAs)	DES 2050 Population (not WPAs)	DES Annual Growth Rate	2006 DES modified for WPAs [1]	2006[2] Yavapai County Parcel Population	2006[2] Population Yavapai County Estimates	2006[3] Population	2050 County Estimates 2.25% Growth [2,4]	2050[1,3] Assumed Population	Annual Growth Rate	Population Change
			%							%	
Camp Verde	11,779	22,387	1.5%		-9,826		12,497		23,277	1.4%	10,780
Dewey Humboldt	4,134	6,943	1.2%		-4,041		4,134		6,943	1.2%	2,809
Clarkdale	3,732	5,146	0.7%	3999	-3,568		3,999		22,460	4.0%	18,461
Cottonwood	11,201	20,411	1.4%	20400	-17,872		20,400		77,630	3.1%	57,230
Jerome	330	334	0.0%	510	-429		510		800	1.0%	290
Prescott Valley	35,609	90,620	2.1%	41610	-42,182	20,400	41,610		146,000	2.9%	104,390
Chino Valley	13,235	37,836	2.4%	12690	-7,874		12,690		63,690	3.7%	51,000
Prescott	42,154	79,588	1.5%	49072	-43,418		49,072		100,000	1.6%	50,928
Sedona	11,080	15,030	0.7%		-8,271		11,080		16,300	0.9%	5,220
Paulden CDP	5,342	14,099	2.2%		-5,890		5,342		14,099	2.2%	8,757
Big Park CDP	6,566	12,582	1.5%	7731	-7,252		7,731		8,810	0.3%	1,079
Cornville CDP	4,075	7,448	1.4%		-3,747		4,075		7,448	1.4%	3,373
Lake Montezuma CDP	4,237	8,308	1.5%		-4,679		4,237		8,308	1.5%	4,071
Ctn-Verde Village CDP	12,572	21,506	1.2%	3373	-1,928		3,373		11,706	2.9%	8,333
Williamson CDP	5,228	11,845	1.9%		-5,107		5,228		11,845	1.8762%	6,617
Verde CCD	2,239	3,309	0.9%		-1,644	-2,239	1,644	4,377	4,377	2.2505%	2,733
Prescott CCD	20,525	26,720	0.6%		-11,012	-25,573	11,012	29,312	29,312	2.2500%	18,300
Mingus Mtn CCD	1,687	3,224	1.5%		-2,741	-1,687	1,700	4,525	4,525	2.2499%	2,825
Humboldt CCD	1,470	1,470	0.0%		-230	-287	230	612	612	2.2491%	382
Ashfork CCD	1,341	2,995	1.8%		-471	-500	471	1,251	36,250	10.4%	35,779
Total	198,536	391,801	1.6%		-182,182		201,035		594,392	2.5%	393,357

1. Modifications to 2006/2050 DES populations based on differences between water service area boundaries and city/town boundaries.

1. Modifications to 2006/2050 DES populations based on input from town/water provider.

2. See Phase I - Data Sources and Documentation for methods and assumptions used to estimate CCD populations.

3. Populations for Camp Verde and Clarkdale include Yavapai-Apache Nation reservations located with each Water Planning Area.

4. Ashfork CCD 2050 Population includes 1,250 plus 35,000 growth for CVCF and Yavapai Ranches.

C. 2006 Demand

A list of water providers and their present use within the study area was developed from several existing documents as well as data from Arizona Corporation Commission (ACC) and ADWR records. The TWG recommended that water usage be examined over a three year period 2005-2007 and the most complete data set would be used in the study. It was decided that 2006 was the most complete. See Appendix A for details.

2006 Water Use Summary Tables were generated for each WPA by summing water provider reported uses, exempt domestic well uses, non-exempt well uses (not previously reported by water providers), and estimates of agricultural uses. These uses were then grouped into Municipal/Domestic Demand, Commercial/Industrial Demand (not served by water provider), and Agriculture Demand. Values from the Water Use Summary Table were used in the comprehensive Demand Analysis Summary Table. Appendix A contains the Demand Analysis Summary Table and supporting documentation.

1. *Municipal/Domestic*

Municipal and domestic demand for each WPA was a sum of the volumes associated with the Water Provider Total, Exempt wells and Non-Exempt Wells. Water use for exempt wells was calculated based on the number of wells identified in the ADWR Wells55 database with a domestic use multiplied by an assumed usage amount of 0.33 AFY per well. Additional domestic use was calculated as the sum of the Non-exempt wells that were identified in the ADWR Wells55 database based on a defined query structure.

Each WPA was reviewed by the CYHWRMS Technical Working Group. Volumes that were deemed to be significant and not already identified as a water provider were added to the overall usage amount for the WPA. Non-exempt wells with a primary domestic use were assigned a value of 0.50 AFY, with domestic as an “other” use were assigned 1 AFY, and with a stock use assigned 0.3 AFY. See Appendix A for additional details.

2. *Commercial/Industrial*

Non-exempt wells located within the Prescott Active Management Area with active Grandfathered Groundwater Rights (GFRs, and Type I or Type II non-irrigation) and Groundwater Withdrawal Permits (e.g., general industrial use and mineral extraction permits) were identified and assigned to the appropriate WPAs. Additionally, 2006 commercial and industrial uses for golf courses, sand and gravel operations, and others, not already identified by water providers, outside of the PrAMA were included. Data for communities outside of the PrAMA were

developed from ADWR Annual Reports, the Verde 2000 Report, and the WAC Verde Valley Projections. See Appendix A for details.

3. *Agricultural*

Agricultural water use throughout the study area was estimated based on total irrigated acres. Areas outside of the AMA used a method that included year-appropriate aerial photography with present and historical irrigation mapping. Within the AMA, annual reports for Irrigation Grandfather Rights provided the volume used in 2006. Agriculture associated with surface water was also verified and use was estimated.

Several documents with irrigation acreages and water use were used to determine agricultural demand in 2006. The most recent source of information across the study area was "Verde Valley Geospatial Database Project Phase I", by Ross, 2008 (Ross, 2011). This study produced irrigation polygons that had been corrected and simplified from the "Verde River Watershed Study", ADWR, 2000 (ADWR 2000) with high-resolution orthorectified aerial photography. In review of this publication it was recognized that the author did not have the resources to update the 1997 crop codes. In order to do this, the ADWR produced a NDVI (Normalized Difference Vegetation Index) data sets using Landsat 5 (2006) satellite imagery. The first two sets were developed for July and September 2006. When these data sets were shared with the CYHWRMS Agricultural subgroup, the numbers were noticeably low in the Verde Valley. It was determined that the NDVI needed to be set to a finer scale to identify more than just the agriculture. It needed to pick up the OT Irrigation (irrigation done as pasture around homes, and other small uses of ditch water) shown in ADWR 2000. Results shown in the "CHYWRMS Irrigated Acres and Irrigation Demand" Table reflect this and were compiled as follows:

NDVI_July 2006 (adjusted scale) – Used in the Verde Valley only
The NDVI technique was repeated July 2006 Landsat imagery was used again and the NDVI was set to a finer scale. This method also picked up golf courses and sports fields. Since a type column was included in the data set these could be removed because the majority of golf courses and sports fields already had their demands documented with non-exempt wells or as part of a municipal system.

ADWR 2000
The column titled "Major Crop" was used for querying purposes and the codes for FA=fallow, NA=not applicable and NC=no crop were removed. This data set was only used for comparison.

WAC, 2003 – Big Chino only

The column titled "Investi" was set equal to irrigated or not investigated. Then any fields identified to be in sub-irrigated areas were removed. For Irrigation demand to be determined, the above three data sets were multiplied by the Total Weighted Water Duty as shown in ADWR, 2000. Williamson Valley = 4.0 AF/Acre, Big Chino including Walnut Creek = 4.0 AF/Acre, and Middle Verde = 3.15 AF/Acre.

Little Chino/Upper Agua Fria 2006 Reported to ADWR – PrAMA only
This portion of the study is the Prescott AMA, where agriculture uses supplied by groundwater are reported annually. Two areas of agriculture, supplied by surface water were reviewed. This volume was also included in the table.

Tables 3-12, 3-13 and 3-16 in the ADWR 2000 document were used to determine volumes by applying the Total Weighted Water Duty for each basin to the irrigated acres. See Appendix A for additional details.

4. *2006 GPPD*

The 2006 GPPD (gallons per capita per day) is a value that was calculated to establish the amount of water used per person per day. These values were determined for each WPA. GPPD was used to attempt to verify the validity of assumptions made with respect to 2006 data. GPPD was calculated by dividing 2006 Municipal/Domestic demand by the 2006 population.

D. 2006 Estimated Water Supply

It is difficult to accurately quantify existing estimated water supply. However, in order to identify the amount of additional water necessary to meet future demands, the existing water supply had to be quantified.

Three methods were considered to evaluate and compare estimates for available water supplies within the study area.

1. Using data developed for the Arizona Water Atlas, to identify Assured and Adequate Water Supply (AAWS) determinations that "locked up" water for a provider or entity within a WPA (Designations – AMAs and non-AMAs, Certificates – AMA only, Water Adequacy reports – non-AMAs*, and Analysis – AMAs and non-AMAs). Assume present demand equal present supply for all water users who are not required to comply with ADWR and ADRE subdivision statutes and rules (e.g., exempt wells, some non-exempt wells, agriculture, etc.)

*Some Water Adequacy reports are still in effect in the AMA due to determinations issued prior to the AMA being declared out of safe-yield. (ADWR, March 2014)

2. Determine a time, demand level, or natural recharge volume where we may be able to sustain pumping and live with the environmental effects. Any water needs above this amount will need to be met through reuse, recharge, augmentation and/or conservation.

3. Assume that 2006 pumping levels were at a "status quo" and designate 2006 water demand as 2006 available supply.

It was challenging to determine a single methodology because one group of participants thought that all existing developed supply should be used and another group, thought that it was necessary to exclude any groundwater overdraft and only present a "sustainable" supply. In order to accommodate both perspectives and associated uncertainties, analyses were completed to provide a range of existing supplies. Identifying AAWS determinations (Method 1) and Status Quo (Method 3) methods provided the low end of the future unmet demand. Method 1 calculated water supply using the AAWS determinations and other areas that didn't have to comply with AAWS determinations were equal to 2006 demands. The Status Quo method assumed that all existing developed supplies in 2006 would be available for the next 50 years and would provide a consistent supply. Therefore, only that amount of future supply that was in excess of the existing supply would need to be developed. Method 2 or the "Water Balance Method" which is the estimated net natural recharge for each sub-basin gave the high end of the unmet demand range for the future. The TWG agreed to use the status quo (method 3) and use the components from existing water budgets (Method 2). The effect of these numbers can be seen in Tables 3, 4, 5, & 6.

Method 1was not used because some of the TWG membership were not certain that their available supply (in AF) based on ADWR's Atlas GIS and AAWS records was correct. In some cases TWG members felt their volume was either too low or too high when compared to 2006 reported demands. Due to the study timeframe, it was determined that it was not possible to complete Method 1 for all WPAs in the study. Findings can be found in *Planning Area Water Use Summary Table* in Appendix A.

E. 2050 Demand

As with current demand, the 2050 demand has been subdivided into three sectors: Municipal/Domestic, Commercial/Industrial, and Agriculture. In order to make reasonable assumptions about the future water demand, past trends and near-term community plans were used. Because this study has an ADWR defined AMA in it, work developed by ADWR staff for the PrAMA Assessment was also reviewed to help develop assumptions about the future (ADWR, 2012).

1. *2050 Municipal/Domestic*

Municipal/Domestic demand was calculated by multiplying the 2050 GPPD by the 2050 population. Representatives from each WPA provided their projected 2050 GPPD and population. Conservation reduction volumes were included in the adjustment of the 2050 GPPD to incorporate effects of predicted conservation efforts. However, the conservation reduction volume is not consistent across planning areas. Some WPAs chose a GPPD with high conservation volumes and others chose GPPD with less conservation. All of the study partners recognize the need for conservation, and their chosen GPPD reflects a planning philosophy and not a value judgement on conservation.

2. *2050 Commercial/Industrial*

Commercial/Industrial demand in 2050 (not served by a provider) was determined in consultation with representatives of the WPAs. Four approaches were considered:

1. All WPAs keep Status Quo – 2050 demand is the same as 2006 demand

2. WPAs outside the AMA keep status quo and inside AMA show full GFRs full allotment

3. WPAs outside the AMA keep status quo and AMA GFRs that are a type 1 are converted to AAWS credits. All type -1s were extinguished in 2015. Conversion of Non-Irrigation Type-1 rights to AAWS (without exemption - the parcel was not irrigated 4 of the 6 years prior to 1/1/2000)
   = # of irrigation acres * 1.5 * (2025 minus Year of Extinguishment).

4. WPAs outside the AMA keep status quo and inside AMA assumptions developed for the PrAMA assessment were applied.

Some areas chose to use the status quo from 2006 for the 2050 value, and others justified changing the value. See Appendix A for more details.

3. *2050 Agriculture*

Agricultural demand for 2050 was determined based on discussion between members of the TWG and WPA representatives. The year 2050 agricultural water use in the Verde Valley sub-basin WPAs is set at two-thirds (66%) of the 2006 value (reduced by 1/3). The 2050 agriculture water use in the Big Chino sub-basin is half (50%) of the 2006 value. The 2050 agricultural use in the Little Chino sub-basin (PrAMA) is calculated based on ADWR records and assumptions by PrAMA staff. See Appendix A for details.

F. 2050 Water Supply Demand +/-

The 2050 water supply is the difference between the estimated available supply and the 2050 total demand. If the number in column P, “2050 Water Supply +/-“ is negative then there is a projected unmet demand for the WPA in planning year 2050. Please refer to Table 3 below.

Table 3. - CYHWRMS Study Area Demand Analysis Summary Status Quo

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
			(C-B)				(E+F+G)	(E/B)	Estimated		(C*K)			(L+M+N)	(J-O)
Water Planning Area[1]	**2006 Population[2]**	**2050 Population[2]**	**Pop. Change**	**2006 Mun/Dom Demand[3]**	**2006 Com/Ind Demand[3]**	**2006 agriculture Demand[3]**	**Total 2006 Demand**	**2006[4]**	**Available Water Supply[5]**	**2050[6]**	**2050 Mun/Dom Demand[6]**	**2050 Com/Ind Demand[7]**	**2050 agricultur e Demand[8]**	**Total 2050 Demand**	**2050 Water Supply +/-**
				(AFY)	(AFY)	(AFY)		GPPD	(AFY)	GPPD	(AFY)	(AFY)	(AFY)	(AFY)	(AFY)
Camp Verde	12,497	23,277	10,780	1701	783	9,320	11,804	122	11,804	112	2,920	783	6,213	9,917	1,887
Dewey Humboldt	4,134	6,943	2,809	629	16	569	1,214	136	1,214	120	933	700	37	1,670	-456
Clarkdale	3,999	22,460	18,461	481	0	31	512	107	512	75	1,887	300	31	2,218	-1,706
Cottonwood	20,400	77,630	57,230	3,399	1,753	1,137	6,289	149	6,289	125	10,870	1,753	758	13,381	-7,092
Jerome*	510	800	290	282	0	0	282	494	282	255	229	53	0	282	0*
Prescott Valley	41,610	146,000	104,390	6,221	545	55	6,821	133	6,821	121	19,790	900	0	20,690	-13,869
Chino Valley	12,690	63,690	51,000	1,325	522	1,691	3,538	93	2,755	75	5,351	4,192	158	9,701	-6,946
Prescott	49,072	100,000	50,928	10,531	1	375	10,907	192	10,907	125	14,003	3,224	375	17,602	-6,695
Sedona	11,080	16,300	5,220	3,801	33	278	4,112	306	4,112	300	5,478	33	185	5,696	-1,584
Paulden CDP	5,342	14,099	8,757	921	7	1,346	2,274	154	2,274	120	1,895	7	962	2,864	-590
Big Park CDP	7,731	8,810	1,079	1,363	1,151	0	2,514	157	2,514	198	1,954	1,151	0	3,105	-591
Cornville CDP	4,075	7,448	3,373	959	0	2,823	3,782	210	3,782	185	1,544	0	1,882	3,426	356
Lake Montezuma CDP	4,237	8,308	4,071	674	709	537	1,920	142	1,920	120	1,117	709	358	2,184	-264
Ctn-Verde Village CDP	3,373	11,706	8,333	119	0	1,124	1,243	31	1,243	125	1,639	0	749	2,388	-1,145
Williamson CDP	5,228	11,845	6,617	1,491	0	0	1,491	255	1,491	221	2,932	0	0	2,932	-1,441
Verde CCD	1,644	4,377	2,733	542	690	1,322	2,554	294	2,554	235	1,152	690	881	2,724	-170
Prescott CCD	11,012	29,312	18,300	1,349	0	4,936	6,285	109	6,285	135	4,433	8	2,556	6,997	-712
Mingus Mtn CCD	1,700	4,525	2,825	484	728	487	1,699	254	1,699	215	1,090	728	325	2,143	-444
Humboldt CCD	230	612	382	54	0	759	813	210	813	170	117	0	506	623	190
Ashfork CCD	471	36,250	35,779	36	0	2,796	2,832	68	2,832	134	5,441	0	1,398	6,839	-4,007
Total	201,035	594,392	393,357	36,362	6,938	29,586	72,886		72,103		84,775	15,231	17,375	117,381	-45,279

1. See Demand Analysis and Data Sources Documentation for discussion of WPA boundaries. Note: Many municipal boundaries vary from the WPA boundaries.

2. See Population Comparisons for 2006 and 2050 population assumptions.

3. See CYHWRMS - Water Planning Area - Water Use and Available Supply Summary Table for all 2006 Demand Estimates. (Note: Mun/Dom demands include Com/Ind demands delivered by water providers. Column F - Com/Ind demands are individually served through private wells.

4. 2006 Gallons Per Person per Day is calculated by dividing the 2006 Mun/Dom demand by the 2006 population (conversion formula: AF/person * 325,851gal/AF / 365day/year = gal/person/day (GPPD)).

5. This data represents the "Status Quo method" - See CYHWMRS – Water Planning Area – Water Use and Available Supply Summary Table for supporting data per Water Planning Area.

6. 2050 GPPD was provided for each Water Planning Area. The value is multiplied by the 2050 population to calculate 2050 Municipal/Domestic Demand (conversion formula: person * gal/person/day / 325,851gal/AF * 365day/year = AF/year)

7. 2050 Commercial/Industrial Demands are held in Status Quo for 2050 for WPAs outside of the PrAMA (except Clarkdale and Jerome who provided their own estimate and 240 AF was added to the Verde CCD for new GC on reservation). WPAs in the PrAMA include existing uses plus additional (currently unused) groundwater rights (Type I and Type II) and withdrawal permits (59s).

8. Outside the PrAMA 2050 Agricultural Groundwater Demand is assumed to be a percentage (67% - Verde Valley Sub-Basin, 50% - Big Chino Sub-Basin) of the 2006 Agricultural Demand (except Clarkdale and Jerome who provided their own estimate). In the PrAMA Agricultural Surface Water Demand (Granite Dells Ranch - Prescott) is assumed to remain constant and 2050 uses of groundwater were determined by ADWR based on extinguishment of rights.

Note: All Water Planning Areas include demands for water providers and private water users - see Planning Area Water Use Summary Table.

Camp Verde - Stanley Bullard reported for the Camp Verde Water System and verified their 2006 pop. - 3622; 2050 population - 7243; 2006 Demand - 491 AF; and 2050 GPCD - 154. 2008 H3J Report estimates for total Camp Verde population and 2050 GPPD were used in this analysis. Includes Camp Verde Yavapai-Apache Nation population based on DES estimates (718-2006, 890-2050).

Table 3. - CYHWRMS Study Area Demand Analysis Summary Status Quo (cont'd)

Dewey Humboldt - All assumptions are based on 2008 H3J Consulting Report.
Clarkdale -The Town of Clarkdale water service area is completely within the town limits, therefore, the Planning Area is the town boundary. 2006 Population numbers were obtained from the 2008 H3J Consulting Report and were verified per correspondence from Mayor Doug Von Gausig email dated October 3, 2008. 2050 GPPD and 2050 C/I &Ag demands were provided by Doug Von Gausig by email dated June 15, 2009. Includes Clarkdale Yavapai-Apache Nation population based in DES estimates (120-2006, 380-2050).
Cottonwood - The City of Cottonwood water department services areas outside of the city limits and, therefore, the planning area includes both the city and the unincorporated areas within the water service area. Demands shown on this table include those of the Cottonwood water services department and other public and private entities - see Water Planning Area - Water Use and Available Supply Summary Table. Population (11,201 Cottonwood + 8,199 Verde Villages) for the entire planning area were verified per correspondence from Assistant City Manager Robert Hardy email dated October 3, 2008. 2050 GPPD assumption is from 2008 H3J Consulting Report.
***Jerome** - The Town of Jerome water service area extends outside of the town limits; therefore the Planning Area includes both the town and unincorporated areas. 2006 and 2050 Population, 2050 GPPD, and water usage numbers were provided per correspondence by Jane Moore. Jane Moore requested that Jerome's 2006 demand be updated to 400 AFY from 282 AFY because they are using updated meter readings & population to 1100 & GPD to 300 8/29/12 via phone – this results in a 2050 supply of -23 for Jerome (column P). This update was added as a footnote to assure consistency throughout the document and appendices.
Prescott Valley - The Town of Prescott Valley water department services areas outside of the town limits and, therefore, the planning area includes both the town and the unincorporated areas within the water service area. 2006 and 2050 Population, 2050 GPPD and water use numbers for the entire planning area were provided per correspondence from Water Resources Manager John Munderloh emails dated October 6, 2008 and November 10, 2008.
Chino Valley - The Town of Chino Valley WPA has a portion of City of Prescott's WPA extending into the area (in CVID area). Population and water use numbers were verified in a meeting on January 28, 2009. See meeting notes "Meeting_012809". 2050 GPPD assumption is from 2008 H3J Consulting Report.
Prescott - 2006 Population reported by Connie Tucker (COP) 2/18/09 and includes service area boundaries in Prescott, the surrounding unincorporated areas within the Prescott water service area, and Chino Valley. 2050 GPPD assumption is from 2008 H3J Consulting Report.
Sedona - 2050 Population and 2050 GPPD were provided by the city of Sedona at meeting on Jan. 8. 2010. Population estimates are from Table 1 and Table 14 of Status Report- City of Sedona Land Use and Population, July 1, 2009. 2050 Population represents residential build out. (Note: Populations include both Yavapai and Coconino Counties.) The city notes that due to high tourism based commercial uses as a proportion of the total water use the unit GPPD is higher than that of communities having more balanced residential/commercial use ratios. The City anticipates that a use situation similar to that prevailing in 2006 will prevail in 2050 with a slightly lower ratio of residential accounts to commercial accounts.
Paulden CDP - 2050 GPPD estimated to be 90% of 2006 GPPD per correspondence from John Rasmussen dated Nov. 2, 2009. All other assumptions are based on 2008 H3J Consulting Report.
Big Park CDP - All assumptions are based on 2008 H3J Consulting Report.
Cornville CDP - 2050 GPPD estimated to be 90% of 2006 GPPD per correspondence from John Rasmussen dated Nov. 2, 2009. All other assumptions are based on 2008 H3J Consulting Report.
Lake Montezuma CDP - 2050 GPPD estimated to be 90% of 2006 GPPD per correspondence from John Rasmussen dated Nov. 2, 2009. All other assumptions are based on 2008 H3J Consulting Report.
Ctn/Verde Villages - A portion of this unincorporated area is served by the Cottonwood water department. Therefore, based on correspondence with Cottonwood Assistant City Manager Robert Hardy email dated December 2, 2008 the population (8,199 served by city of Cottonwood) and water usage amount reported for the city of Cottonwood were subtracted from the numbers provided in the 2008 H3J Consulting Report. 2050 GPPD assumption is from 2008 H3J Consulting Report.
Williamson CDP - Population using DES data.
Prescott CCD - 2006 and 2050 populations includes Las Vegas Ranch. 2006 population estimated using Yavapai County parcel data. 2050 population calculated assuming an approximate 2.25% growth rate. 2050 GPPD estimated to be 90% of 2006 GPPD per correspondence from John Rasmussen dated Nov. 2, 2009.
Mingus Mountain and Humboldt CCDs - 2006 population estimated using Yavapai County parcel data. 2050 population calculated assuming an approximate 2.25% growth rate. 2050 GPPD estimated to be 90% of 2006 GPPD per correspondence from John Rasmussen dated Nov. 2, 2009.
Ashfork CCD - 2006 and 2050 populations include CVCF and Yavapai Ranches. 2006 population estimated using Yavapai County parcel data. 2050 population calculated assuming an approximate 2.25% growth rate plus projected population for the Ranches. 2050 GPPD estimated to be 90% of 2006 GPPD per correspondence from John Rasmussen dated Nov. 2, 2009. 2006 GPPD very low because much water supply is actually hauled instead of delivered.

Table 4. - Verde Valley Sub-basin Status Quo & Water Balance Method

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
			(C-B)				(E+F+G)	(E/B)	Estimated		(C*K)			(L+M+N)	(J-O)
Water Planning Area[1]	**2006 Population[2]**	**2050 Population[2]**	**Pop. Change**	**2006 Mun/Dom Demand[3]**	**2006 Com/Ind Demand[3]**	**2006 agriculture Demand[3]**	**Total 2006 Demand**	**2006[4]**	**Available Water Supply[5]**	**2050[6]**	**2050 Mun/Dom Demand[6]**	**2050 Com/Ind Demand[7]**	**2050 agriculture Demand[8]**	**Total 2050 Demand**	**2050 Water Supply +/-**
				(AFY)	(AFY)	(AFY)		GPPD	(AFY)	GPPD	(AFY)	(AFY)	(AFY)	(AFY)	(AFY)
Camp Verde	12,497	23,277	10,780	1,701	783	9,320	11,804	122	11,804	112	2,920	783	6,213	9,917	1,887
Clarkdale	3,999	22,460	18,461	481	0	31	512	107	512	75	1,887	300	31	2,218	-1,706
Cottonwood	20,400	77,630	57,230	3,399	1,753	1,137	6,289	149	6,289	125	10,870	1,753	758	13,381	-7,092
Jerome	510	800	290	282	0	0	282	494	282	255	229	53	0	282	0
Sedona	11,080	16,300	5,220	3,801	33	278	4,112	306	4,112	300	5,478	33	185	5,696	-1,584
Big Park CDP	7,731	8,810	1,079	1,363	1,151	0	2,514	157	2,514	198	1,954	1,151	0	3,105	-591
Cornville CDP	4,075	7,448	3,373	959	0	2,823	3,782	210	3,782	185	1,544	0	1,882	3,426	356
Lake Montezuma CDP	4,237	8,308	4,071	674	709	537	1,920	142	1,920	120	1,117	709	358	2,184	-264
Ctn-Verde Village CDP	3,373	11,706	8,333	119	0	1,124	1,243	31	1,243	125	1,639	0	749	2,388	-1,145
Verde CCD	1,644	4,377	2,733	542	690	1,322	2,554	294	2,554	235	1,152	690	881	2,724	-170
Mingus Mtn CCD (portion)*	510	1,358	848	145	218	487	851	254	851	215	327	218	325	870	-19
Humboldt CCD (portion)**	225	600	374	53	0	759	812	210	812	170	114	0	506	620	192
Total	70,281	183,073	112,792	13,519	5,337	17,818	36,675		**36,675**		29,231	5,690	11,889	**46,811**	**-10,136**
Water Balance Method															
VV Sub-Basin (with net natural recharge)	See Blasch, 2006, pg. 82. Inflow (167,000) - base flow out (144,100)								22,900					46,811	-23,911
VV Sub-Basin (with 1997 demands)	See ADWR, 2000 pg. 5-23. Sum of Dom., Other/Industrial, Municipal, and agriculture								26,660					46,811	-20,151

Assumptions:

1. See Demand Analysis and Data Sources Documentation for discussion of WPA boundaries. Note: Many municipal boundaries vary from the WPA boundaries.
2. See Population Comparison for 2006 and 2050 population assumptions.
3. See CYHWRMS - Water Planning Area - Water Use and Available Supply Summary Table for all 2006 Demand Estimates. (Note: Mun/Dom demands include Com/Ind demands delivered by water providers. Column F - Com/Ind demands are individually served through private wells.
4. 2006 Gallons Per Person per Day is calculated by dividing the 2006 Mun/Dom demand by the 2006 population (conversion formula: AF/person * 325,851gal/AF / 365day/year = gal/person/day (GPPD))
5. Estimated Available Water Supply represents either the "Status Quo" (amount available in 2006 is available in perpetuity) or the "Water Balance" (estimated amount available using components from existing water budgets for the area) methods - See Phase I - Demand Analysis Data Sources and Documentation.
6. 2050 GPPD was provided for each Water Planning Area. The value is multiplied by the 2050 population to calculate 2050 Municipal/Domestic Demand (conversion formula: person * gal/person/day / 325,851gal/AF * 365day/year = AF/year)
7. 2050 Commercial/Industrial Demands are held in Status Quo for 2050 for WPAs outside of the PrAMA (except Clarkdale and Jerome who provided their own estimate and 240 AF was added to the Verde CCD for new GC on reservation).
8. 2050 Agricultural Groundwater Demand is assumed to be $^{2}/_{3}$ of the 2006 Agricultural Groundwater Demand (except Clarkdale and Jerome who provided their own agriculture estimate).

* 30% of the Mingus Mountain CCD Water Planning Area is in the Verde Valley Sub-Basin. (100% of the Mingus Mountain CCD Water Planning Area irrigated acreage is in the Verde Valley Sub-Basin.)

** 98% of the Humboldt CCD Water Planning Area is in the Verde Valley Sub-Basin. (100% of the Humboldt CCD Water Planning Area irrigated acreage is in the Verde Valley Sub-Basin.)

Table 5. - Little Chino and Upper Agua Fria Sub-basin (Prescott AMA) Status Quo & Water Balance Method

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
			(C-B)				(E+F+G)	(E/B)	Estimated		(C*K)			(L+M+N)	(J-O)
Water Planning Area[1]	**2006 Population[2]**	**2050 Population[2]**	**Pop. Change**	**2006 Mun/Dom Demand[3]**	**2006 Com/Ind Demand[3]**	**2006 agriculture Demand[3]**	**Total 2006 Demand**	**2006[4]**	**Available Water Supply[5]**	**2050[6]**	**2050 Mun/Dom Demand[6]**	**2050 Com/Ind Demand[7]**	**2050 agriculture Demand[8]**	**Total 2050 Demand**	**2050 Water Supply +/-**
				(AFY)	(AFY)	(AFY)		GPPD	(AFY)	GPPD	(AFY)	(AFY)	(AFY)	(AFY)	(AFY)
Dewey Humboldt	4,134	6,943	2,809	629	16	569	1,214	136	1,214	120	933	700	37	1,670	-456
Prescott Valley	41,610	146,000	104,390	6,221	545	55	6,821	133	6,821	121	19,790	900	0	20,690	-13,869
Chino Valley	12,690	63,690	51,000	1,325	522	1,691	3,538	93	2,755	75	5,351	4,192	158	9,701	-6,946
Prescott	49,072	100,000	50,928	10,531	1	375	10,907	192	10,907	125	14,003	3,224	375	17,602	-6,695
Paulden CDP (portion)*	107	282	175	18	0	578	597	154	597	120	38	0	578	616	-20
Williamson CDP (portion)**	3,241	7,344	4,103	924	0	0	924	255	924	221	1,818	0	0	1,818	-894
Prescott CCD (portion)***	9,580	25,501	15,921	1,174	0	176	1,349	109	1,349	135	3,857	7	176	4,040	-2,690
Mgs Mtn CCD (portion)****	1,190	3,168	1,978	339	510	0	848	254	848	215	763	510	0	1,272	-424
Humboldt CCD (portion)*****	5	12	8	1	0	0	1	210	1	170	2	0	0	2	-1
Total	121,629	352,940	231,311	21,162	1,594	3,444	26,200		**25,416**		46,555	9,533	1,324	**57,411**	**-31,995**
Water Balance Method															
PrAMA (using net nat. recharge)	K. Nelson, 2009 Nat. Recharge memo (8,070) - Avg. outflow from ADWR, 1999 declaration (4,850)								3,220					57,411	-54,191
Prescott AMA (using avg 1990 - 1997 demands)	ADWR. 1999 declaration, Table 2 Sum of 1990-1997 Muni (incls. Exempt), agriculture and Industrial)								16,317					57,411	-41,094

Assumptions:

1. See Demand Analysis and Data Sources Documentation for discussion of WPA boundaries. Note: Many municipal boundaries vary from the WPA boundaries.
2. See Population Comparison for 2006 and 2050 population assumptions.
3. See CYHWRMS - Water Planning Area - Water Use and Available Supply Summary Table for all 2006 Demand Estimates. (Note: Mun/Dom demands include Com/Ind demands delivered by water providers. Column F - Com/Ind demands are individually served through private wells.
4. 2006 Gallons Per Person per Day is calculated by dividing the 2006 Mun/Dom demand by the 2006 population (conversion formula: AF/person * 325,851gal/AF / 365day/year = gal/person/day (GPPD))
5. Estimated Available Water Supply represents either the "Status Quo" (amount available in 2006 is available in perpetuity) or the "Water Balance" (estimated amount available using components from existing water budgets for the area) methods - See Phase I - Demand Analysis Data Sources and Documentation.
6. 2050 GPPD was provided for each Water Planning Area. The value is multiplied by the 2050 population to calculate 2050 Municipal/Domestic Demand (conversion formula: person * gal/person/day / 325,851gal/AF * 365day/year = AF/year)
7. 2050 Commercial/Industrial Demands are held in Status Quo for 2050 for WPAs outside of the PrAMA (except Clarkdale and Jerome who provided their own estimate and 240 AF was added to the Verde CCD for new GC on reservation).
8. In the PrAMA Agricultural Surface Water Demand (Granite Dells Ranch - Prescott) is assumed to remain constant and 2050 uses of groundwater were determined by ADWR based on extinguishment of rights.

* 2% of the Paulden CDP Water Planning Area is in the Prescott AMA. (43% of the Paulden CDP Water Planning Area irrigated acres is in the Prescott AMA.)

**62% of the Williamson CDP Water Planning Area is in the Prescott AMA.

*** 87% of the Prescott CCD Water Planning Area is in the Prescott AMA. (4% of the Prescott CCD Water Planning Area irrigated acres is in the Prescott AMA.)

**** 70% of the Mingus Mountain CCD Water Planning Area is in the Prescott AMA. (None of the Mingus Mountain CCD Water Planning Area irrigated acres are in the Prescott AMA.)

***** 2% of the Humboldt CCD Water Planning Area is in the Prescott AMA. (None of the Humboldt CCD Water Planning Area irrigated acres are in the Prescott AMA.)

Table 6. - Big Chino Sub-basin Status Quo & Water Balance Method

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
			(C-B)				(E+F+G)	(E/B)	Estimated		(C*K)			(L+M+N)	(J-O)
Water Planning Area[1]	**2006 Population[2]**	**2050 Population[2]**	**Pop. Change**	**2006 Mun/Dom Demand[3]**	**2006 Com/Ind Demand[3]**	**2006 agriculture Demand[3]**	**Total 2006 Demand**	**2006[4]**	**Available Water Supply[5]**	**2050[6]**	**2050 Mun/Dom Demand[6]**	**2050 Com/Ind Demand[7]**	**2050 agriculture Demand[8]**	**Total 2050 Demand**	**2050 Water Supply +/-**
				(AFY)	(AFY)	(AFY)		GPPD	(AFY)	GPPD	(AFY)	(AFY)	(AFY)	(AFY)	(AFY)
Paulden CDP*	5,235	13,817	8,582	903	7	768	1,677	154	1,677	120	1,857	7	384	2,248	-571
Williamson CDP (portion)**	1,987	4,501	2,514	567	0	0	567	255	567	221	1,114	0	0	1,114	-548
Prescott CCD (portion)***	1,432	3,811	2,379	175	0	4,760	4,936	109	4,936	135	576	1	2,380	2,957	1,978
Ashfork CCD	471	36,250	35,779	36	0	2,796	2,832	68	2,832	134	5,441	0	1,398	6,839	-4,007
Total	9,124	58,379	49,254	1,681	7	8,324	10,012		**10,012**		8,989	8	4,162	**13,159**	**-3,148**
Water Balance Method															
Big Chino Sub-Basin (Using net nat. recharge)	See Blasch, 2006. Pg 82 Inflow (30,300) - base flow out (17,900)								**12,400**					**13,159**	**-759**
Big Chino Sub-Basin (using avg 1990 -1997 demands	See ADWR, 2000 pg 5-8. Sum of Dom., Other/Industrial, Sm Providers, and agriculture								**15,720**					**13,159**	**2,561**

Assumptions:

1. See Demand Analysis and Data Sources Documentation for discussion of WPA boundaries. Note: Many municipal boundaries vary from the WPA boundaries.
2. See Population Comparison for 2006 and 2050 population assumptions.
3. See CYHWRMS - Water Planning Area - Water Use and Available Supply Summary Table for all 2006 Demand Estimates. (Note: Mun/Dom demands include Com/Ind demands delivered by water providers. Column F - Com/Ind demands are individually served through private wells.
4. 2006 Gallons Per Person per Day is calculated by dividing the 2006 Mun/Dom demand by the 2006 population (conversion formula: AF/person * 325,851gal/AF / 365day/year = gal/person/day (GPPD))
5. Estimated Available Water Supply represents either the "Status Quo" (amount available in 2006 is available in perpetuity) or the "Water Balance" (estimated amount available using components from existing water budgets for the area) methods - See Phase I - Demand Analysis Data Sources and Documentation.
6. 2050 GPPD was provided for each Water Planning Area. The value is multiplied by the 2050 population to calculate 2050 Municipal/Domestic Demand (conversion formula: person * gal/person/day / 325,851gal/AF * 365day/year = AF/year)
7. 2050 Commercial/Industrial Demands are held in Status Quo for 2050 for WPAs outside of the PrAMA (except Clarkdale and Jerome who provided their own estimate and 240 AF was added to the Verde CCD for new GC on reservation).
8. 2050 Agricultural Groundwater Demand is assumed to be 1/2 of the 2006 Agricultural Groundwater Demand.

*98% of the Paulden CDP Water Planning Area is in the Big Chino Sub-Basin. (57% of the Paulden CDP Water Planning Area irrigated acreage is in the Big Chino Sub-Basin.)

**38% of the Williamson CDP Water Planning Area is in the Prescott AMA.

***13% of the Prescott CCD Water Planning Area is in the Big Chino Sub-Basin. (96% of the Prescott CCD Water Planning Area irrigated acreage is in the Big Chino Sub-Basin.)

V. Water Supply Assessment (Phase II)

The second phase of the study, Water Supply Assessment, is a water resources inventory. The purpose of the inventory is to identify potential sources of water to satisfy 2050 unmet demands that were identified within WPAs in Phase I. Surface water, groundwater, wastewater, flood water, storm water and effluent, as evaluated below, are considered as potential supplies. Potential water sources can be located within or outside of the study area (Table 7). For information on the analysis of potential sources of water refer to Appendix B.

A. Sources of Water within the Study Area

Table 7. - Sources of Water within the Study Area

Water Supply Type	Big Chino Sub-Basin	Little Chino &Upper Agua Fria Sub-Basin (Prescott AMA)	Verde Valley Sub-Basin
Surface Water	No	No	No
Groundwater	Yes	Yes	Yes
Wastewater			
Septic	Yes	Yes	Yes
Mine Drainage	No	No	No
Brackish/Saline	No	No	No
Flood Water	Yes	Yes	Yes
Storm Water	Yes	Yes	Yes
Effluent	Yes	Yes	Yes

1. *Surface Water*

Arizona Revised Statues § 45-101 defines surface water as "waters of all sources, flowing in streams, canyons, ravines or other natural channels, or in definite underground channels, whether perennial or intermittent, floodwaters, wastewaters, or surplus water, and of lakes, ponds and springs on the surface." For the purpose of this analysis, this broad definition of surface water is narrowed to include rivers, streams, lakes, reservoirs and springs.

Rivers and Streams

There are two major river systems in the study area; the Verde River and the Agua Fria River. The Verde River watershed in the study area contains portions of the Big Chino, Little Chino and Verde Valley sub-basins. The Verde River runs 94 miles through the study area. Significant tributaries with measured flow to the Verde River include Williamson Valley Wash, Sycamore Creek, Oak Creek, Beaver Creek, West Clear Creek and Granite Creek. The Agua Fria River begins in the Prescott Active Management Area (PrAMA) and runs approximately 20 miles through the study area.

Analysis of Statements of Claimant (SOCs) and surface water filings in the Verde and Agua Fria Watersheds concludes that existing claims for surface water far exceed available supply. Therefore, with the exception of major flood events (see Chapter V. 4. Flood Water); new sources of surface water are not available within the study area to meet new water demands.

Springs

According to USGS National Water Information System data a total of 33 major springs are found in the study area. Major springs are defined as having a discharge of greater than 10 gallons per minute (gpm). Major springs are largely concentrated in the Verde Valley sub-basin, which includes 30 of the 33 major springs.

As with other surface water claims, the amount of water claimed for beneficial use from each spring exceeds the amount physically available. Additionally, it is assumed that all surface water produced from springs in the study area today is either fully consumed or contributes to stream flow, therefore, it is concluded that there is no new surface water available in the study area from springs.

Lakes and Reservoirs

Several large capacity reservoirs exist within the study area (Table 8). (A large capacity reservoir is defined as having a capacity of 500 acre feet or greater). The Prescott AMA has four large reservoirs while the remaining sub-basins include two. Table 8 shows the available data for these reservoirs. The largest reservoir is Willow Creek Reservoir in the Prescott AMA. The reservoir is City of Prescott surface water supply and is primarily filled by Willow Creek. Watson Lake is also a City of Prescott surface water supply. Granite Creek is the main water source for Watson Lake. Water from these reservoirs is delivered to the cities recharge facility to augment the aquifer. Complex legal restrictions, variable surface flow and the cities desire to maintain recreation volumes, limit the amount and timing of deliveries to the recharge facility (City of Prescott, 2011)

Table 8. - Reservoirs within the Study Area

Name	Sub-basin	Owner/operator	Maximum storage (af)	Use
Willow Creek Reservoir	Prescott AMA	City of Prescott	7,800	Water supply, Recreation
Watson Lake	Prescott AMA	City of Prescott	4,900	Water supply, Recreation
Lynx Lake	Prescott AMA	Arizona Game and Fish	2,763	Recreation
Hells Canyon Tank	Verde	AZ Dept of Transportation	1,545	Fire Protection
Wineglass Ranch	Big Chino	AZ State Land Dept	1,226	Fire Protection
Upper Goldwater	Prescott AMA	City of Prescott	700	Recreation

Source: ADWR Water Atlas

Water supply from the larger lakes and reservoirs is quantified; however, data is very limited for smaller reservoirs. Willow Creek Reservoir and Watson Lake are the largest lakes in the study area. All water from these two lakes is claimed for use and already accounted for in the CYHWRMS Demand Analysis by the City of Prescott. Based on the best available data, it is assumed that no new water is available within the study area from lakes and reservoirs.

2. *Groundwater*

Groundwater is the primary source of water for domestic use in the study area. The most reliable and accessible groundwater resource is the aquifers composed of younger (Cenozoic age) sedimentary and volcanic rocks. These younger materials are found in basin-fill aquifers of the Big Chino sub-basin, the Little Chino sub-basin and the Verde Valley sub-basin.

There are many factors associated with quantifying groundwater available in the study area:

1. Uncertainty (amounts are best expressed as a range)
2. Recoverable water (not all water in storage can be recovered by wells for a variety of reasons)
3. Water Quality
4. Natural Groundwater discharge (groundwater contribution to base flow; some groundwater is supplying base flow to streams; may be counted in the surface water quantification)
5. Water budgets (e.g. groundwater natural and artificial recharge amounts, pumping amounts)

6. State Water law (defines groundwater as a different source from surface water)

Basin-Fill Aquifers
Based on referenced information and specific yield calculations, the Big Chino sub-basin aquifer has between 6 and 15 million acre feet (maf) of water available for pumping. The Prescott AMA aquifer has approximately 3.0 maf, and the Verde Valley sub-basin has between 4.5 and 11 maf in places beneath the Big Chino and Verde Valley sub-basins (WAC, 2009).

Some of the available supply may be of poor quality or subject to other limitations imposed by aquifer properties, legal, environmental, or economic issues. Additionally, groundwater use in amounts greater than the net recharge results in the overdraft of the aquifer. The Prescott AMA and the Verde Valley sub-basin are currently in a state of overdraft (ADWR, 1999; Garner and others, 2013).

Paleozoic age rock Aquifers
There may be additional water in Paleozoic aquifers where they exist, however they are not well understood in the study area. Some of the available supply may be of poor quality or subject to other limitations imposed by aquifer properties, legal, environmental, or economic issues.

3. *Waste Water*

The U.S. Environmental Protection Agency defines wastewater as "the spent or used water from homes, communities, farms and businesses that contains enough harmful material to damage the water's quality. Wastewater includes both domestic sewage and industrial waste from manufacturing sources. Metals, organic pollutants, sediment, bacteria and viruses may all be found in wastewater. As a result, untreated wastewater can cause serious harm to the environment and threaten human life." (EPA, August 2014)

Waste water does not mean:
1. Storm Water
2. Discharges authorized under the De Minimus General Permit
3. Other allowable non-storm water discharges permitted under the Construction
4. General Permit or the Multi-Sector General Permit, or
5. Storm water discharge from a municipal storm sewer system containing incidental amount of non-storm water

For the purpose of this study, wastewater will include water developed from septic systems, mine drainage, or brackish/saline sources.

Mine Drainage

Metals, that find their way into the surface waters of the Verde River, are one of most significant water quality problems in the Verde Watershed because of the potential toxicity to aquatic life. Constituent groups evaluated for Verde Watershed are: mercury, copper, zinc, and arsenic. The primary sources for metals in the Verde Watershed are probably runoff and erosion from active and abandoned mines. Developed urban areas may also be considered as a nonpoint source for metals pollutants.

While there are many mines in the study area, there appears to be little or no data to quantify mine drainage water volumes available for use anywhere in the study area. Drainage from mines does not appear to be a viable option as source water for local or regional supply.

Brackish/Saline Water

There are little or no brackish/saline waters of consequence within the study area. Brackish/saline waters, within the study area, are not considered to be available for development as a local or regional water supply.

4. *Flood Water*

The *Arizona Revised Statutes*; *Title 45, Chapter 1, Section 45-141, Paragraph A*, defines surface water as "The waters of all sources, flowing in streams, canyons, ravines or other natural channels, or in definite underground channels, whether perennial or intermittent, flood, waste or surplus water, and of lakes, ponds and springs on the surface, belong to the public and are subject to appropriation and beneficial use."

Although claims for surface water exceed available supply, there is little dedicated flood control space in the Verde River system and water from flood events is often released rather than stored in the system for later use. And, although flood events are relatively rare, capturing unappropriated flood water is a potential source of new supply in the study area.

Flood water is generated in tributaries in each of the sub-basins and is available to be developed as an additional supply in the study area. Water supply developed from the collection and storage of unappropriated flood water is dependent on high flow events and therefore will be relatively unreliable. Additionally, this supply will likely be quite expensive and may have many issues associated with location of diversion and potential exchanges on the Verde River.

5. *Storm Water*

The term "Storm water" means storm water runoff, snow melt runoff, and surface runoff and drainage within an urban setting. Impervious surfaces like driveways, sidewalks, and streets prevent storm water runoff from naturally soaking into the ground. Storm water can pick up debris, chemicals, dirt, and other pollutants and

flow into a storm sewer system or directly to a lake, stream, river, wetland, or coastal water. Most of the time anything that enters a storm sewer system is discharged untreated into the water bodies that are used for swimming, fishing and providing drinking water.

Information relating to storm water runoff volumes is limited. Storm water may have the potential to produce large volumes of surface runoff within developed community and potentially, on a larger landscape scale, however, information relating to storm water runoff volumes is limited.

6. *Effluent*

Effluent, or reclaimed water, means water that has been collected in a sanitary sewer for subsequent treatment in a facility that is regulated pursuant to *Arizona Revised Statutes, Title 49, Chapter 2, Water Quality Control*. Such water remains effluent until it acquires the characteristics of groundwater or surface water.

There are three sources of effluent development in the study area. The first is the conversion of existing septic to sewer systems. This source is estimated to potentially produce more than 3,000 AFY. The second effluent source assumes that all new growth would be provided access to a sewer system. This source is estimated to potentially produce 30,000 AFY of new supply within the study area by 2057. The third source is effluent not currently utilized by treatment facilities. This source is estimated to potentially produce 1,900 AFY.

B. Water Resources Outside the Study Area

For the purpose of this study, it is assumed that wastewater, storm water and effluent are localized sources and are not feasible for development and importation into the study area. Therefore, only surface water, including flood water, and groundwater were examined for development outside of the study area.

1. *Surface Water*

There are six (6) Arizona surface water basins surrounding the Verde River Basin (equivalent to a portion of the CYHWRMS area). The surface water basins are: Agua Fria River, Colorado River, Little Colorado River, Salt River, Middle Gila River, and Bill Williams River. As with surface water availability in the study area, surface water availability in the surrounding basins is likewise limited. With ongoing general stream adjudications and Indian waters rights settlements, it is difficult to quantify surface water available, in excess of existing appropriations, to meet the future water supply needs in the study area. For the purpose of this study, it is assumed that the most likely sources of surface water outside of the study area are the Colorado and Bill Williams Rivers (Table 9). Although the Verde River has many SOCs, legal and environmental concerns, unappropriated

flood water may be available for development outside of the study area (i.e. Horseshoe and Bartlett Dams).

Table 9. - Surface Water Resource Availability Outside the Study Area

River Basin	Surface Water
Agua Fria	No
Colorado	Yes
Little Colorado	No
Salt	No
Middle Gila	No
Bill Williams	Yes
Verde	No

2. *Groundwater*

There are 12 groundwater basins that touch one or more sub-basins of the study area. Groundwater is the main source of water supply in the CYHWRMS study area and throughout much of rural Arizona. Although there are sources outside of the study area, those immediately to the east and north of the study area have been investigated in other water resources planning studies (i.e. Mogollon Rim Water Resources Management Study and North Central Water Supply Study) and in most cases have been found to be unsustainable as a renewable supply. It is possible that groundwater may be available for development in the study area from basins to the west (i.e. Bill Williams Basin) or from any basin on a groundwater mining basis. Due to the relative proximity and potential sustainability of groundwater development, the Agua Fria, Upper Hassayampa, Big Sandy and Bill Williams basins were identified as potential sources of groundwater development outside of the study area (Table 10). The Upper Hassayampa and Agua Fria basins were not considered in alternatives due to the size and proximity of the alluvial aquifers in those basins.

Table 10. - Groundwater Resource Availability Outside the Study Area

Groundwater Basins	Groundwater
Coconino Plateau	Yes
Little Colorado Plateau	Yes
Agua Fria	Yes
Salt River	Yes
Tonto Creek	Yes
Upper Hassayampa	Yes
Verde River	Yes
Phoenix AMA	Yes
Prescott AMA	Yes
Big Sandy	Yes
Bill Williams	Yes
Peach Springs	Yes
Shivwits Plateau	Yes

VI. Alternative Development & Evaluation (Phase III)

The purpose of Phase III is to describe and analyze, at an appraisal level, water supply alternatives to satisfy unmet water demand in the CYHWRMS study area in 2050. During Phase II, potential water supply sources are identified and during Phase III, alternatives are developed from the potential water supply sources which are inside and outside of the study area. The alternatives are analyzed relative to the environment, costs, public perception and legal and institution issues and then evaluated for viability.

A. Future Without a Regional Plan - No Action Alternative

Under the Future Without a Regional Plan, the various communities, water providers and private individuals with wells would proceed with their current supplies or individually developed new supplies. This scenario includes continuation of groundwater pumping and overdraft in order to meet new demand associated with increases in population (new surface water sources do not appear available within the study area). Individual communities and providers would likely pursue effluent reuse and conservation efficiencies as necessary components of their water planning. However, it would be difficult and impractical for each individual WPA to pursue complete solutions to their specific issues, which include not only securing adequate water supplies, but assuring adequate quality and reliability as well. The overall water supply available for use within the study area is limited due to the restrictions on groundwater development within the PrAMA and the concern over increased groundwater pumping inside and outside the AMA that may cause undesirable impacts. Without access to reliable water supplies that can be developed and delivered at an affordable cost, there will need to be significant changes made to the current development and lifestyle trends, and/or there will be substantial changes to the economic conditions within the study area.

1. *Consequences of Long-term Non-safe-yield Conditions*

- Groundwater Storage capacity is reduced
- Future reliability of water supplies is less certain
- Water levels decline
- Wells may require deepening
- Water Quality problems may increase
- Wells may go dry
- Pumping and drilling cost increase
- Natural discharge to springs and streams diminish
- Land subsidence and earth fissuring may occur

B. Alternatives

Through the stakeholder process, 13 potential water supply alternatives were developed for the available water supply type identified in Phase II. Alternatives that were developed by the TWG for each water supply source are listed in the table 11 below.

Table 11. - Water Supply Alternatives and Description Grouped by Water Supply Type

Water Supply Type	Alternative	Alternative Description
Groundwater	**1**	Local Groundwater Development within the WPA (Inside and outside PrAMA)
	2	Regional Groundwater Development – Big Chino Pipelines (PrAMA and Verde Valley)
	3	Regional Groundwater Development Outside Study Area - Bill Williams Sub-basin and Big Sandy Sub-basin
Effluent	**4**	Conversion of Existing Systems - Urban
	5	Conversion of Existing Systems - Rural
	6	Additional Effluent from Increased Population
Flood Water	**7**	Capture and Store Unappropriated Verde River or tributary water
Storm Water	**8**	Rainwater Harvesting – Aquifer Storage
Conservation	**9**	Implement Conservation (e.g., low flow toilets, turf restrictions, educational programs, etc.)
Surface Water	**10**	Alamo Lake
	11	Colorado River via (a) Alamo Lake, (b) Diamond Creek, (c) Lake Mead, (d) Lake Havasu, (e) Lake Mohave, and (f) Lake Powell
Other	**12**	Weather Modification – Cloud Seeding
	13	Watershed Management

C. Analyses of Water Supply Alternatives

Analyses of Environmental impacts, Legal and Institutional issues, Public Perceptions, and Costs are completed for each alternative. These are the primary factors for identifying whether an alternative would be considered for further assessment under a future, potential feasibility study. Details of the analyses can be found in Appendix C.

1. *Environmental Analysis Description*

A brief description of potential environmental issues and a summary table listing the environmental issues, their effect and notes is provided for each alternative in consideration for meeting future unmet water demands in the study area. Environmental issues are separated into three categories: hydrologic, biologic, and watershed. The effect is classified as positive (+), negative (-), or neutral (0). A notes column provides an explanation for the rationale used to assess the potential effects. This analysis can be found in Appendix C.

The environmental considerations analysis assesses environmental issues and impacts within the study area only. Water development outside the study area would require additional environmental assessment relative to impacts to those areas where water is derived from, including groundwater and/or surface water sources.

2. *Legal & Institutional Analysis Description*

A description of the legal and institutional considerations for each water supply alternative in the study area is provided. The intent is to identify potential significant issues or obstacles associated with each of the alternatives relative to Federal, state, or local regulations and other institutional criteria. The legal and institutional assessment provides an overview of potential issues and cultural views and a listing of pertinent regulations and legal considerations for each alternative. This analysis can be found in Appendix C.

3. *Public Perception Description*

Public perception is developed based on popular opinion, media coverage, reputation, past experience, motivation, mood, social status, and social norms. Perceptions may be based on data, information or beliefs. It can be difficult to overcome a negative public perception of an issue. Negative public perception and potential denial of voter approval for financing and construction of proposed water development, transport, and infrastructure projects can prevent a viable alternative from moving forward.

4. *Costs Analysis Description*

Identifying and securing funding can be a challenge for any alternative identified in the Study. Construction, operation and maintenance costs are used to evaluate the viability of an alternative. Costs are noted in the Water Supply Alternatives Report and are used to compare magnitude of costs between alternatives only and are not actual construction costs. Detailed field costs would be prepared if an alternative is assessed under a feasibility study. Cost definitions and assumptions are summarized below:

- Field cost = construction costs plus contingencies.
- Amortized Annual Construction Cost = annual payment necessary to amortize the field costs over 50 yrs. at the 4.125%.
- Annual Cost per acre foot = amortized annual construction cost plus the annual O&M costs divided by the water supply yield in AFY.
- Annual Cost per 1,000 gallons = amortized annual construction cost plus the annual O&M costs divided by the water supply yield in 1,000 gallons.
- Present Worth Cost per acre foot = field costs plus present value of 50yrs of O&M costs at 4.125% divided by the water supply yield in AFY.
- Present Worth Cost per 1,000 gallons = field costs plus present value of 50yrs of O&M costs at 4.125% divided by the water supply yield in 1,000 gallons.
- Contingencies include mobilization at 5%, unlisted items at 15%, and additional contingencies at 25%.
- Costs were indexed to 2011.

O&M cost inflation is not factored in over the 50 year evaluation period. The Cost Analysis for each alternative can be found in CYHWRMS "Water Supply Alternatives 4-8-2013" Report contained in Appendix C.

D. Viability Criteria for Evaluating Water Supply Alternatives

1. *Definitions of Viability*

Each alternative is screened based on four evaluation criteria: completeness, effectiveness, efficiency, and acceptability. Minimum standards are established to assess viability for four criteria to determine if an alternative is worthy of further consideration. The standards are subjective and each alternative is measured relative to other proposed alternatives. As long as an alternative exceeds the minimum standard for each criterion it qualifies for further consideration and comparison with other alternatives.

Completeness
Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. This may require relating the plan to other types of public or private plans if the other plans are crucial to realization of the contributions to the objective.

Effectiveness
Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.

Efficiency
Efficiency is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent while protecting the Nation's environment. Costs refer to the amount of money required to implement an alternative and the opportunities that would be sacrificed if the alternative is implemented. Efficiency refers to the allocation of resources. When all monetary and non-monetary costs are considered, is the alternative the least costly to meet the objective.

Acceptability
Acceptability is the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public, and compatibility with existing laws, regulations, and public policies. Acceptability may be the most useful criterion for assessing potential alternatives.

E. Water Supply Alternative Description, Analyses & Evaluation

A summary for each of the water supply alternatives was completed and includes the following: a brief description of the water supply alternative including assumptions; the WPAs for which the alternative is considered; summary results of the analyses done for environmental, legal and institutional issues and public perception; an alternative cost analysis and volumes of water that will be developed; evaluation results and report of findings for viability. For details of the alternatives and analyses refer to the CYHWRMS Water Supply Alternatives Report, Legal and Institutional Considerations and Environmental Assessment in Appendix C. Located near the end of the section, Table 12 summarizes viability of evaluated alternatives, and Table 13 summarizes the volume and cost calculations for evaluated alternatives.

Alt. #1 Local Groundwater Development within the WPA (Outside the PrAMA)

Description
This alternative relies solely on the continued development of groundwater to meet the water supply deficit in 2050 with either urban non-exempt wells, rural exempt wells or a combination thereof for WPAs outside the Prescott AMA (PrAMA). For each WPA, an analysis was done to determine what percentage of municipal demand is provided either by a water provider or by private domestic wells. It was assumed that groundwater in rural areas is generally accessed by private domestic wells that are referred to as exempt wells. Conversely, it was assumed that urban areas are generally served by water providers of varying sizes by non-exempt wells. The proportion of non-exempt wells and exempt wells reflects an approximation of rural and urban populations in each planning area. It is assumed that the present pattern for rural or urban areas will be similar in future growth. For this option, WPAs considered in this alternative are those that show a 2050 water supply deficit and are outside the PrAMA. There are thirteen WPAs

considered; Clarkdale, Cottonwood, Jerome, Paulden, Sedona, Big Park, Lake Montezuma, Cottonwood-Verde Village, Williamson, Verde CCD, Prescott CCD, Mingus Mtn. CCD and Ashfork CCD.

Environmental Issues

Primary environmental issues of concern with development of groundwater to meet the 2050 deficit include potential impacts to surface water supplies where there is a groundwater-surface water connection. Anticipated issues include eventual declines and loss of stream and spring flows, changes in stream flow magnitude, duration and flood events, and the impact to groundwater availability. Activities affecting hydrology of the system also affect the biologic dynamics of the riparian and spring systems. Detrimental effects of loss of flow (and other hydrologic parameters) impact native vegetation and plant communities, native wildlife habitat and species productivity, and the potential loss of native aquatic species. Habitat degradation due to changes in water availability may also lead to the establishment of unwanted exotic and non-native invasive plants and animal species. Other potential issues may arise if groundwater pumping were to affect groundwater levels and surface water flows including problems associated with land subsidence, and water quality including concentration of contaminants.

Legal and Institutional Issues

Requirements for groundwater development within a WPA that is outside of the PrAMA may include right of way permissions and approval by the ACC. Water Infrastructure Finance Authority (WIFA) funding may be available. Depending on the outcome of the general adjudication of surface water rights, certain well locations could be subject to adjudication requirements. New groundwater development would be subject to Notice of Intent (NOI) requirements, statutory limits on groundwater transportation, and well spacing requirements. Potable water deliveries would be subject to potable water facilities, Safe Drinking Water Act (SDWA) and Water Treatment regulations. Depending on new well locations, groundwater development may be subject to Federal Reserved Rights for Indian Tribes.

Public Perception

New groundwater pumping could cause groundwater overdraft, potentially impact existing wells and surface water supplies, and subject to reliability concerns.

Cost

Alt #	Description of Alternative	Volume (AFY)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per 1,000 ($/Kgal)
1	Local GW Development Outside AMA –Urban Wells	12,178	8,144,135	387,300		31.80	0.10
1	Local GW Development Outside AMA – Rural Wells	7,592	607,708,336	28,897,100		3,806.26	11.68
1	TOTAL - Local GW Development Outside AMA (urban & rural wells)	19,770	615,852,471	29,284,400		3,838.06	11.78

*This alternative comprises of both rural and urban volumes and costs added together.

Evaluation
Acceptability (yes)
Effectiveness (yes)
Efficiency (yes)
Completeness (yes)

Findings
Viable: Continued use of groundwater to meet future demands will likely be, at minimum, a component of the future water supplies for these WPAs. There is concern over the effectiveness because it's not a sustainable solution and there will be impacts if it continues.

Alt. #1 Local Groundwater Development within the WPA (Inside the PrAMA)

Description
This alternative relies solely on the development of groundwater to meet the water supply deficit in 2050 with urban non-exempt wells and rural exempt wells for WPAs inside the Prescott AMA (PrAMA). For this option, WPAs considered are City of Prescott, Chino Valley, Dewey-Humboldt and Prescott Valley.

The development of groundwater to meet municipal demand inside the Prescott Active Management Area (PrAMA) is limited by the Assured Water Supply regulations. The 1999 declaration that the PrAMA was out of safe yield resulted in the implementation of more stringent Assured Water Supply requirements,

particularly more stringent limitations on the volume of groundwater that could be utilized by new subdivisions.

Because City of Prescott is a designated provider, it was evaluated differently. The method used to determine the manner in which local groundwater could be developed and utilized within the Prescott WPA was guided by the City of Prescott's Modified Designation of Assured Water Supply issued December 30, 2009 - Decision and Order No. 86-401501.0001 (Modified Designation). It was determined that there is existing well capacity to meet the Prescott WPA 2050 water supply deficit, therefore drafting cost estimates for new wells the was determined to be unnecessary for the Prescott WPA.

For Chino Valley, Dewey-Humboldt and Prescott Valley WPAs, currently platted subdivisions were queried in order to determine the maximum groundwater allowance allowed under currently issued Certificates of Assured Water Supply. The maximum groundwater allowance volume associated with currently undeveloped subdivisions lots was assumed to be met by new non-exempt, municipal wells. Any volume of groundwater in excess of the maximum groundwater allowance, or the 2050 water supply deficit must be met by exempt wells or by an alternative water supply.

Environmental Issues

Primary environmental issues of concern with development of groundwater to meet the 2050 deficit include potential impacts to surface water supplies where there is a groundwater-surface water connection. Anticipated issues include eventual declines and loss of stream and spring flows, changes in stream flow magnitude, duration and flood events, and the impact to groundwater availability. Activities affecting hydrology of the system also affect the biologic dynamics of the riparian and spring systems. Detrimental effects of loss of flow (and other hydrologic parameters) are anticipated on native vegetation and plant communities, native wildlife habitat and species productivity, and the potential loss of native aquatic species. Habitat degradation due to changes in water availability may also lead to the establishment of unwanted exotic and non-native invasive plants and animal species. Other potential issues may arise if groundwater pumping were to affect groundwater levels and surface water flows including problems associated with land subsidence, and increasing issues in water quality including concentration of contaminants.

Legal and Institutional Issues

Requirements for groundwater development within a WPA that is inside of the PrAMA would have to meet Assured and Adequate Water Supply rules and may require right of way permissions and approval by the ACC. Depending on the outcome of the general adjudication of surface water rights, certain well locations could be subject to adjudication requirements. New groundwater development would be subject to NOI requirements, statutory limits on groundwater transportation, and well spacing requirements. Potable water deliveries would be

subject to potable water facilities, SDWA and Water Treatment regulations. Depending on new well locations, groundwater development may be subject to Federal Reserved Rights for Indian Tribes. WIFA funding may be available.

Public Perception

New groundwater pumping could increase groundwater overdraft, potentially impact existing wells and surface water supplies, and subject to reliability concerns.

Cost

Alt #	Description of Alternative	Volume (AFY)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per 1,000 ($/Kgal)
1	Local GW Development Inside AMA – Urban Wells	1,648	1,080,713	51,400		31.19	0.10
1	Local GW Development Inside AMA – Rural Wells	19,623	1,570,685,813	74,687,700		3,806.13	11.68
1	TOTAL - Local GW Development inside AMA (urban & rural wells)	21,271	1,571,766,526	74,739,100		3,837.32	11.78

*This alternative comprises of both rural and urban volumes and costs added together.

Evaluation

Acceptability (no)
Effectiveness (no)
Efficiency (yes)
Completeness (no)

Findings

Not Viable: This alternative is contrary to the 1980 Groundwater Management Act and the safe yield goals and fails because it is not compatible with existing regulations.

Alt. #2 Regional Groundwater Development Big Chino Pipelines (PrAMA & Verde Valley)

Description

This alternative proposes two versions that rely on development of groundwater supplies from the Big Chino Sub-basin for transportation via pipeline to either specific WPAs within the PrAMA or to specific WPAs within the Verde Valley. This alternative is considered to be regional groundwater development because it requires development of groundwater supply from the Big Chino Water Ranch, within the study area.

The WPAs considered in the PrAMA version of this alternative are: City of Prescott, Prescott Valley and Town of Chino Valley. The water supply deficits for Prescott and Prescott Valley WPAs were limited by provisions within the City of Prescott's Modified Designation of Assured Water Supply which are 4,365 AFY for City of Prescott and 3,703 AFY for Prescott Valley. The water supply deficit of 4,400 AFY for the Town of Chino Valley to be met by this alternative was determined by the Town of Chino Valley.

The WPAs considered in the Verde Valley version of this alternative are: Clarkdale, Cottonwood, Sedona, Big Park CDP, Lake Montezuma CDP and Verde Village CDP. This alternative meets the total 2050 water supply deficit of 12,382 AFY for these WPAs. Rural WPAs that are primarily served from private, domestic wells were not included within this alternative.

Environmental Issues

Primary environmental issues of concern with development of groundwater supplies from the Big Chino Sub-basin to meet the 2050 deficit include potential impacts to surface water supplies where there is a groundwater-surface water connection. Anticipated issues include eventual declines and loss of stream and spring flows, changes in stream flow magnitude, duration and flood events, and the impact to groundwater availability. Activities affecting hydrology of the system also affect the biologic dynamics of the riparian and spring systems. Detrimental effects of loss of flow (and other hydrologic parameters) are anticipated on native vegetation and plant communities, native wildlife habitat and species productivity, and the potential loss of native aquatic species. Habitat degradation due to changes in water availability may also lead to the establishment of unwanted exotic and non-native invasive plants and animal species. Other potential issues may arise if groundwater pumping were to affect groundwater levels and surface water flows including problems associated with land subsidence, and increasing issues in water quality including concentration of contaminants.

This alternative also considers a mitigation framework for the maintenance of base flow, which in the event the withdrawal of water from the Big Chino Sub-Basin is negatively affecting the flow of water in the Upper Verde River,

mitigation of impacts will be considered (refer to "An Agreement in Principle among the City of Prescott, the Town of Prescott Valley, and the Salt River Valley Water Users' Association and the Salt River Project Agricultural Improvement and Power District and Comprehensive Agreement No. 1").

Benefits may be anticipated to the basin where water is transported including sustaining groundwater contribution to streams, helping reach safe-yield and providing an alternative to local groundwater pumping.

Legal and Institutional Issues

Requirements of floodplain ordinances, grading permits and right of ways would have to be met. Requirements under the State Historic Preservation Act and Arizona Native Plant Laws would apply. Depending on the outcome of the general adjudication of surface water rights, certain well locations could be subject to adjudication requirements. Assured and Adequate Water Supply, Transportation of Groundwater, NOI and well spacing rules would apply. Potable water deliveries would be subject to Potable Water Facilities, SDWA and Water Treatment regulations. If Federal lands are crossed or if Federal funding is used, all National Environmental Policy Act (NEPA) requirements must be satisfied. Depending on new well locations, groundwater development may be subject to Federal Reserved Rights for Indian Tribes. Pipeline alignments would be subject to Native American Graves Protection and Repatriation Act. Groundwater pumping may require coordination and contractual agreements with the Salt River Project.

Public Perception

New groundwater pumping could cause groundwater overdraft and potentially impact existing wells and surface water supplies. High infrastructure costs for long-distance conveyance of water with potential for denial of voter approval for financing and construction. Concern exists over the potential for a high risk on investment returns for water infrastructure. Some perceive that current water supplies are adequate and that there is no need for additional water supplies. Also of note is the perception that augmenting current supplies will result in increased population without any environmental benefits.

Cost

Alt #	Description of Alternative	Volume (AFY)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per 1,000 ($/Kgal)
2	Pipeline from Big Chino to PrAMA	12,468	121,892,305	5,796,100	1,868,805	615	1.89
2	Pipeline from Big Chino to Verde Valley	12,382	311,005,854	14,788,600	2,643,426	1,408	4.32

Evaluation
Acceptability (yes)
Effectiveness (yes)
Efficiency (yes)
Completeness (yes)

Findings
Viable: Importation of water may be beneficial in sustaining groundwater levels within the sub-basin receiving the water. There are provisions for future mitigation in the Big Chino Sub-basin should there be impacts due to pumping. For the alternative for the Verde Valley, there are no legal mechanisms in place to transfer water from the Big Chino Sub-basin to this area, but if in place, it would most likely have the same provisions as listed for the PrAMA.

Alt. # 3 Outside Study Area (Bill Williams Sub-basin & Big Sandy Sub-basin)

Description
This alternative proposes two options that rely on the development of groundwater supplies from either the Bill Williams Sub-basin or the Big Sandy Sub-basin for transportation via pipeline to the WPAs. This alternative is considered regional groundwater development because it is development of groundwater from one localized area outside of the study area. In the Big Sandy version of the alternative, the groundwater is developed near Wikieup, Arizona and in the Bill Williams version the groundwater is developed at Burro Creek.

The WPAs considered in this alternative are those that show a 2050 water supply deficit with the exception of Jerome and rural WPAs that are primarily served from private, domestic wells. The following WPAs were not included within this alternative: Jerome, Verde CCD, Prescott CCD, Mingus Mountain CCD, Humboldt CCD and Ashfork CCD.

Environmental Issues
The importation of water supplies to meet the 2050 deficit is anticipated to provide overall environmental benefit to the study area, and specifically to each basin where water is imported. Augmenting water supplies may help sustain groundwater contributions to streams, provides an alternative to local groundwater pumping, and protects vegetation, wildlife and aquatic species. There may be an impact to water quality due to greater mineral content from outside sources, but the environmental concerns would be minimal because it is assumed that imported water will be treated. This environmental review only considered environmental issues within the study area. Further environmental review would be required outside the study area to address impacts from removing groundwater from the Bill Williams and Big Sandy Sub-basins.

Legal and Institutional Issues

Requirements of floodplain ordinances, grading permits and right of ways would have to be met. ACC approval may be required. Requirements under the State Historic Preservation Act and Arizona Native Plant Laws would apply. Depending on the outcome of the general adjudication of surface water rights, certain well locations could be subject to adjudication requirements. Assured and Adequate Water Supply, Transportation of Groundwater, Water Exchanges, NOI and well spacing rules would apply. Potable water deliveries would be subject to Potable Water Facilities, SDWA and Water Treatment regulations. If Federal lands are crossed or if Federal funding is used, all NEPA requirements must be satisfied. Depending on new well locations, groundwater development may be subject to Federal Reserved Rights for Indian Tribes. Pipeline alignments would be subject to Native American Graves Protection and Repatriation Act.

Public Perception

New groundwater pumping could cause groundwater overdraft and potentially impact existing wells and surface water supplies. High infrastructure costs for long-distance conveyance of water with potential for denial of voter approval for financing and construction. Concern exists over the potential for a high risk on investment returns for water infrastructure. Some perceive that current water supplies are adequate and that there is no need for additional water supplies. Also of note is the perception that augmenting current supplies will result in increased population without any environmental benefits.

Cost

Alt #	Description of Alternative	Volume (AFY)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per 1,000 ($/Kgal)
3	Regional GW Outside Study Area-Big Sandy	42,379	987,537,108	46,958,400	11,595,880	1,382	4.24
3	Regional GW Outside Study Area-Bill Williams	42,379	910,985,979	43,318,300	11,124,148	1,285	3.94

Evaluation

Acceptability (yes)
Effectiveness (yes)
Efficiency (yes)
Completeness (yes)

Findings
Viable: Importation of water may be beneficial in sustaining groundwater levels within the sub-basin receiving the water. There are no legal mechanisms in place to transfer water from either of these sub-basins. Although, it was considered viable, there is concern over public acceptability on pumping groundwater in the sub-basins. In the past, Mohave County and the Hualapai Tribe stopped a power plant from pumping in the Big Sandy Sub-basin.

Alt. #4 Conversion of Existing Septic Systems – Urban

Description
This alternative considers conversion of urban residential septic systems to sewer connections. For the purposes of this study, "Urban" refers to a WPA that is serviced by a water provider, sewer provider, or is within the boundary of a Certificates of Convenience and Necessity (CC&N). A CC&N defines an area where an entity holds exclusive rights to supply water or wastewater services within a specified geographic area.

This analysis estimated the number of residential properties in urban areas that use on-site septic systems. Under this alternative, residential septic systems would be converted to connections with sewer conveyance infrastructure. This would involve extending sewer conveyance infrastructure into areas where residences are currently on septic systems. For this option, eleven WPAs are considered urban; Camp Verde, Chino Valley, Clarkdale, Cottonwood, Jerome, Prescott, Prescott Valley, Sedona, Big Park, Lake Montezuma and Paulden.

Environmental Issues
The conversion of existing septic systems to sewer may benefit environmental resources if the increasing availability of treated effluent lessens the need to pump water to meet the 2050 deficit. The assumption is that the treated effluent would be either reused or recharged and not discharged into a stream. If discharged, the location of recharge would dictate the level of effect, if any, on stream water quality. Treated effluent is typically better quality than septic tank leachate, so local water quality could be improved from the current baseline due to removal of septic systems. Recharge could augment groundwater and stream flow. Impact to vegetation and wildlife could be minimal and possibly positive if it reduced groundwater level decline and if recharge facilities are located to optimize augmentation of stream flow and riparian groundwater levels. Environmental issues to consider are concerns with water quality and biologic impacts from emerging contaminants on aquatic species, and in very low concentrations. Changing septic tanks to a sanitary sewer system and conventional waste water treatment should improve treatment levels and hence result in lower electrical conductivity (EC) in the effluent.

Legal and Institutional Issues
Septic tank owners would be required to comply with local hook-up and septic tank abandonment requirements. If new wastewater treatment facility (WWTF) infrastructure crosses natural drainages, local regulations including a Flood Plain Ordinance and Grading Permit may be required. New infrastructure may require right of way permissions. Changes to existing or construction of new WWTF's would require obtaining permission through the appropriate Regional Water Quality Management Planning (208) authority. Changes to existing WWTF's or construction of new WWTF's would require modification or acquisition of new Arizona Department of Environmental Quality (ADEQ) permits including: Aquifer Protection Permit (APP), Arizona Pollutant Discharge Elimination System (AZPDES), Reclaimed Water Conveyance, and Reclaimed Water Quality Standards. WIFA could be used for financing. If no Federal lands are crossed and there is no Federal interest, then NEPA will not apply. However, if Federal funding is used, all NEPA requirements must be satisfied.

Public Perception
The general public may have negative perceptions of indirect and direct potable reuse. Water quality issues in reused water are a concern. The additional costs of conversion from private septic tanks to a public system may seem unnecessary. The cost to construct conveyance infrastructure and expand or construct new WWTF's will be borne by people who already have a satisfactory solution for their generated waste.

Cost

Alt #	Description of Alternative	Volume (AFY)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per 1,000 ($/Kgal)
4	Conversion of Existing Systems – Urban	3,367	237,629,700	11,299,500	19,010,400	9,002.04	27.63

Evaluation
Acceptability (yes)
Effectiveness (yes)
Efficiency (yes)
Completeness (yes)

Findings
Viable: There are no fatal flaws in the legal & institutional. However there may be some public perception issues in regards to reuse and conversion costs. It is a reliable source of water supply that is local. Although it doesn't meet the entire

deficit demand, it can complement other projects. During the environmental analysis, there were several positives and there could be benefits to water quality.

Alt. #5 Conversion of Existing Septic Systems – Rural

Description

This alternative involves conversion of residential septic systems to sewer service to increase the availability of effluent for reuse, in rural areas. This assessment considers rural areas to be outside of a water provider service area, a sewer service area or a CC&N. Rural areas tend to have larger lots and lower household density than urban areas. The WPAs are assessed individually.

Rural wastewater volumes were calculated using the number of rural parcels (2007 Yavapai County Geographic Information System), population (US Census 2000), and an average wastewater production of 69 gallons per person per day. Only residential parcels are considered for conversion of septic systems to a sewer system. This process yielded a rural population estimate by planning area. For this option, thirteen WPAs are considered having rural population; Ashfork, Cornville, Cottonwood, Humboldt, Lake Montezuma, Mingus Mount, Paulden, Prescott CD, Prescott Valley, Prescott, Verde Cottonwood-Verde Village and Williamson.

Environmental Issues

The conversion of existing septic systems to sewer may benefit environmental resources if the increasing availability of treated effluent lessens the need to pump water to meet the 2050 deficit. The assumption is that the treated effluent would be either reused or recharged and not discharged into a stream. If discharged, the location of recharge would dictate the level of effect, if any, on stream water quality. Treated effluent is typically better quality than septic tank leachate, so local water quality could be improved from the current baseline due to removal of septic systems. Recharge could augment groundwater and stream flow. Impact to vegetation and wildlife could be minimal and possibly positive if it reduced groundwater level decline and if recharge facilities are located to optimize augmentation of stream flow and riparian groundwater levels. Possible negative impacts to water quality and fish/aquatic species. Environmental issues to consider are concerns with water quality and biologic impacts from emerging contaminants on aquatic species, and in very low concentrations. Conventional treatment over septic tanks should improve treatment levels and hence result in lower ECs in the effluent.

Legal and Institutional Issues

Septic tank owners would be required to comply with local hook-up and septic tank abandonment requirements. If new wastewater treatment facility (WWTF) infrastructure crosses natural drainages, local regulations including a Flood Plain Ordinance and Grading Permit may be required. New infrastructure may require right of way permissions. Changes to existing or construction of new WWTF's would require obtaining permission through the appropriate Regional Water

Quality Management Planning (208) authority. Changes to existing WWTF's or construction of new WWTF's would require modification or acquisition of new ADEQ permits including: APP, AZPDES, Reclaimed Water Conveyance, and Reclaimed Water Quality Standards. WIFA could be used for financing. If no Federal lands are crossed and there is no Federal interest, then NEPA will not apply. However, if Federal funding is used, all NEPA requirements must be satisfied.

Public Perception

The general public may have negative perceptions of indirect and direct potable reuse. Water quality issues in reuse water are a concern. The additional costs of conversion from private septic tanks to a public system may seem un-necessary. The cost to construct conveyance infrastructure and expand or construct new WWTF's will be borne by people who already have a satisfactory solution for their generated waste.

Cost

Alt #	Description of Alternative	Volume (AFY)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per 1,000 ($/Kgal)
5	Conversion of Existing Systems – Rural	2,766	200,201,200	9,519,800	16,016,096	9232.07	28.33

Evaluation

Acceptability (yes)
Effectiveness (no)
Efficiency (no)
Completeness (no)

Findings

Not Viable: Because rural areas are spread out across a long distance, there isn't sufficient existing infrastructure; and it is a "no" for the completeness criteria.

Alt. #6 New Effluent from New Population

Description

This alternative focuses on new wastewater volumes as a result of new population in each of the twenty WPAs from 2006 to 2050 and identifies the potential volume of water that would be available. The new population was determined during the Phase I - Demand Analysis conducted for this study. The new population was multiplied by an average wastewater production of 69 gallons per day per person to estimate the new wastewater volume available in 2050.

The volume of effluent generated from the new wastewater is presented as a range of high and conservative volumes. The high estimate assumes that all new wastewater is captured in a sewer system for treatment, reuse and/or recharge. The conservative estimate takes into account the percentage of population in the region served by WWTF's. In 2002, the Northern Arizona Council of Governments (NACOG) Section 208 Plan estimated that 45% of the population in Yavapai County was served by WWTF's. The conservative estimate uses the percent of the population that is served by a WWTF which may vary for each WPA based on projected land use and wastewater management plans.

In this analysis, infrastructure requirements for each alternative are based on the status of the WWTF's. When average daily flow into a WWTF reaches 80% of its rated capacity, it was determined that a WWTF would require expansion. Based on this criterion, the WWTF's are categorized into three groups within each WPA.

Group A – Existing WWTF can accommodate additional wastewater capacity. Expansion of sewer conveyance infrastructure is required.

Group B – Existing WWTF requires expansion to accommodate additional wastewater capacity Expansion of sewer conveyance infrastructure is required.

Group C – Construction of new WWTF and sewer conveyance infrastructure is required.

Under Alternative 6, all WPAs were considered.

Environmental Issues

The development and use of new effluent may benefit environmental resources if the increasing availability of treated effluent lessens the need to pump water to meet the 2050 deficit. The assumption is that the treated effluent would be either reused or recharged and not discharged into a stream. If discharged, the location of recharge would dictate the level of effect if any on stream water quality. Treated effluent is typically better quality than septic tank leachate, so local water quality could also be improved from the current baseline due to removal of septic systems. Recharge could augment groundwater and stream flow. Impact to vegetation and wildlife could be minimal and possibly positive if it reduced groundwater level decline and if recharge facilities are located to optimize augmentation of stream flow and riparian groundwater levels. It may offset some development of other water resources. Likewise recharge benefits to groundwater could also benefit biologic and watershed conditions. Environmental issues to consider are concerns with water quality and biologic impacts from emerging contaminants on aquatic species, and in very low concentrations.

Legal and Institutional Issues

If new wastewater treatment facility (WWTF) infrastructure crosses natural drainages, local regulations including a Flood Plain Ordinance and Grading Permit may be required. New infrastructure may require right of way permissions. Changes to existing or construction of new WWTF's would require obtaining permission through the appropriate Regional Water Quality Management Planning (208) authority. Changes to existing WWTF's or construction of new WWTF's would require modification or acquisition of new ADEQ permits including: APP, AZPDES, Reclaimed Water Conveyance, and Reclaimed Water Quality Standards. WIFA could be used for financing. If Federal lands are crossed, there is a Federal interest or if Federal funding is used, all NEPA requirements must be satisfied.

Public Perception

There may be negative perception of indirect and direct potable reuse. Questions exist regarding the need for public WWTF systems versus private septic systems. There are concerns regarding cost to construct conveyance infrastructure and expand or construct new WWTF's. Water quality issues to upgrade water to standards are an issue.

Cost

Alt #	Description of Alternative	Volume (AFY)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per 1,000 ($/Kgal)
6	New Effluent from New Population – High Volume	34,934	963,742,300	45,826,900	77,099,400	3,518.82	10.80
6	New Effluent from New Population – Conservative Volume	21,614	834,349,600	39,674,100	66,748,000	4,923.76	15.11

Evaluation

Acceptability (yes)
Effectiveness (yes)
Efficiency (yes)
Completeness (yes)

Findings

Viable: This will be likely a component to all future water supplies in all the WPAs either for reuse or as mitigation to offset groundwater pumping. City of Prescott will not have a new water supply from this alternative but recharge from new population will be dedicated to the aquifer.

Alt. #7 Capture and Store Unappropriated Verde River or Tributary water

Description

This alternative proposes a source of supply from the capture of unappropriated water from the Verde River watershed during a spill condition. This volume of floodwater is an intermittent source that is only available when all senior downstream water rights are being satisfied and storage capacity is being exceeded at Salt River Project's (SRP) reservoirs. There are a number of versions (7.1-7.4) of this alternative but all include either increasing or creating additional reservoir storage. The increased reservoir storage would result in the ability to store water within the system that would normally be lost during the occasional spill condition. Water supply credits would accrue in the new space and be designated for the WPA participants, and then debited when the water is used upstream.

In both Alternatives 7.1 and 7.2, the proposed reservoir volume increases are based on the reservoir yield potential concept: 10,000 AFY, 25,000 AFY, and 45,000 AFY. Versions 7.1 and 7.2 of this alternative require modifications to existing SRP dams in addition to construction of upstream catchments and transmission facilities. Infrastructure requirements for these versions include: increasing dam height, dam spillway modification, dam inlet/outlet modification, access improvements and relocation/reconstruction of ancillary facilities associated with dams, construction of reservoir for off-stream storage, water treatment plant, pump station and waterline. In this evaluation, the catchment locations and transmission facilities are conceptualized and estimated based on the various increased dam heights and water volumes captured. Conceptualized transmission lines are based on eight miles of pipeline; addition transmission lines to WPAs are not estimated.

Version 7.3 of this alternative is intake and catchment of water at Sullivan Lake, located about 1.5 miles south of Paulden. The catchment facility size and location was based on the surrounding topography, existing infrastructure, and proposed water treatment plant. This version assumed a two million gallon per day packaged water treatment plant that yielded 2,240 AFY.

Version 7.4 of this alternative is catchment of water near Page Springs on the Oak Creek drainage area. The catchment facility size and location was based on the surrounding topography, existing infrastructure, and proposed water treatment plant. This version assumed a two million gallon per day packaged water treatment plant that yielded the 2,240 AFY.

The WPAs considered in versions 7.1 and 7.2 of this alternative are those that show a 2050 water supply deficit, except for Jerome. The WPAs considered in

version 7.3 of this alternative are Dewey-Humboldt and Prescott. The WPAs considered in version 7.4 are Clarkdale and Cottonwood.

Environmental Issues

Primary environmental issues of concern from the development of on-stream or off-stream reservoirs to capture and store unappropriated Verde water are based on the overarching alteration of the natural hydrologic regime, impacting both upstream and downstream habitats, affecting the natural flow regime including flood flows, which are needed for a multitude of biologic parameters including native vegetation regeneration and aquatic species life cycles. Recruitment and survival of riparian vegetation is linked to high flows and removal of a portion of those flows could have a negative impact. Also it would be anticipated that where impacts to riparian and aquatic vegetation exist, there would also be anticipated impacts to species of wildlife that nest, forage, and otherwise utilize that habitat for all or portions of their life cycles. Impacts to ESA species or designated/proposed critical habitat could require increased regulatory compliance. In addition, storage/reservoir conditions may favor non-native species establishment and/or expansion. High flows are an important part of the stream flow regime and do much geomorphological work, which contributes to maintaining riparian and aquatic conditions in many ways. For instance, high flows and maintenance of riffle conditions are an important function in many aquatic species reproductive cycles. Removal of a portion of the high flow regime could impact ecological response in ways that would require considerable study to fully delineate.

There may be localized benefit due to increased bank storage, groundwater storage, and/or reduced pumping requirements.

Legal and Institutional Issues

Activities would to meet requirements of floodplain ordinances, grading permits and right of ways. May require approval by the ACC. Requirements under the State Historic Preservation Act and Arizona Native Plant Laws would apply. Assured and Adequate Water Supply, Colorado River Water Transfers, Supervision of Dams, Reservoirs and Projects, Surface Water Appropriation and Regulation, and Water Exchanges rules would apply. Activities would have to meet Arizona Pollutant Discharge Elimination System requirements. Potable water deliveries would be subject to Potable Water facilities, SDWA and Water Treatment regulations. Activities would be required to comply with the Boulder Canyon Project Act. If Federal lands are crossed or if Federal funding is used, all NEPA requirements must be satisfied. Any new appropriation for surface water would be subject to existing Federal Reserved Rights for Indian Tribes that have been settled in the Gila River General Stream Adjudication. Pipeline alignments would be subject to Native American Graves Protection and Repatriation Act. This alternative will require coordination with Salt River Project as the operator of Bartlett and Horseshoe Reservoirs and consultation with the federal government regarding Safety of Dams requirements.

Public Perception

Apprehension exists over the feasibility of dam modification. Legal availability of appropriated and unappropriated surface water is a matter in question reliability of spilled surface water supplies and physical availability for water storage are also concerns. Increased seepage, increased evaporation losses, land ownership, liability, modified operation of expanded reservoirs are issues. The complexity of water accounting, water rights, and exchanges such as the unquantified tribal rights or claims and pending surface water adjudication are potential concerns. There is negative perception of building and/or expanding surface water reservoirs and potential denial of voter approval for financing and construction of proposed water development projects.

Cost

Alt #	Description of Alternative	Volume (AFY)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per 1,000 ($/Kgal)
7.1	Capture & Store Unappropriated Verde River– Bartlett Dam & Conceptual Upstream Catchment A	10,000	166,981,000	7,940,100	1,923,800	986	3.03
7.1	Capture & Store Unappropriated Verde River– Bartlett Dam & Conceptual Upstream Catchment B	25,000	345,877,000	16,446,800	4,888,000	853	2.62
7.1	Capture & Store Unappropriated Verde River– Bartlett Dam & Conceptual Upstream Catchment C	45,000	570,108,000	27,109,200	8,378,350	789	2.42
7.2	Capture & Store Unappropriated Verde River– Horseshoe Dam & Conceptual Upstream Catchment A	10,000	157,956,000	7,511,000	1,923,000	943	2.90

Alt #	Description of Alternative	Volume (AFY)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per 1,000 ($/Kgal)
7.2	Capture & Store Unappropriated Verde River– Horseshoe Dam & Conceptual Upstream Catchment B	25,000	335,785,000	15,966,900	4,887,995	834	2.56
7.2	Capture & Store Unappropriated Verde River– Horseshoe Dam & Conceptual Upstream Catchment C	45,000	559,746,000	26,616,500	8,378,350	778	2.39
7.3	Sullivan Dam	2,240	48,229,000	2,293,300	480,640	1,238	3.80
7.4	Page Springs	2,240	44,664,000	2,123,800	488,040	1,166	3.58

Evaluation
Acceptability (yes)
Effectiveness (yes)
Efficiency (yes)
Completeness (yes)

Findings
Viable: Although viable, this option would have to be firmed with another water supply due to the sporadic availability of unappropriated spill water. There is concern of the possible impacts to the ecology due to the removal of a portion of the high flow regime of the Verde River.

Alt. #8 Rainwater Harvesting-Aquifer Storage

Description

This alternative evaluates a variety of rainwater harvesting methods to capture rainwater that would normally be lost to evaporation and transpiration. The methods evaluated in this alternative are considered large-scale, or macro-rainwater harvesting methods, that capture storm water and re-direct a portion of the rainwater to recharge facilities. It assumes that the water gathered via rainwater harvesting efforts is water that would not be considered appropriable as surface water. For each alternative, the rainwater that is harvested is gathered at numerous smaller locations (lots) and then transmitted to another location for recharge and recovery.

There were two general categories of rainwater harvesting considered in this alternative. The first is harvesting from developed areas such as existing residential and commercial properties. The second is harvesting from undeveloped areas that have land surfaces modified to increase runoff from storm events (scenario 10, open space lots of 2.0 acres).

In this alternative, there were 10 water harvesting scenarios developed for specific lots that differ by lot location, lot size, the amount of development on the lot (pervious versus impervious versus pervious made impervious land surfaces), existing infrastructure and proposed infrastructure improvements. For each scenario, the horizontal land surface, nature of the land surface, and rainfall records were used to estimate the annual volume of rainwater that could be harvested based on a collective 12 lot sample wherein the lots were physically linked through lateral and collector infrastructure improvements. There was no attempt to evaluate impacts to downstream water right holders.

The WPAs evaluated in this alternative are Prescott Valley, Chino Valley, Prescott and Prescott CCD. However, this alternative is applicable to all WPAs.

Environmental Issues

The collection of rainwater from developed areas may provide some benefit to the environment if direct uses of groundwater and surface water can be offset or alleviated. Although overall effect to the environment is considered minimal, water quality may still be a concern, whether water is collected in cisterns or recharged underground.

In un-developed areas some benefit would be derived if direct use of groundwater is offset with additional supplies, the environmental issues associated with land surface and/or vegetation treatment for the capture of water that would otherwise remain in the water cycle is not clear, and could be significant. Land surface disturbance has the potential to impact vegetation and wildlife species and their habitats. There are also indirect affects to consider including changes to micro-

climate affecting soil, vegetation attributes, disturbed trophic-level interactions, and life cycle elements needed for species viability. Much additional study is needed to determine how redirecting water from the natural water cycle might directly or indirectly affect species, communities, and ecosystem function. In addition, disturbed land surfaces may cause non-native species proliferation which then impacts native plants and wildlife.

Legal and Institutional Issues

Activities would have to meet requirements of floodplain ordinances, grading permits and right of ways. WIFA funding may be available. Requirements under the State Historic Preservation Act and Arizona Native Plant Laws would apply. Projects may be subject to Regional Water Quality Management Planning (208) authority requirements. Depending on the outcome of the general adjudication of surface water rights, could be subject to adjudication requirements. Assured and Adequate Water Supply; Groundwater Use Authority inside AMA; NOI; Supervision of Dams, Reservoirs and Projects; Surface Water Appropriation and Regulations; Underground Water Storage, Savings, and Replenishment Act; and Well Spacing Rules could apply. Activities would have to meet Arizona Pollutant Discharge Elimination System, Aquifer Protection Permit, and Aquifer Water Quality Standard requirements. If Federal lands are crossed or if Federal funding is used, all NEPA requirements must be satisfied. Activities may be subject to Federal Reserved Rights for Indian Tribes and Native American Graves Protection and Repatriation Act.

Rainwater harvesting is required to comply with applicable water laws (e.g, ARS 45-101). Groundwater recharge is required to comply with Federal and State water quality standards.

Public Perception

Issues include: Legal availability of appropriated and unappropriated surface water; complexity of water accounting, water rights, and exchanges; unquantified tribal rights or claims and pending surface water adjudication. There are concerns over negative perception and potential denial of voter approval for financing and construction of proposed water development projects. Enhanced benefit to aquifer that is accountable. Questions arise over quantifiable benefits and a high risk of potential return on investment.

Cost

Alt #	Description of Alternative	Volume (AFY)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per 1,000 ($/Kgal)
8	Rainwater Harvesting – Aquifer	18	-	-	-	$4,389	$13.47

Alt #	Description of Alternative	Volume (AFY)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per 1,000 ($/Kgal)
	Storage Scenario 1						
8	Rainwater Harvesting – Aquifer Storage Scenario 2	20	-	-	-	$4,805	$14.74
8	Rainwater Harvesting – Aquifer Storage Scenario 3	20	-	-	-	$3,691	$11.33
8	Rainwater Harvesting – Aquifer Storage Scenario 4	20	-	-	-	$3,161	$9.70
8	Rainwater Harvesting – Aquifer Storage Scenario 5	14	-	-	-	$4,328	$13.28
8	Rainwater Harvesting – Aquifer Storage Scenario 6	9	-	-	-	$8,370	$25.69
8	Rainwater Harvesting – Aquifer Storage Scenario 7	8	-	-	-	$6,796	$20.77
8	Rainwater Harvesting – Aquifer Storage Scenario 8	26	-	-	-	$5,449	$16.72
8	Rainwater Harvesting – Aquifer Storage Scenario 9	36	-	-	-	$1,746	$5.36
8	Rainwater Harvesting – Aquifer Storage Scenario 10	26	-	-	-	$5,571	$17.10

Evaluation
Acceptability (yes)
Effectiveness (yes)
Efficiency (yes)
Completeness (yes)

Findings
Viable: Rainwater harvesting will likely be encouraged and be part of any water portfolio. It is already occurring in some areas and this alternative increases the efficiency. Depending on the nature of the water harvesting technique and location, there may be issues with public acceptability and compatibility with existing laws. It was noted by some TWG members that rainwater harvesting for the Undeveloped Area Scenario would be more acceptable if done in areas that are already disturbed.

Alts. 10 & 11- Surface Water in Alamo Lake and Colorado River water via Alamo Lake, Diamond Creek, Lake Mead, Lake Havasu, Lake Mohave and Lake Powell

Description
This alternative proposes use of surface water obtained from outside of the study area in the volume of 42,379 AFY. Alternative 10 proposes delivery of water from Alamo Lake via pipeline. The variations of Alternative 11 propose delivery of water from the Colorado River via pipelines from several different locations: Alamo Lake, Diamond Creek, Lake Mead, Lake Havasu, Lake Mohave and Lake Powell.

The WPAs considered in this alternative are those that show a 2050 water supply deficit with the exception of Jerome and rural WPAs that are primarily served from private domestic wells. The following WPAs were not included within this alternative: Jerome, Verde CCD, Prescott CCD, Mingus Mountain CCD, Humboldt CCD and Ashfork CCD.

Environmental Issues
The importation of water supplies to meet the 2050 deficit is anticipated to provide overall environmental benefit to the study area, and specifically to each basin where water in imported. Augmenting water supplies may help sustain groundwater contributions to streams, provides an alternative to local groundwater pumping, and protects vegetation, wildlife and aquatic species. There may be an impact to water quality but the environmental concerns would be minimal because it is assumed that imported water will be treated. This environmental review only considered environmental issues within the study area. Further environmental review would be required outside the study area to address impacts from removing and piping surface water supplies from Alamo Lake, Diamond Creek, Lake Mead, Lake Havasu, Lake Mohave and Lake Powell.

Legal and Institutional Issues

Construction would have to meet requirements of floodplain ordinances, grading permits and right of ways. Activities may be subject to Regional Water Quality Management Planning (208) authority requirements. Requirements under the State Historic Preservation Act and Arizona Native Plant Laws would apply. Assured and Adequate Water Supply, Colorado River Water Transfers, and Water Exchanges rules could apply. Arizona Pollutant Discharge Elimination System requirements would apply. Potable water deliveries would be subject to Potable Water Facilities, SDWA and Water Treatment regulations. Boulder Canyon Project Act could apply. If Federal lands are crossed or if Federal funding is used, all NEPA requirements must be satisfied. Activities may be subject to Federal Reserved Rights for Indian Tribes, Native American Graves Protection and Repatriation Act and Tribal rights-of-way.

Public Perception

Perception issues include legal availability of appropriated and unappropriated surface water, complexity of water accounting, water rights, and exchanges. Also, unquantified tribal rights or claims and pending surface water adjudication may impact this alternative. Surface water impacts and surface water quality are of concern. There may be negative perception and potential denial of voter approval for financing and construction of proposed water development projects. Questions exist about quantifiable benefits. Debate may occur over a high risk of potential return on investment. Debate exists over adequacy of current water supplies and the need for additional water supplies. Perception exists that augmenting current supplies will result in increased population without benefit to the aquifers. Uncertainty also exists over impacts to the source areas.

Cost

Alt #	Description of Alternative	Volume (AFY)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per 1,000 ($/Kgal)
10	Alamo Lake	42,379	895,515,610	42,582,700	11,744,870	1,282	3.93
11	Colorado River via Alamo Lake	42,379	895,515,610	42,582,700	11,744,870	1,282	3.93
11	Colorado River via Diamond Creek	42,379	1,028,225,962	48,893,200	12,243,356	1,443	4.43
11	Colorado River via Lake Mead	42,379	1,447,553,494	68,832,600	14,700,056	1,971	6.05
11	Colorado River via Lake Havasu	42,379	1,397,988,786	66,475,800	13,966,410	1,898	5.83

Alt #	Description of Alternative	Volume (AFY)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per 1,000 ($/Kgal)
11	Colorado River via Lake Mohave	42,379	1,273,716,646	60,566,500	14,709,294	1,776	5.45
11	Colorado River via Lake Powell	42,379	1,161,614,426	55,235,900	12,722,029	1,605	4.92

Evaluation
Acceptability (yes)
Effectiveness (yes)
Efficiency (yes)
Completeness (yes)

Findings
Viable: This alternative is a viable option and provides a reliable supply of over 42,000 AFY to meet the deficit demand. However, in order to implement this alternative, it will be necessary to acquire surface water rights. Although surface water rights were not included, it is a relatively cost effective alternative.

F. Viability Summary

A summary of alternatives evaluated viable and not viable are listed below in Table 12.

Table 12. - Viability of Alternatives Evaluated

Viability	Alternative
Viable	Alt. 1 Local Groundwater Development within the WPA (Outside the PrAMA)
Not Viable	Alt. 1 Local Groundwater Development within the WPA (Inside the PrAMA)
Viable	Alt. 2 Regional Groundwater Development Big Chino Pipelines (PrAMA)
Viable	Alt. 2 Regional Groundwater Development Big Chino Pipelines (Verde)
Viable	Alt. 3 Regional Groundwater Development Outside Study Area (Bill Williams & Big Sandy Sub-basins)
Viable	Alt. 4 Conversion of Existing Septic Systems (Urban)
Not Viable	Alt. 5 Conversion of Existing Septic Systems (Rural)
Viable	Alt. 6 New Effluent From New Population
Viable	Alt. 7 Capture and Store Unappropriated Verde River
Viable	Alt. 8 Rainwater Harvesting-Aquifer Storage

Viability	Alternative
Viable	Alt. 10 & 11 Surface Water in Alamo Lake and Colorado River Water via Alamo Lake, Diamond Creek, lake Mead, lake Havasu, lake Mohave and Lake Powell

G. Volume & Cost Summary

Table 13. - Summary of Alternative Volumes & Costs

Alt #	Description of Alternative	Volume (AFY)	Costs	
			Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
Alternatives Using Groundwater Supplies				
1	Local GW – Inside PrAMA, Non-exempt Wells	1,648	31	0.10
1	Local GW – Inside PrAMA, Exempt Wells	19,623	3,806	11.68
1	Local GW – Outside PrAMA, Non-exempt or Urban Wells	12,178	32	0.10
1	Local GW – Outside PrAMA, Exempt or Rural Wells	7,592	3,806	11.68
2	Regional GW – Big Chino to PrAMA	12,468	615	1.89
2	Regional GW – Big Chino to Verde Valley	12,382	1,408	4.32
3	Regional GW Outside Study Area – Big Sandy Sub-basin	42,379	1,382	4.24
3	Regional GW Outside Study Area – Bill Williams Sub-basin	42,379	1,285	3.94
Alternatives Using Effluent Supplies				
4	Conversion of Existing Systems – Urban	3,367	9,002.04	27.63
5	Conversion of Existing Systems – Rural	2,766	7,004.41	21.50
6	New Effluent from New Population – High Volume	34,934	3,518.82	10.80
6	New Effluent from New Population – Conservative Volume	21,614	4,923.76	15.11
Alternatives Using Flood Water				
7	Capture and Store Unappropriated Verde River - Bartlett Dam A	10,000	986	3.03
7	Capture and Store Unappropriated Verde River - Bartlett Dam B	25,000	853	2.62
7	Capture and Store Unappropriated Verde River - Bartlett Dam C	45,000	789	2.42
7	Capture and Store Unappropriated Verde River - Horseshoe Dam A	10,000	943	2.90
7	Capture and Store Unappropriated Verde River - Horseshoe Dam B	25,000	834	2.56
7	Capture and Store Unappropriated Verde River - Horseshoe Dam C	45,000	778	2.39
7	Sullivan Dam	2,240	1,238	3.80
7	Page Springs	2,240	1,166	3.58
Alternatives Using Storm Water				

Alt #	Description of Alternative	Volume (AFY)	Costs	
			Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
8	Rainwater Harvesting – Aquifer Storage Scenario 1	18	4,389	13.47
8	Rainwater Harvesting – Aquifer Storage Scenario 2	20	4,805	14.74
8	Rainwater Harvesting – Aquifer Storage Scenario 3	20	3,691	11.33
8	Rainwater Harvesting – Aquifer Storage Scenario 4	20	3,161	9.70
8	Rainwater Harvesting – Aquifer Storage Scenario 5	14	4,328	13.28
8	Rainwater Harvesting – Aquifer Storage Scenario 6	9	8,370	25.69
8	Rainwater Harvesting – Aquifer Storage Scenario 7	8	6,796	20.77
8	Rainwater Harvesting – Aquifer Storage Scenario 8	26	5,449	16.72
8	Rainwater Harvesting – Aquifer Storage Scenario 9	36	1,746	5.36
8	Rainwater Harvesting – Aquifer Storage Scenario 10	26	5,571	17.10
Alternatives Using Surface Water				
10	Alamo Lake	42,379	1,282	3.93
11	Colorado River via Alamo Lake	42,379	1,282	3.93
11	Colorado River via Diamond Creek	42,379	1,443	4.43
11	Colorado River via Lake Mead	42,379	1,971	6.05
11	Colorado River via Lake Havasu	42,379	1,898	5.83
11	Colorado River via Lake Mohave	42,379	1,776	5.45
11	Colorado River via Lake Powell	42,379	1,605	4.92

H. Alternatives Not Evaluated

Upon further consideration and investigation, three of the alternatives were removed from the list because, although considered, they were not evaluated. These alternatives were either a demand side reduction or resulted in increased volumes of surface water flow and do not have a component for collecting the water supply. Because in the Phase I Demand Analysis each WPA had an opportunity to incorporate conservation measures into the 2050 GPPD, Alt. 9 Implement Conservation was not pursued. Notwithstanding, the study partners believe that conservation will be an important part of future water management. Furthermore, the amount of conservation included in the 2050 GPPD choice reflects a planning philosophy and not a level of commitment to conservation (i.e. all the WPAs will pursue conservation measures in the future despite how much they chose to include in the 2050 GPPD for this study). Alt. 12 Weather Modification-Cloud Seeding and Alt. 13 Watershed Management did not have a

component for collecting the water supply and couldn't be compared to the other alternatives equally.

Table 14 describes the alternatives that were considered but were not evaluated and additional information regarding those alternatives is in the CYHWRMS Alternative Report in Appendix C.

Table 14. - Alternatives Considered But Not Evaluated

Water Supply	Alternative	Alternative Description
Conservation	9	Implement Conservation (e.g. low flow toilets, turf restrictions, educational programs, etc.)
Other	12	Weather Modification – Cloud Seeding
	13	Watershed Management

Alternative 9 - Conservation

This alternative proposes to improve water efficiency which is a simple, effective way to conserve water. Conservation measures such as high efficiency toilets, waterless urinals, hot water recirculation, rainwater harvesting, grey water reuse, xeriscaping, public ordinances for new development and public education are examples of the programs that can be implemented.

This alternative was not developed further as part of this study because conservation reduction volumes were inconsistently included in the Phase I Demand Analysis which allowed WPAs to incorporate their own conservation efforts into their future GPPD. Notwithstanding, the study partners believe that conservation will be an important part of future water management. Furthermore, the amount of conservation included in the 2050 GPPD choice reflects a planning philosophy and not a level of commitment to conservation (i.e. all the WPAs will pursue conservation measures in the future despite how much they chose to include in the 2050 GPPD for this study). There have been many conservation studies done in the study area and because this is a locally led process, it was left to the individual WPAs to decide. There was no consistent set of criteria to ensure an equal application of conservation for all WPAs, which made it difficult to go forward with the alternative. Each WPA provided their projected 2050 GPPD for the Demand Analysis and conservation reduction volumes vary for each WPA.

If the Conservation Alternative were developed, it may duplicate conservation reductions already accounted for in the Demand Analysis and could be misinterpreted as double counting the volume of water saved as a result of water use reductions from conservation. However, there could be some potential additional conservation measures that could be pursued and a more in-depth analysis would be done if this alternative moved forward to feasibility.

Alternative 12 – Weather Modification – Cloud Seeding
This alternative considers at weather modification, commonly known as cloud seeding for producing additional water. The process enhances a cloud's ability to produce precipitation. It has been "proposed that the 7,000 foot contour be used to identify potential target areas in Arizona (The Potential Use of Winter Cloud Seeding Programs to Augment the Flow of the Colorado River, Upper Colorado River Commission, March 2006)

For this alternative, only cloud seeding during the monsoon season was considered because most of the rainfall in Arizona occurs during this season, mainly by convective clouds which are conducive to hygroscopic seeding

Volume totals were calculated from the monthly average precipitation increase of 4% and 12% for July, August and September and multiplied by the area to determine increased water yield. This alternative does not include any losses due to evaporation, transpiration, depth-area reduction or surface retention which could be up to a 75% reduction loss. Volume is strictly the amount of precipitation that is possible to enhance, not what is available to distribute as a water supply. This alternative is for enhancing rainfall yield only and does not include any infrastructure for recovery.

Refer to CYHWRMS Alternatives Report in Appendix C for more information on the Weather Modification Alternative.

Alternative 13 – Watershed Management – Enhanced water yield through ponderosa pine forest restoration treatments
Watershed management in the form of vegetation manipulation has often been cited as a method to increase water yield in Arizona (Barr 1956, Baker 2003, Flolliot and Thorud 1977). Water yield improvement with vegetation reduction is based on the premise that stream flow and/or groundwater recharge are increased by an amount equal to the net reduction in evapotranspiration (Hibbert 1979). Although ponderosa pine occupies only about 20% of the Salt-Verde River watershed, nearly 50% of the total water yield in this basin originates from the pine type (Barr 1956).

Water yield enhancement in the Verde River watershed is anticipated due to mechanical thinning and burning treatments that are part of the landscape-scale Four Forest Restoration Initiative (4FRI). A side benefit of the restoration will be enhanced water yield due to decreased evapotranspiration that occurs as a result of forest thinning. While the initial cost of treatments will be paid by the U.S. Forest Service and their contractor implementing the treatments, the Forest Service's current budget projections are that there will be a 50% funding need for follow-up burning treatments. The follow-up burning treatments, along with

providing other forest health benefits, are expected to help extend the period of time in which water yields are enhanced post treatment, through reduced evapotranspiration by shrubs and small trees.

In summary, it is estimated that restoration treatments on 4FRI first analysis acres plus shelf stock acres in the Verde River watershed have the potential to enhance water yield in the range from 310 to 5,279 acre-feet per year over 25 years with a long-term average of 2,600 acre-feet per year when diminishing returns are considered. Estimated total annual cost ranges from $646 to $3,765 per acre-foot of enhanced yield. In a 44-year period from when follow-up treatments start the overall average annual cost per acre-foot would be $1,594. The cost and water volume estimates also do not account for possible transmission losses due to groundwater recharge or riparian water use between the forested areas yielding the water and the downstream water use areas. Estimates also do not include the cost of conveying the water by means other than stream channels.

Refer to CYHWRMS Alternatives Report in Appendix C for more information on the Watershed Management Alternative.

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VII. Federal Interest/Nexus

There are many issues that warrant a Federal interest in a regional plan that justifies Reclamation's future involvement in a Feasibility Study. There are Reclamation studies that have been and are currently being conducted in the Verde Watershed. Alternative 7, Capture and Store Unappropriated Verde River or Tributary Water, proposes improvements to Reclamation facilities Bartlett and Horseshoe Dams. There are Federal lands located within the study area including the Bureau of Land Management, the Forest Service and the National Park Service lands. Reclamation also has Trust responsibilities to the Yavapai Apache and Yavapai Prescott Indian Nations.

VIII. Findings and Recommendations

This appraisal study brought together diverse stakeholders in a transparent and objective process to advance towards achieving a common goal of securing long-term water supplies for the region. The study determined the location and magnitude of future challenges in a regional context and provided an assessment of potentially available alternatives to meet that those challenges. To date, the use of surface, groundwater pumping, effluent and conservation measures within the study area are the options to meeting present needs. Because all surface water within the study area is already claimed and because there are stringent groundwater regulations and or desire to limit groundwater mining, augmenting water supplies from outside the study area appears necessary to meet future demand.

To meet the total study area demand in the year 2050, additional water supplies of at least about 45,000 AFY will need to be developed. Through the stakeholder process, 13 potential water supply alternatives were developed and 8 were considered viable. While surface water importation, met most of the demand, no single alternative met the total water supply demand for the study area. In order to meet the future demand, WPAs can individually or as a region, implement one of the potential viable alternatives, or a combination thereof. It stands to reason that there are more benefits to combining their regional resources and working together to meet their individual needs.

Federal projects, land and Indian Trust responsibilities justify Federal involvement in a regional alternative. Therefore, with stakeholder interest, the regional viable alternatives may move forward to feasibility.

Reclamation will continue to collaborate with the central Yavapai communities in managing water resources. The next step for stakeholders is to determine if they are interested in involving Reclamation with any of the viable water supply alternatives to move forward to feasibility.

IX. References

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Central Yavapai Highlands Water Resource Management Study (CYHWRMS)

APPENDICES

Appendix A – Phase 1: Water Supply and Demand Analysis Results and Documentation

Appendix B – Phase 2: Water Resources Inventory Report

Appendix C – Phase 3: Alternatives Analysis Results and Documentation

Appendix D – Water Planning Area Maps

Central Yavapai Highlands Water Resource Management Study (CYHWRMS)

Appendix A

Phase 1: Water Supply and Demand Analysis Results and Documentation

Phase 1 Results:

- **Demand Analysis Summary Table Part 1**
- **Demand Analysis Summary Table Part 2**
- **Planning Area Water Use Summary Table**

Phase 1 Supporting Documents:

- **Demand Analysis Data Sources and Documentation**
- **2006 Demands for PrAMA Communities**
- **2050 AG in PrAMA 11-18-09**
- **2050 Commercial and Industrial Assumptions for PrAMA Table 4-1-10**
- **2050 Commercial and Industrial Assumptions for PrAMA 4-1-10**
- **AG Demand Method 4-1-10**
- **AG summary 4-1-10**
- **Asphalt Paving And Supply SW Use 11-18-09**
- **Budget Reference Docs 11-18-09**
- **Components from Existing Water Budgets 4-1-10**
- **Comprehensive Water Provider List 4-1-10**
- **DES 2006 and 2050 4-1-10**
- **Estimated Available Supplies-AAWS Method 4-1-10**
- **Exempt Well Query 4-1-10**
- **Golf Course 2006 Commercial and Industrial Use 4-1-10**
- **Non-Exempt Well Count 4-1-10**
- **Non Exempt Well Query 4-1-10**
- **Population Comparison 4-1-10**
- **Population Using YC Parcels 4-1-10**
- **PrAMA AG Demand with SW 4-1-10**
- **PrAMA Type I Type II 59s 4-1-10**
- **Volume for Exempt Wells 4-1-10**

Central Yavapai Highlands Water Resources Management Study - Phase I Demand Analysis

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
			(C-B)				(E+F+G)	(E/B)	Estimated		(C*K)			(L+M+N)	(J-O)
Water Planning Area[1]	2006 Population[2]	2050 Population[2]	Pop. Change	2006 Mun/Dom Demand[3]	2006 Com/Ind Demand[3]	2006 AG Demand[3]	Total 2006 Demand	2006[4]	Available Water Supply[5]	2050[6]	2050 Mun/Dom Demand[6]	2050 Com/Ind Demand[7]	2050 AG Demand[8]	Total 2050 Demand	2050 Water Supply +/-
				(AF/yr)	(AF/yr)	(AF/yr)		GPPD	(AF/yr)	GPPD	(AF/yr)	(AF/yr)	(AF/yr)	(AF/yr)	(AF/yr)
Camp Verde	12,497	23,277	10,780	1701	783	9,320	11,804	122	11,804	112	2,920	783	6,213	9,917	1,887
Dewey Humboldt	4,134	6,943	2,809	629	16	569	1,214	136	1,214	120	933	700	37	1,670	-456
Clarkdale	3,999	22,460	18,461	481	0	31	512	107	512	75	1,887	300	31	2,218	-1,706
Cottonwood	20,400	77,630	57,230	3,399	1,753	1,137	6,289	149	6,289	125	10,870	1,753	758	13,381	-7,092
Jerome*	510	800	290	282	0	0	282	494	282	255	229	53	0	282	0*
Prescott Valley	41,610	146,000	104,390	6,221	545	55	6,821	133	6,821	121	19,790	900	0	20,690	-13,869
Chino Valley	12,690	63,690	51,000	1,325	522	1,691	3,538	93	2,755	75	5,351	4,192	158	9,701	-6,946
Prescott	49,072	100,000	50,928	10,531	1	375	10,907	192	10,907	125	14,003	3,224	375	17,602	-6,695
Sedona	11,080	16,300	5,220	3,801	33	278	4,112	306	4,112	300	5,478	33	185	5,696	-1,584
Paulden CDP	5,342	14,099	8,757	921	7	1,346	2,274	154	2,274	120	1,895	7	962	2,864	-590
Big Park CDP	7,731	8,810	1,079	1,363	1,151	0	2,514	157	2,514	198	1,954	1,151	0	3,105	-591
Cornville CDP	4,075	7,448	3,373	959	0	2,823	3,782	210	3,782	185	1,544	0	1,882	3,426	356
Lake Montezuma CDP	4,237	8,308	4,071	674	709	537	1,920	142	1,920	120	1,117	709	358	2,184	-264
Ctn-Verde Village CDP	3,373	11,706	8,333	119	0	1,124	1,243	31	1,243	125	1,639	0	749	2,388	-1,145
Williamson CDP	5,228	11,845	6,617	1,491	0	0	1,491	255	1,491	221	2,932	0	0	2,932	-1,441
Verde CCD	1,644	4,377	2,733	542	690	1,322	2,554	294	2,554	235	1,152	690	881	2,724	-170
Prescott CCD	11,012	29,312	18,300	1,349	0	4,936	6,285	109	6,285	135	4,433	8	2,556	6,997	-712
Mingus Mtn CCD	1,700	4,525	2,825	484	728	487	1,699	254	1,699	215	1,090	728	325	2,143	-444
Humboldt CCD	230	612	382	54	0	759	813	210	813	170	117	0	506	623	190
Ashfork CCD	471	36,250	35,779	36	0	2,796	2,832	68	2,832	134	5,441	0	1,398	6,839	-4,007
Total	201,035	594,392	393,357	36,362	6,938	29,586	72,886		72,103		84,775	15,231	17,375	117,381	-45,279

1. See Demand Analysis and Data Sources Documentation for discussion of WPA boundaries. Note: Many municipal boundaries vary from the WPA boundaries.

2. See Population Comparisons for 2006 and 2050 population assumptions.

3. See CYHWRMS - Water Planning Area - Water Use and Available Supply Summary Table for all 2006 Demand Estimates. (Note: Mun/Dom demands include Com/Ind demands delivered by water providers. Column F - Com/Ind demands are individually served through private wells.

4. 2006 Gallons Per Person per Day is calculated by dividing the 2006 Mun/Dom demand by the 2006 population (conversion formula: AF/person * 325,851gal/AF / 365day/year = gal/person/day (GPPD)).

5. This data represents the "Status Quo method" - See CYHWMRS – Water Planning Area – Water Use and Available Supply Summary Table for supporting data per Water Planning Area.

6. 2050 GPPD was provided for each Water Planning Area. The value is multiplied by the 2050 population to calculate 2050 Municipal/Domestic Demand (conversion formula: person * gal/person/day / 325,851gal/AF * 365day/year = AF/year)

7. 2050 Commercial/Industrial Demands are held in Status Quo for 2050 for WPAs outside of the PrAMA (except Clarkdale and Jerome who provided their own estimate and 240 AF was added to the Verde CCD for new GC on reservation). WPAs in the PrAMA include existing uses plus additional (currently unused) groundwater rights (Type I and Type II) and withdrawal permits (59s).

8. Outside the PrAMA 2050 Agricultural Groundwater Demand is assumed to be a percentage (67% - Verde Valley Sub-Basin, 50% - Big Chino Sub-Basin) of the 2006 Agricultural Demand (except Clarkdale and Jerome who provided their own estimate). In the PrAMA Agricultural Surface Water Demand (Granite Dells Ranch - Prescott) is assumed to remain constant and 2050 uses of groundwater were determined by ADWR based on extinguishment of rights.

Note: All Water Planning Areas include demands for water providers and private water users - see Planning Area Water Use Summary Table.

Camp Verde - Stanley Bullard reported for the Camp Verde Water System and verified their 2006 pop. - 3622; 2050 population - 7243; 2006 Demand - 491 AF; and 2050 GPCD - 154. 2008 H3J Report estimates for total Camp Verde population and 2050 GPPD were used in this analysis. Includes Camp Verde Yavapai-Apache Nation population based on DES estimates (718-2006, 890-2050)

Dewey Humboldt - All assumptions are based on 2008 H3J Consulting Report.

Clarkdale -The Town of Clarkdale water service area is completely within the town limits, therefore, the Planning Area is the town boundary. 2006 Population numbers were obtained from the 2008 H3J Consulting Report and were verified per correspondence from Mayor Doug Von Gausig email dated October 3, 2008. 2050 GPPD and 2050 C/I &Ag demands were provided by Doug Von Gausig by email dated June 15, 2009. Includes Clarkdale Yavapai-Apache Nation population based in DES estimates (120-2006, 380-2050).

Cottonwood - The City of Cottonwood water department services areas outside of the city limits and, therefore, the planning area includes both the city and the unincorporated areas within the water service area. Demands shown on this table include those of the Cottonwood water services department and other public and private entities - see Water Planning Area - Water Use and Available Supply Summary Table. Population (11,201 Cottonwood + 8,199 Verde Villages) for the entire planning area were verified per correspondence from Assistant City Manager Robert Hardy email dated October 3, 2008. 2050 GPPD assumption is from 2008 H3J Consulting Report

***Jerome - The Town of Jerome water service area extends outside of the town limits; therefore the Planning Area includes both the town and unincorporated areas. 2006 and 2050 Population, 2050 GPPD, and water usage numbers were provided per correspondence by Jane Moore. Jane Moore requested that Jerome's 2006 demand be updated to 400 AFY from 282 AFY because they are using updated meter readings & population to 1100 & GPD to 300 8/29/12 via phone – this results in a 2050 supply of -23 for Jerome (column P). This update was added as a footnote to assure consistency throughout the document and appendicies.**

Prescott Valley - The Town of Prescott Valley water department services areas outside of the town limits and, therefore, the planning area includes both the town and the unincorporated areas within the water service area. 2006 and 2050 Population, 2050 GPPD and water use numbers for the entire planning area were provided per correspondence from Water Resources Manager John Munderloh emails dated October 6, 2008 and November 10, 2008.

Chino Valley - The Town of Chino Valley WPA has a portion of City of Prescott's WPA extending into the area (in CVID area). Population and water use numbers were verified in a meeting on January 28, 2009. See meeting notes "Meeting_012809". 2050 GPPD assumption is from 2008 H3J Consulting Report.

Prescott - 2006 Population reported by Connie Tucker (COP) 2/18/09 and includes service area boundaries in Prescott, the surrounding unincorporated areas within the Prescott water service area, and Chino Valley. 2050 GPPD assumption is from 2008 H3J Consulting Report.

Sedona - 2050 Population and 2050 GPPD were provided by the city of Sedona at meeting on Jan. 8. 2010. Population estimates are from Table 1 and Table 14 of Status Report- City of Sedona Land Use and Population, July 1, 2009. 2050 Population represents residential build out. (Note: Populations include both Yavapai and Coconino Counties.) The city notes that due to high tourism based commercial uses as a proportion of the total water use the unit GPPD is higher than that of communities having more balanced residential/commercial use ratios. The City anticipates that a use situation similar to that prevailing in 2006 will prevail in 2050 with a slightly lower ratio of residential accounts to commercial accounts.

Paulden CDP - 2050 GPPD estimated to be 90% of 2006 GPPD per correspondence from John Rasmussen dated Nov. 2, 2009. All other assumptions are based on 2008 H3J Consulting Report.

Big Park CDP - All assumptions are based on 2008 H3J Consulting Report.

Cornville CDP - 2050 GPPD estimated to be 90% of 2006 GPPD per correspondence from John Rasmussen dated Nov. 2, 2009. All other assumptions are based on 2008 H3J Consulting Report.

Lake Montezuma CDP - 2050 GPPD estimated to be 90% of 2006 GPPD per correspondence from John Rasmussen dated Nov. 2, 2009. All other assumptions are based on 2008 H3J Consulting Report.

Ctn/Verde Villages - A portion of this unincorporated area is served by the Cottonwood water department. Therefore, based on correspondence with Cottonwood Assistant City Manager Robert Hardy email dated December 2, 2008 the population (8,199 served by city of Cottonwood) and water usage amount reported for the city of Cottonwood were subtracted from the numbers provided in the 2008 H3J Consulting Report. 2050 GPPD assumption is from 2008 H3J Consulting Report.

Williamson CDP - Population using DES data.

Prescott CCD - 2006 and 2050 populations includes Las Vegas Ranch. 2006 population estimated using Yavapai County parcel data. 2050 population calculated assuming an approximate 2.25% growth rate. 2050 GPPD estimated to be 90% of 2006 GPPD per correspondence from John Rasmussen dated Nov. 2, 2009.

Mingus Mountain and Humboldt CCDs - 2006 population estimated using Yavapai County parcel data. 2050 population calculated assuming an approximate 2.25% growth rate. 2050 GPPD estimated to be 90% of 2006 GPPD per correspondence from John Rasmussen dated Nov. 2, 2009.

Ashfork CCD - 2006 and 2050 populations include CVCF and Yavapai Ranches. 2006 population estimated using Yavapai County parcel data. 2050 population calculated assuming an approximate 2.25% growth rate plus projected population for the Ranches. 2050 GPPD estimated to be 90% of 2006 GPPD per correspondence from John Rasmussen dated Nov. 2, 2009. 2006 GPPD very low because much water supply is actually hauled instead of delivered.

Central Yavapai Highlands Water Resources Management Study - Phase I Demand Analysis
Per Sub-Basin

Verde Valley Sub-Basin
Status Quo

A	B	C		D	E	F	G	H	I	J	K	L	M	N	O
		P (C-B)				(E+F+G)	(E/B)	Estimated	(C*K)		(L+M+N)	(J-O)			
Water Planning Area[1]	2006 Population[2]	2050 Population[2]	Pop. Change	2006 Mun/Dom Demand[3]	2006 Com/Ind Demand[3]	2006 AG Demand[3]	Total 2006 Demand	2006[4]	Available Water Supply[5]	2050[6]	2050 Mun/Dom Demand[6]	2050 Com/Ind Demand[7]	2050 AG Demand[8]	Total 2050 Demand	2050 Water Supply +/-
				(AF/yr)	(AF/yr)	(AF/yr)		GPPD	(AF/yr)	GPPD	(AF/yr)	(AF/yr)	(AF/yr)	(AF/yr)	(AF/yr)
Camp Verde	12,497	23,277	10,780	1,701	783	9,320	11,804	122	11,804	112	2,920	783	6,213	9,917	1,887
Clarkdale	3,999	22,460	18,461	481	0	31	512	107	512	75	1,887	300	31	2,218	-1,706
Cottonwood	20,400	77,630	57,230	3,399	1,753	1,137	6,289	149	6,289	125	10,870	1,753	758	13,381	-7,092
Jerome	510	800	290	282	0	0	282	494	282	255	229	53	0	282	0
Sedona	11,080	16,300	5,220	3,801	33	278	4,112	306	4,112	300	5,478	33	185	5,696	-1,584
Big Park CDP	7,731	8,810	1,079	1,363	1,151	0	2,514	157	2,514	198	1,954	1,151	0	3,105	-591
Cornville CDP	4,075	7,448	3,373	959	0	2,823	3,782	210	3,782	185	1,544	0	1,882	3,426	356
Lake Montezuma CDP	4,237	8,308	4,071	674	709	537	1,920	142	1,920	120	1,117	709	358	2,184	-264
Ctn-Verde Village CDP	3,373	11,706	8,333	119	0	1,124	1,243	31	1,243	125	1,639	0	749	2,388	-1,145
Verde CCD	1,644	4,377	2,733	542	690	1,322	2,554	294	2,554	235	1,152	690	881	2,724	-170
Mingus Mtn CCD (portion)*	510	1,358	848	145	218	487	851	254	851	215	327	218	325	870	-19
Humboldt CCD (portion)**	225	600	374	53	0	759	812	210	812	170	114	0	506	620	192
Total	70,281	183,073	112,792	13,519	5,337	17,818	36,675		**36,675**		29,231	5,690	11,889	**46,811**	**-10,136**

Water Balance Method															
VV Sub-Basin (with net natural recharge)	See Blasch, 2006, pg. 82. Inflow (167,000) - baseflow out (144,100)								22,900					46,811	-23,911
VV Sub-Basin (with 1997 demands)	See ADWR, 2000 pg. 5-23. Sum of Dom., Other/Industrial, Municipal, and AG								26,660					46,811	-20,151

Assumptions:

1. See Demand Analysis and Data Sources Documentation for discussion of WPA boundaries. Note: Many municipal boundaries vary from the WPA boundaries.
2. See Population Comparison for 2006 and 2050 population assumptions.
3. See CYHWRMS - Water Planning Area - Water Use and Available Supply Summary Table for all 2006 Demand Estimates. (Note: Mun/Dom demands include Com/Ind demands delivered by water providers. Column F - Com/Ind demands are individually served through private wells.
4. 2006 Gallons Per Person per Day is calculated by dividing the 2006 Mun/Dom demand by the 2006 population (conversion formula: AF/person * 325,851gal/AF / 365day/year = gal/person/day (GPPD))
5. Estimated Available Water Supply represents either the "Status Quo" (amount available in 2006 is available in perpetuity) or the "Water Balance" (estimated amount available using components from existing water budgets for the area) methods - See Phase I - Demand Analysis Data Sources and Documentation.
6. 2050 GPPD was provided for each Water Planning Area. The value is multiplied by the 2050 population to calculate 2050 Municipal/Domestic Demand (conversion formula: person * gal/person/day / 325,851gal/AF * 365day/year = AF/year)
7. 2050 Commercial/Industrial Demands are held in Status Quo for 2050 for WPAs outside of the PrAMA (except Clarkdale and Jerome who provided their own estimate and 240 AF was added to the Verde CCD for new GC on reservation).
8. 2050 Agricultural Groundwater Demand is assumed to be 2/ of the 2006 Agricultural Groundwater Demand (except Clarkdale and Jerome who provided their own AG estimate).

* 30% of the Mingus Mountain CCD Water Planning Area is in the Verde Valley Sub-Basin. (100% of the Mingus Mountain CCD Water Planning Area irrigated acreage is in the Verde Valley Sub-Basin.)

** 98% of the Humboldt CCD Water Planning Area is in the Verde Valley Sub-Basin. (100% of the Humboldt CCD Water Planning Area irrigated acreage is in the Verde Valley Sub-Basin.)

Little Chino and Upper Agua Fria Sub-Basins (Prescott AMA)

Status Quo

A	B	C		D	E	F	G	H	I	J	K	L	M	N	O
		P (C-B)				(E+F+G)	(E/B)	Estimated	(C*K)		(L+M+N)	(J-O)			
Water Planning Area[1]	2006 Population[2]	2050 Population[2]	Pop. Change	2006 Mun/Dom Demand[3]	2006 Com/Ind Demand[3]	2006 AG Demand[3]	Total 2006 Demand	2006[4]	Available Water Supply[5]	2050[6]	2050 Mun/Dom Demand[6]	2050 Com/Ind Demand[7]	2050 AG Demand[8]	Total 2050 Demand	2050 Water Supply +/-
				(AF/yr)	(AF/yr)	(AF/yr)		GPPD	(AF/yr)	GPPD	(AF/yr)	(AF/yr)	(AF/yr)	(AF/yr)	(AF/yr)
Dewey Humboldt	4,134	6,943	2,809	629	16	569	1,214	136	1,214	120	933	700	37	1,670	-456
Prescott Valley	41,610	146,000	104,390	6,221	545	55	6,821	133	6,821	121	19,790	900	0	20,690	-13,869
Chino Valley	12,690	63,690	51,000	1,325	522	1,691	3,538	93	2,755	75	5,351	4,192	158	9,701	-6,946
Prescott	49,072	100,000	50,928	10,531	1	375	10,907	192	10,907	125	14,003	3,224	375	17,602	-6,695
Paulden CDP (portion)*	107	282	175	18	0	578	597	154	597	120	38	0	578	616	-20
Williamson CDP (portion)**	3,241	7,344	4,103	924	0	0	924	255	924	221	1,818	0	0	1,818	-894
Prescott CCD (portion)***	9,580	25,501	15,921	1,174	0	176	1,349	109	1,349	135	3,857	7	176	4,040	-2,690
Mgs Mtn CCD (portion)****	1,190	3,168	1,978	339	510	0	848	254	848	215	763	510	0	1,272	-424
Humboldt CCD (portion)*****	5	12	8	1	0	0	1	210	1	170	2	0	0	2	-1
Total	121,629	352,940	231,311	21,162	1,594	3,444	26,200		**25,416**		46,555	9,533	1,324	**57,411**	**-31,995**

Water Balance Method															
PRAMA (using net nat. recharge)	K. Nelson, 2009 Nat. Recharge memo (8,070) - Avg. outflow from ADWR, 1999 declaration (4,850)								3,220					57,411	-54,191
Prescott AMA (using avg 1990 - 1997 demands)	ADWR. 1999 declaration, Table 2 Sum of 1990-1997 Muni (incls. Exempt), AG and Industrial)								16,317					57,411	-41,094

Assumptions:

1. See Demand Analysis and Data Sources Documentation for discussion of WPA boundaries. Note: Many municipal boundaries vary from the WPA boundaries.
2. See Population Comparison for 2006 and 2050 population assumptions.
3. See CYHWRMS - Water Planning Area - Water Use and Available Supply Summary Table for all 2006 Demand Estimates. (Note: Mun/Dom demands include Com/Ind demands delivered by water providers. Column F - Com/Ind demands are individually served through private wells.
4. 2006 Gallons Per Person per Day is calculated by dividing the 2006 Mun/Dom demand by the 2006 population (conversion formula: AF/person * 325,851gal/AF / 365day/year = gal/person/day (GPPD))
5. Estimated Available Water Supply represents either the "Status Quo" (amount available in 2006 is available in perpetuity) or the "Water Balance" (estimated amount available using components from existing water budgets for the area) methods - See Phase I - Demand Analysis Data Sources and Documentation.
6. 2050 GPPD was provided for each Water Planning Area. The value is multiplied by the 2050 population to calculate 2050 Municipal/Domestic Demand (conversion formula: person * gal/person/day / 325,851gal/AF * 365day/year = AF/year)
7. 2050 Commercial/Industrial Demands are held in Status Quo for 2050 for WPAs outside of the PrAMA (except Clarkdale and Jerome who provided their own estimate and 240 AF was added to the Verde CCD for new GC on
8. In the PrAMA Agricultural Surface Water Demand (Granite Dells Ranch - Prescott) is assumed to remain constant and 2050 uses of groundwater were determined by ADWR based on extinguishment of rights.

* 2% of the Paulden CDP Water Planning Area is in the Prescott AMA. (43% of the Paulden CDP Water Planning Area irrigated acres is in the Prescott AMA.)

**62% of the Williamson CDP Water Planning Area is in the Prescott AMA.

*** 87% of the Prescott CCD Water Planning Area is in the Prescott AMA. (4% of the Prescott CCD Water Planning Area irrigated acres is in the Prescott AMA.)

**** 70% of the Mingus Mountain CCD Water Planning Area is in the Prescott AMA. (None of the Mingus Mountain CCD Water Planning Area irrigated acres are in the Prescott AMA.)

***** 2% of the Humboldt CCD Water Planning Area is in the Prescott AMA. (None of the Humboldt CCD Water Planning Area irrigated acres are in the Prescott AMA.)

Big Chino Sub-Basin

Status Quo

A	B	C		D	E	F	G	H	I	J	K	L	M	N	O
		P (C-B)				(E+F+G)	(E/B)	Estimated	(C*K)		(L+M+N)	(J-O)			
Water Planning Area[1]	2006 Population[2]	2050 Population[2]	Pop. Change	2006 Mun/Dom Demand[3]	2006 Com/Ind Demand[3]	2006 AG Demand[3]	Total 2006 Demand	2006[4]	Available Water Supply[5]	2050[6]	2050 Mun/Dom Demand[6]	2050 Com/Ind Demand[7]	2050 AG Demand[8]	Total 2050 Demand	2050 Water Supply +/-
				(AF/yr)	(AF/yr)	(AF/yr)		GPPD	(AF/yr)	GPPD	(AF/yr)	(AF/yr)	(AF/yr)	(AF/yr)	(AF/yr)
Paulden CDP*	5,235	13,817	8,582	903	7	768	1,677	154	1,677	120	1,857	7	384	2,248	-571
Williamson CDP (portion)**	1,987	4,501	2,514	567	0	0	567	255	567	221	1,114	0	0	1,114	-548
Prescott CCD (portion)***	1,432	3,811	2,379	175	0	4,760	4,936	109	4,936	135	576	1	2,380	2,957	1,978
Ashfork CCD	471	36,250	35,779	36	0	2,796	2,832	68	2,832	134	5,441	0	1,398	6,839	-4,007
Total	9,124	58,379	49,254	1,681	7	8,324	10,012		**10,012**		8,989	8	4,162	**13,159**	**-3,148**

Water Balance Method															
Big Chino Sub-Basin (Using net nat. recharge)	See Blasch, 2006. Pg 82 Inflow (30,300) - baseflow out (17,900)								**12,400**					**13,159**	**-759**
Big Chino Sub-Basin (using avg 1990 - 1997 demands	See ADWR, 2000 pg 5-8. Sum of Dom., Other/Industrial, Sm Providers, and AG								**15,720**					**13,159**	**2,561**

Assumptions:

1. See Demand Analysis and Data Sources Documentation for discussion of WPA boundaries. Note: Many municipal boundaries vary from the WPA boundaries.
2. See Population Comparison for 2006 and 2050 population assumptions.
3. See CYHWRMS - Water Planning Area - Water Use and Available Supply Summary Table for all 2006 Demand Estimates. (Note: Mun/Dom demands include Com/Ind demands delivered by water providers. Column F - Com/Ind demands are individually served through private wells.
4. 2006 Gallons Per Person per Day is calculated by dividing the 2006 Mun/Dom demand by the 2006 population (conversion formula: AF/person * 325,851gal/AF / 365day/year = gal/person/day (GPPD))
5. Estimated Available Water Supply represents either the "Status Quo" (amount available in 2006 is available in perpetuity) or the "Water Balance" (estimated amount available using components from existing water budgets for the area) methods - See Phase I - Demand Analysis Data Sources and Documentation.
6. 2050 GPPD was provided for each Water Planning Area. The value is multiplied by the 2050 population to calculate 2050 Municipal/Domestic Demand (conversion formula: person * gal/person/day / 325,851gal/AF * 365day/year = AF/year)
7. 2050 Commercial/Industrial Demands are held in Status Quo for 2050 for WPAs outside of the PrAMA (except Clarkdale and Jerome who provided their own estimate and 240 AF was added to the Verde CCD for new GC on reservation).
8. 2050 Agricultural Groundwater Demand is assumed to be $^{1}/_{2}$ of the 2006 Agricultural Groundwater Demand.

*98% of the Paulden CDP Water Planning Area is in the Big Chino Sub-Basin. (57% of the Paulden CDP Water Planning Area irrigated acreage is in the Big Chino Sub-Basin.)

**38% of the Williamson CDP Water Planning Area is in the Prescott AMA.

***13% of the Prescott CCD Water Planning Area is in the Big Chino Sub-Basin. (96% of the Prescott CCD Water Planning Area irrigated acreage is in the Big Chino Sub-Basin.)

CYHWRMS- Demand Analysis
Water Planning Area
Water Use and Available Supply Summary Table

Water Planning Area	Water User[1]	2006 Demand[1] (AF/YR)	Estimated Available Supplies (using 2006 Status-Quo) (AF/YR)	Estimated Available Supplies (using Assured and Adequate Determination)[2] (AF/YR)
Camp Verde	Camp Verde Water System	502	502	1923.86
	Lake Verde Water Co.	19	19	
	Verde Lakes Water Corp.	241	241	
	Verde West Irrigation	0	0	
	Rainbow Acres	17	17	
	Yavapai-Apache – Middle Verde Sys.	37	88	
	Yavapai-Apache – Casino System	21	85	
	Water Provider Total	837	952	1923.86
	Exempt wells (2303@.33AF/yr)	760	760	760
	Nonexempt wells	104	104	104
	Total Mun/Dom Water Use	**1701**	**1816**	**2787.86**
	Total Agricultural Water Use	**9320**	**9320**	**9320**
**	Yavapai Apache Sand and Rock	100	100	100
**	United Metro Materials	403	403	403
**	Superior Materials	280	280	280
	Total Com/Ind Water Use	**783**	**783**	**783**
	PLANNING AREA TOTAL	**11804**	**11919**	**12891**
Dewey-Humboldt	Humboldt Water Co.	83	83	204
	Soft Winds MHP	7	7	
	Wilhoit Water Co.	9	9	
	Water Provider Total	99	99	204
	Exempt wells (1539@.33AF/yr)	508	508	508
	Nonexempt wells	22	22	22
	Total Mun/Dom Water Use	**629**	**629**	**734**
58-101303.0004	802224 -Bagby	58	58	57.87

Water Planning Area	Water User[1]	2006 Demand[1] (AF/YR)	Estimated Available Supplies (using 2006 Status-Quo) (AF/YR)	Estimated Available Supplies (using Assured and Adequate Determination)[2] (AF/YR)
58-101303.0003	802224 -Bagby	28	28	18.69
58-111928.0002	626917 Cain Verde	28	28	561.7
58-111927.0000	626311 Jensen	38	38	77.92
58-104351.0000	610078 Statler	65	65	14.12
58-102965.0000	623447 Wingfield	37	37	79.4
58-100544.0002	625770, 802224, 626034 Yavapai Land Holdings, LLC	315	315	427.05
	Total Agricultural Water Use	**569**	**569**	**1237**
58-106508.0002	633842-Yavapai Land Holdings LLC	0	0	6
58-106509.0001	633841-Yavapai Land Holdings LLC	16	16	20
58-110149.0003	625214-Yavapai Land Holdings LLC	0	0	5
	Total Com/Ind Water Use	**16**	**16**	**31**
	PLANNING AREA TOTAL	**1214**	**1214**	**2002**
Clarkdale	Town of Clarkdale	405	405	1373.3
	Bent River Apartments	6	6	
	Water Provider Total	411	411	1373.3
	Exempt wells (202@.33AF/yr)	67	67	67
	Nonexempt wells	3	3	3
	Total Mun/Dom Water Use	**481**	**481**	**1443.3**
	Total Agricultural Water Use	**31**	**31**	**31**
	Total Com/Ind Water Use	**0**	**0**	**0**
	PLANNING AREA TOTAL	**512**	**512**	**1474**
Cottonwood	Cottonwood Mun. Water System	3145	3145	1299.68
	On the Greens	12	12	

CYHWRMS- Demand Analysis
Water Planning Area
Water Use and Available Supply Summary Table

Water Planning Area	Water User[1]	2006 Demand[1] (AF/YR)	Estimated Available Supplies (using 2006 Status-Quo) (AF/YR)	Estimated Available Supplies (using Assured and Adequate Determination)[2] (AF/YR)
	Water Provider Total	3157	3157	1300
	Exempt wells (646@.33AF/yr)	213	213	213
	Nonexempt wells	29	29	29
	Total Mun/Dom Water Use	**3399**	**3399**	**1541.68**
	Total Agricultural Water Use	**1137**	**1137**	**1137**
***	Pine Shadows GC	120	120	120
***	Verde Santa Fe GC	1313	1313	1313
**	Hanson Aggregates	320	320	320
	Total Com/Ind Water Use	**1753**	**1753**	**1753**
	PLANNING AREA TOTAL	**6289**	**6289**	**4432**
Jerome+	**Town of Jerome**	**282+**	**282+**	**0**
Prescott Valley	Prescott Valley Mun. Water System	6169	6169	5874.26
	Hanely Park	2	2	
Note: Bradshaw WC developed and served 2 AF in 2006, the balance of their use was delivered by PV.	Bradshaw WC (PV water)	2	2	
	Diamond Valley (PV water)	0	0	
	Mingus West (PV water)	0	0	
	Viewpoint SubD (PV water)	0	0	
	Water Provider Total	6173	6173	5874.26
	Exempt wells (128@.33AF/yr)	42	42	42
	Nonexempt wells	6	6	6
	Total Mun/Dom Water Use	**6221**	**6221**	**5922.26**
58-101347.0002	617662 Maughan	55	55	47
	Total Agricultural Water Use	**55**	**55**	**47**

Water Planning Area	Water User[1]	2006 Demand[1] (AF/YR)	Estimated Available Supplies (using 2006 Status-Quo) (AF/YR)	Estimated Available Supplies (using Assured and Adequate Determination)[2] (AF/YR)
58-108469.0002	530375 - Prescott Country Club GC	449	449	469
58-111699.0003	631279 - Humboldt USD	0	0	75
58-111963.0000	613018 – Fain Land and Cattle Co.	0	0	12
58-111966.0001	613018 - Norman W Fain	0	0	201
58-115744.0002	613018 - Fain Land and Cattle Co.	0	0	259
	Stone Ridge GC (PV Water)	0	0	0
	Asphalt Paving and Supply Inc. (SW)	96	96	96
	Total Com/Ind Water Use	**545**	**545**	**1112**
	PLANNING AREA TOTAL	**6821**	**6821**	**7081**
Chino Valley	Appaloosa Water Co.	78	78	8713.62
	PacWest Properties	26	26	
	H&R Enterprises	4	4	
	Chino Meadows II Water Co.	211	211	
	Manneken Apartments	3	3	
	Town of Chino Valley	157	157	
	Sunset Village Mobile Home Park	3	3	
	Roadrunner MHP	16	16	
	Water Provider Total	498	498	8714
	Exempt wells (2412@.33AF/yr)	796	796	796
	Nonexempt wells	31	31	31
	Total Mun/Dom Water Use	**1325**	**1325**	**9540.62**
58-100966.0000	802261 Collier	223	223	297
58-102756.0000	619377 Dunbar	254	254	63
58-102755.0001	619376 Dunbar Stone	135	135	339
58-114294.0008	800605 Fletcher	10	10	46

Water Planning Area	Water User[1]	2006 Demand[1] (AF/YR)	Estimated Available Supplies (using 2006 Status-Quo) (AF/YR)	Estimated Available Supplies (using Assured and Adequate Determination)[2] (AF/YR)
58-106251.0000	602747 Hoult	58	58	59
58-114294.0011	561376 Siegel	37	37	42
58-111870.0015	609088 Vlachos Enterprises LLC	67	67	81
58-120017.0005	617596 West Meadows LLC	125	125	224
74-571073.0002	CVID	782	0	0
	Total Agricultural Water Use	**1691**	**909**	**1151**
58-100771.0004	512905 – J&KA Fletcher	0	0	3
58-101428.0007	571626 - Hines Nursery, Inc	54	54	99
58-101753.0008	504619 - Town of Chino Valley	21	21	14
58-102352.0001	624833 - Josal Enterprises	95	95	12
58-106092.0005	608241 – The Bond Ranch @DRS	0	0	1406
58-111870.0017	609088 – Vlachos Enterprises LLC	0	0	102
58-107940.0005	635256 – Cravath Whole Life LLC	0	0	55
58-108364.0002	802111 - Town of Chino Valley	0.3	0.3	10
58-109278.0002	627269 - Kulmer/Nielsen	0.02	0.02	69
58-111865.0005	617671 - LDS Church	10	10	7
58-111930.0002	599981 – Silver Mtn Ventures LLC	0	0	4
58-111958.0001	504619 – Town of Chino Valley	0	0	6
58-117267.0000	606020 – City of Prescott	0	0	*(COP) 3169*
58-120028.0001	60629? – Town of Chino Valley	0	0	11
58-120029.0001	608241 – The Bond Ranch @DRS	0	0	63
58-120031.0000	604449 – Patrick Moore	0	0	30
59-217097.0000	635256 – Fletcher Land & Cattle LLC	0	0	279
59-538980.0001	610173 - Gilford Bisjak	6	6	10
59-566798.0000	566799 – Del Rio Drill & Pump	0	0	25
59-570754.0000	501609 – CV School - Del Rio	73	73	80

Water Planning Area	Water User[1]	2006 Demand[1] (AF/YR)	Estimated Available Supplies (using 2006 Status-Quo) (AF/YR)	Estimated Available Supplies (using Assured and Adequate Determination)[2] (AF/YR)
59-570755.0000	631384 - CVHS	121	121	120
59-578329.0000	507356 – R&L Howlett	0	0	25
59-585032.0000	579607 - Metro Materials	2	2	20
59-591433.0000	606295 - Yavapai College	43	43	80
59-593403.0001	593404 - Lonesome Valley LLC	97	97	100
	Total Com/Ind Water Use	**522**	**522.32**	**2630**
	PLANNING AREA TOTAL	**3538**	**2756**	**13322**
Prescott	City of Prescott	10151	10151	16803.04
	Dells Water Co.	24	24	
	Granite Dells Water Co.	5	5	
	Holiday Hills DWID (COP water)	0	0	
	Wilhoit Water Co.	27	27	
	Beverly Gardens TP (COP water)	0	0	
	Highland Pines DWID (COP water)	0	0	
	Water Provider Total	10207	10207	16803
	Exempt wells (961@.33AF/yr)	317	317	317
	Nonexempt wells	7	7	7
	Total Mun/Dom Water Use	**10531**	**10531**	**17127**
	Total Agricultural Water Use	**375**	**375**	**0**
58-101244.0000	602924 - Industrial Dev. Authority	0.7	0.7	15
59-218227.0000	212087 – City of Prescott	0	0	10
56-003017.0000	Antelope Hills GC (COP Water)	0	0	
56-003017.0000	Prescott Lakes GC (COP Water)	0	0	
56-003017.0000	Hassayampa GC (COP Water)	0	0	
	Total Com/Ind Water Use	**1**	**1**	**25**

CYHWRMS- Demand Analysis
Water Planning Area
Water Use and Available Supply Summary Table

Water Planning Area	Water User[1]	2006 Demand[1] (AF/YR)	Estimated Available Supplies (using 2006 Status-Quo) (AF/YR)	Estimated Available Supplies (using Assured and Adequate Determination)[2] (AF/YR)
	PLANNING AREA TOTAL	**10907**	**10907**	**17152**
Sedona	Arizona Water Co Sedona	3332	3332	1583.05
	Oak Creek Water Co. No. 1	309	309	
	Sedona Venture Water Co.	111	111	
	Sunset Mobile Home Park	11	11	
	Water Provider Total	3763	3763	1583
	Exempt wells (94@.33AF/yr)	31	31	31
	Nonexempt wells	7	7	7
	Total Mun/Dom Water Use	**3801**	**3801**	**1621**
	Total Agricultural Water Use	**278**	**278**	**278**
**	Los Abrigados	0	0	0
***	Poco Diablo GC	33	33	33
	Total Com/Ind Water Use	**33**	**33**	**33**
	PLANNING AREA TOTAL	**4112**	**4112**	**1932**
Paulden CDP	Abra Water Co.	163	163	2434.92
	Antelope Lakes	157	157	
	Gilpins Trailer Park	11	11	
	Water Provider Total	331	331	2435
	Exempt wells (1356@.33 AF/yr)	447	447	447
	Nonexempt wells	143	143	143
	Total Mun/Dom Water Use	**921**	**921**	**3025**
	Big Chino AG Water	768	768	768
58-106507.0000	623516, 623517 Wells	578	578	578
	Total Agricultural Water Use	**1346**	**1346**	**1346**

Water Planning Area	Water User[1]	2006 Demand[1] (AF/YR)	Estimated Available Supplies (using 2006 Status-Quo) (AF/YR)	Estimated Available Supplies (using Assured and Adequate Determination)[2] (AF/YR)
**	United Metro/Dunbar	7	7	7
	Total Com/Ind Water Use	**7**	**7**	**7**
	PLANNING AREA TOTAL	**2274**	**2274**	**4378**
Big Park CDP	Arizona Water Co Valley Vista System	420	420	1548.2
	Big Park Water Co.	880	880	
	Pine Valley Water Co.	47	47	
	Water Provider Total	1347	1347	1548
	Exempt wells (42@.33 AF/yr)	14	14	14
	Nonexempt wells	2	2	2
	Total Mun/Dom Water Use	**1363**	**1363**	**1564**
	Total Agricultural Water Use	**0**	**0**	**0**
	Sedona GC	481	481	481
	Canyon Mesa GC	230	230	230
	Oak Creek Village GC	440	440	440
	Total Com/Ind Water Use	**1151**	**1151**	**1151**
	PLANNING AREA TOTAL	**2514**	**2514**	**2715**
Cornville CDP	Oak Creek Public Service	66	66	473.04
	Oak Creek Valley	479	479	
	Water Provider Total	545	545	473
	Exempt wells (1159@.33 AF/yr)	382	382	382
	Nonexempt wells	32	32	32
	Total Mun/Dom Water Use	**959**	**959**	**887**
	Total Agricultural Water Use	**2823**	**2823**	**2823**
	Total Com/Ind Water Use	**0**	**0**	**0**

Water Planning Area	Water User[1]	2006 Demand[1] (AF/YR)	Estimated Available Supplies (using 2006 Status-Quo) (AF/YR)	Estimated Available Supplies (using Assured and Adequate Determination)[2] (AF/YR)
	PLANNING AREA TOTAL	**3782**	**3782**	**3710**
Lake Montezuma CDP	AZ Water Co Rimrock	326	326	733.92
	Montezuma Rimrock WC (Montezuma Estates POA)	42	42	
	Beaver Creek Store	8	8	
	Water Provider Total	376	376	733.92
	Exempt wells (773@.33 AF/yr)	255	255	255
	Nonexempt wells	43	43	43
	Total Mun/Dom Water Use	**674**	**674**	**1032**
	Total Agricultural Water Use	**537**	**537**	**537**
	B & B Materials	200	200	200
***	Beaver Creek GC	509	509	509
	Total Com/Ind Water Use	**709**	**709**	**709**
	PLANNING AREA TOTAL	**1920**	**1920**	**2278**
Ctn-Verde Villages CDP	Exempt wells (359@.33 AF/yr)	118	118	118
	Nonexempt Wells	1	1	1
	Total Mun/Dom Water Use	**119**	**119**	**119**
	Total Agricultural Water Use	**1124**	**1124**	**1124**
	Total Com/Ind Water Use	**0**	**0**	**0**
	PLANNING AREA TOTAL	**1243**	**1243**	**1243**
Williamson CDP	American Ranch DWID	25	25	
	Granite Mountain Water Co.	56	56	
	Granite Oaks WUA	207	207	

Water Planning Area	Water User[1]	2006 Demand[1] (AF/YR)	Estimated Available Supplies (using 2006 Status-Quo) (AF/YR)	Estimated Available Supplies (using Assured and Adequate Determination)[2] (AF/YR)
	Inscription Canyon Ranch & Talking Rock GC	568	568	
	Water Provider Total	856	856	
	Exempt wells (1854@.33 AF/yr)	612	612	
	Nonexempt Wells	23	23	
	Total Mun/Dom Water Use	**1491**	**1491**	**0**
	Total Agricultural Water Use	**0**	**0**	**0**
	Total Com/Ind Water Use	**0**	**0**	**0**
	PLANNING AREA TOTAL	**1491**	**1491**	**0**
Verde CCD	Boynton Cyn Enchantment HOA	63	63	2352.84
	Cathedral Vista WC	19	19	
	Clear Creek Mobile Home	4	4	
	C-Oasis Park	3	3	
	Cup of Gold Water Co.	20	20	
	Little Park Water Co.	45	45	
	Michaels Ranch WUA	13	13	
	Montezuma Heights	25	25	
	Red Rock Crossing Mobile	6	6	
	Seven Canyons	27	27	
	Verde Valley Manor	37	37	
	White Hills Trailer Park	47	47	
	Water Provider Total	309	309	2353
	Exempt wells (583@.33 AF/yr)	192	192	192
	Nonexempt wells	41	41	41
	Total Mun/Dom Water Use	**542**	**542**	**2586**

CYHWRMS- Demand Analysis
Water Planning Area
Water Use and Available Supply Summary Table

Water Planning Area	Water User[1]	2006 Demand[1] (AF/YR)	Estimated Available Supplies (using 2006 Status-Quo) (AF/YR)	Estimated Available Supplies (using Assured and Adequate Determination)[2] (AF/YR)
	Total Agricultural Water Use	**1322**	**1322**	**1322**
*	Out of Africa	0	0	0
***	Seven Canyons GC	276	276	276
***	Sedona National GC	414	414	414
	Total Com/Ind Water Use	**690**	**690**	**690**
	PLANNING AREA TOTAL	**2554**	**2554**	**4598**
Prescott CCD				5350.88
	(COP water)	Well produces < 1 AF, receives 5AF from COP	Well produces < 1 AF, receives 5AF from COP	
	Buffalo Run MHP	12	12	
	Cactus Mobile Ranch	1	1	
*	Chino Mobile Home Ranch	0	0	
*	Dells View Water Co.	0	0	
	Double G TP	7	7	
	Jackson Acres WC	5	5	
	Lakeside Water Co.	6	6	
	Pinehurst Water Co.	29	29	
	Quail Ridge DWID	65	65	
	Sherman Pines	4	4	
	Water Provider Total	129	129	5351
	Exempt wells (3513@.33 AF/yr)	1159	1159	1771
	Nonexempt wells	61	61	78
	Total Mun/Dom Water Use	**1349**	**1349**	**7200**
58-106507.0000	623515 Wells	176	176	176

Water Planning Area	Water User[1]	2006 Demand[1] (AF/YR)	Estimated Available Supplies (using 2006 Status-Quo) (AF/YR)	Estimated Available Supplies (using Assured and Adequate Determination)[2] (AF/YR)
	Big Chino Ag	4760	4760	4760
	Total Agricultural Water Use	**4936**	**4936**	**4936**
59-561258.0002	527848 – Camp Tepeyac, Life Teen Inc.	0	0	10
	Total Com/Ind Water Use	**0**	**0**	**10**
	PLANNING AREA TOTAL	**6285**	**6285**	**12146**
Mingus Mtn. CCD	Exempt Wells (1392@.33 AF/yr)	459	459	459
	Placeholder for AAWS Determinations – no WPs in area			281.74
	Nonexempt	25	25	21
	Total Mun/Dom Water Use	**484**	**484**	**762**
	Total Agricultural Water Use	**487**	**487**	**487**
**	Phoenix Cement	350	350	350
58-111964.0000	575576 – Heritage Memorial Park	6	6	55
58-111967.0004	550395 – Fain Family Lmt Part (Quailwood Greens GC)	344	344	176.25
58-109214.0001	202098 - Empire Res. Const.	0	0	3
59-218233.0000	558501 – Hanson Aggregate	0	0	200
59-585030.0001	579444 – United Metro Materials	28	28	70
	Total Com/Ind Water Use	**728**	**728**	**854**
	PLANNING AREA TOTAL	**1699**	**1699**	**2103**
Humboldt CCD	Exempt Wells (147@.33 AF/yr)	49	49	49
	Placeholder for AAWS Determinations – no WPs in area			22
	Nonexempt	5	5	5
	Total Mun/Dom Water Use	**54**	**54**	**76**

CYHWRMS- Demand Analysis
Water Planning Area
Water Use and Available Supply Summary Table

Water Planning Area	Water User[1]	2006 Demand[1] (AF/YR)	Estimated Available Supplies (using 2006 Status-Quo) (AF/YR)	Estimated Available Supplies (using Assured and Adequate Determination)[2] (AF/YR)
	Total Agricultural Water Use	**759**	**759**	**759**
	Total Com/Ind Water Use	**0**	**0**	**0**
	PLANNING AREA TOTAL	**813**	**813**	**835**
Ashfork CCD	Exempt Wells (84@.33 AF/yr)	28	28	28
	Placeholder for AAWS Determinations – no WPs in area			18,500
	Nonexempt	8	8	8
	Total Mun/Dom Water Use	**36**	**36**	**18536**
	Agricultural Water Use	**2796**	**2796**	**2796**
	Total Com/Ind Water Use	**0**	**0**	**0**
	PLANNING AREA TOTAL	**2832**	**2832**	**21332**
1. Sources of Water Provider information and 2006 uses are Arizona Corporation Commission Records,				
Arizona Department of Water Resources – Community Water Plans or Registry of Groundwater Rights,				
or other existing publications as noted below:				
*Data Unavailable – Value assumed to be zero.				
**Data from Verde 2000 Report				
***YCWAC Verde Valley Projection, April 2003				
2. AAWS data from Arizona Department of Water Resources - Arizona Water Atlas.				
When AAWS data not available values are considered to be "status quo".				
+Jerome has revised 2006 supply and demand to 400 AF based on updated data				

Central Yavapai Highlands Water Resources Management Study
Phase I - Demand Analysis
Data Sources and Documentation

The Central Yavapai Highlands Water Resources Management Study (CHYWRMS) area encompasses a part of central Yavapai County that includes the Prescott Active Management Area (e.g., Chino Valley, Dewey-Humboldt, Prescott, Prescott Valley, and county lands), the Big Chino area (e.g., Williamson Valley area, Paulden area, and potential ranch developments) and the Verde Valley area (e.g., Camp Verde, Clarkdale, Cottonwood, Jerome, Sedona, and unincorporated areas). The area represents regions of high potential growth and commensurate water demands.

This document is organized by column headings in the Demand Analysis Summary Table (*filename: CYHWRMS_m_Demand Analysis Summary Table_4-1-10)* from left to right. Supporting work that documents the data in the table are listed below each section. The documents will be attached to this paper under Attachment 1 (*to be attached*). A brief bibliography will be included as Attachment 2 (*to be attached*).

Water Planning Areas

The study area has been divided into 20 water planning areas (WPAs) as described below:

Municipal WPAs are defined by the municipal boundary and any portion of the water service area that originates inside the municipal boundary and extend outside of it. (Camp Verde, Dewey-Humboldt, Clarkdale, Cottonwood, Jerome, Prescott Valley, Chino Valley, Prescott, and Sedona)

WPA boundaries for Census Designated Places (CDPs), as identified by the United States Census Bureau and used in the Yavapai County Water Advisory Committee – Long-term Development Scenarios – Scenario #1 Report, 2008 (2008 H3J report), were like-wise used for this analysis. (Paulden, Big Park, Cornville, Lake Montezuma, Ctn-Verde Villages, and Williamson)

The larger Census County Divisions (CCDs) as identified in the 2008 H3J report were clipped to include only those portions of the CCD that is within the CYHWRMS study area. (Verde, Prescott, Mingus Mtn, Humboldt, and Ashfork) Also recognized in the CCDs are three ranches expected to be developed for residential use: CVCF Ranch; Yavapai Ranch; and Las Vegas Ranch.)

Documentation:
Study Map titled "Central Yavapai Highlands Water Resources Management Study (filename: CYHWRMS_m_Study Area Map_4-1-10);
*Individual WPA maps (filenames: CYHWRMS_s_* **by name of the WPA**_*4-1-10).*

Population

Population was developed based on previous studies and assessments, past trends, and/or GIS analysis. All population values were finalized in consultation with technical and political representatives from each planning area.

Present population (2006) for most WPAs used DES estimates; modified DES estimates based on town/water provider input, or modified DES based on the difference between water service area boundaries and city/town boundaries. For example, City of Cottonwood modified their DES estimate because their service lines extend to the Ctn-Verde Village CDP. Where they extended into the CDP, that population was added to Cottonwood WPA and subtracted from Ctn-Verde Village CDP.

Present population (2006) for CCDs is based on 2006 Yavapai County Parcel Data (i.e. single and multi family) times the average DES persons per household by census designated areas.

Future population (2050) in most WPAs referenced 2008 H3J report with slight modifications as mentioned previously for 2006 populations. The CCDs were not whole due to the study area boundary excluding some portions. Ultimately, 2050 populations in the CCDs were developed with a 2.25% compounded growth rate. The 2.25% rate for CCDs was based on analysis of past trends (e.g. last 10 years) and discussions with the County Supervisors. The Ashfork CCD had an additional 35,000 people added to the 2050 total in order to represent a planning population that includes residential growth in the Yavapai and CVCF ranches. (Note: this was reduced from the 65,000 value used in the H3J report because 65,000 was thought to be too high due to lack of any current development and discussions with County Supervisor Carol Springer which indicate knowledge that Yavapai Ranch may not develop as quickly, or densely as previously assumed).

Documentation: CYHWRMS_s_DES 2006 and 2050_4-1-10;
CHYWRMS_s_Population Comparison_4-1-10;
CHYWRMS_s_PopulationUsingYCparcels_4-1-10;
CHYWRMS_s_Populations2050CCDs_4-1-10

Water Providers and 2006 Water Demand

Water Provider Use -

A list of water providers and their present use within the study area was developed from several existing documents as well as data from Arizona Corporation Commission (ACC) and Arizona Department of Water Resources (ADWR) records.

Documentation: CYHWRMS_s_ComprehensiveWaterProviderList_4-1-10;
CYHWRMS_s_2006DemandsFor PramaCommunities_4-1-10

2006 Water Use -

Water use for 2006 was calculated for each WPA by summing water provider uses, exempt domestic well uses, non-exempt well uses (not previously reported by water providers), and estimates of agricultural uses. These uses were then grouped into Muni/Dom Demand (Municipal/Domestic), Com/Ind Demand (Commercial/Industrial – not served by provider), and AG Demand (Agriculture).

Documentation: CHYWRMS_m_Planning Area Water Use Summary Table_4-1-10

Municipal/Domestic was a sum, by WPA, of the volumes associated with the Water Provider Total, Exempt wells and Non-Exempt Wells. Water use for exempt wells was calculated based on the number of wells identified in the ADWR Wells55 database with a domestic use and based on a defined query structure. The assumed usage amount per well was determined to be 0.33 AF/yr. (Note: Exempt commercial wells (not captured by the query – having a sole water use listed as commercial) were also queried at the request of Chino Valley. The number of exempt commercial wells in Chino Valley and throughout the study area was less than 1% of the overall exempt wells and, therefore, the study's Technical Working Group opted not to include them in the 2006 demand calculations.)

Additional domestic use was calculated as the sum of the Non-exempt wells that were identified in the ADWR Wells55 database and based on a defined query structure. Each planning area was reviewed by the CYHWRMS Technical Working Group. Volumes that were deemed to be significant and not already identified as a water provider were added to the overall usage amount for the WPA. (Non-exempt wells with a primary domestic use were assigned a value of 0.50 AF/yr, with domestic as an "other" use were assigned 1 AF/yr, and with a stock use assigned 0.3 AF/yr.)

Documentation: CYHWRMS_s_ExemptWellQuery_4-1-10;
CYHWRMS_s_VolumeForExemptWells_4-1-10;
CYHWRMS_s_NonExemptWellQuery_4-1-10;
CYHWRMS_s_NonExemptWellCount_4-1-10

Commercial/Industrial
Non-exempt wells located within the Prescott Active Management Area with active Grandfathered Groundwater Rights (GFRs, and Type I or Type II non-irrigation) and Groundwater Withdrawal Permits (e.g., general industrial use and mineral extraction permits) were identified and assigned to the appropriate WPAs. Additionally, commercial and industrial uses for golf courses, sand and gravel operations, and others, not already identified by water providers, outside of the PrAMA were collected for 2006. The data for communities outside of the PrAMA was developed from ADWR Annual Reports, the Verde 2000 Report, and the YCWAC Verde Valley Projections.

Documentation: CYHWRMS_s_Golf Course 2006 ComInd Use_4-1-10;
CYHWRMS_s_PrAMA Type I Type II 59s_4-1-10

Agricultural water use throughout the study area was estimated based on total irrigated acres. Areas outside of the AMA used a method that included year appropriate aerial

photography with present and historical irrigation mapping. Within the AMA, annual reports for Irrigation Grandfather Rights provided the volume used in 2006. Agriculture associated with surface water was also verified and use was estimated.

Documentation: CYHWRMS_s_AG Demand Method_4-1-10;
CYHWRMS_s_AG Summary_4-1-10;
CYHWRMS_s_PrAMA AG Demand with SW_4-1-10

2006 Gallons per Person per Day (GPPD)

GPPD is a value that may be calculated to establish the amount of water used per person per day. These values were determined for each WPA. GPPD was used to attempt to verify the validity of assumptions made with respect to 2006 data. GPPD was calculated by dividing 2006 Muni/Dom demand by the 2006 population; unit conversion required.

Estimated Available Water Supply

Over time, water resources for communities within the AMA have been evaluated more closely than those outside because of the 1980 Groundwater Management Act and associated rules. There is much more data available for these communities and this offers more opportunity for evaluating and comparing methodologies. To date, three methods have been considered to evaluate and compare estimates for available water supplies within the study area.

1. Using data developed for the Arizona Water Atlas, to identify Assured and Adequate Water Supply determinations that "locked up" water for a provider or entity within a WPA (Designations – AMAs and non-AMAs, Certificates – AMA only, Water Adequacy reports – non-AMAs*, and Analysis – AMAs and non-AMAs). Assume present demand equal present supply for all water users who are not required to comply with ADWR and ADRE subdivision statutes and rules (e.g., exempt wells, some non-exempt wells, agriculture, etc.)
   *Some Water Adequacy reports are still in effect in the AMA due to determinations issued prior to the AMA being declared out of safe-yield.

2. Determine a time, demand level, or natural recharge volume where we may be able to sustain (indefinitely) pumping and live with the environmental affects. Any water needs above this amount will need to be met through reuse, recharge, augmentation and/or conservation.

3. Assume that 2006 pumping levels were at a "status quo" and designate 2006 water demand as 2006 available supply.

The TWG agreed to use the status quo (item 3. above) and the use components from existing water budgets (item 2. above). The affect of these numbers can be seen in the Demand Analysis Summary Tables, tabs 1 and 2.

Documentation: CYHWRMS_s_Components from Existing Water Budgets_4-1-10;
CYHWRMS_s_Budget Reference Docs_11-18-09;

CYHWRMS_s_Estimated Available Supplies_AAWSmethod_4-1-10

2050 Water Demand

Representatives of each WPA provided their 2050 GPPD and estimates were made for commercial/industrial (not served by a provider), and agriculture volumes for a total 2050 water use value.

Municipal/Domestic was calculated by multiplying the 2050 GPPD by the 2050 population.

Commercial/Industrial (not served by a provider) was determined in consultation with representatives of the Water Provider Areas. Some areas chose to use the status quo from 2006 for the 2050 value, and others justified changing the value.

Documentation: CYHWRMS_s_2050 ComInd Assumptions for PrAMA_4-1-10;
CYHWRMS_s_2050 ComInd Assumptions for PrAMA Table_4-1-10;
CHYWRMS_s_AsphaltPavingAndSupply SW use_11-18-09;
CYHWRMS_s_2050 ComInd Assumptions outside PrAMA_4-1-10

Agriculture was determined based on discussion between members of the Technical Working Group and WPA representatives. The year 2050 agricultural water use in the Verde Valley planning areas is set at two-thirds (66%) of the 2006 value (reduced by 1/3). The 2050 agriculture water use in the Big Chino sub basin is half (50%) of the 2006 value. The 2050 agricultural use in the Little Chino sub basin (Prescott AMA) is calculated based on ADWR records and assumptions by PrAMA staff for the assessment (2025 projections).

Documentation: CYHWRMS_s_2050 AG in PrAMA_11-18-09

2050 Water Supply

The 2050 water supply is the difference between the estimated available supply and the 2050 total demand. If the number is negative there is a projected unmet demand for the WPA in planning year 2050.

CYHWRMS
2050 AG Demand in PrAMA

Detailed explanation of which AG rights were assumed to be extinguished by 2025 and what would remain in 2050.

Dewey-Humboldt WPA 2006 AG total = 569

Bagby (2) – note from Bagby that both wells were capped at the end of 2006. Zero use since 2007. Assumption that rights will be extinguished by 2050. – 86

Cain Verde – PrAMA assessement made the assumption that is right would be extinguished by 2010. – 28

Jensen – 19.30 irrigation acres. Since this is less than 20 acres, assumption that this right will be extinguished by 2050. – 38

Statler (2) – 104351 uses gw on their land but also sends water to 104350. Overall the irrigation acres of these two rights totals 11.1. Since this is less than 20 acres, assumption that this right will be extinguished by 2050. – 65

Wingfield – PrAMA assessement made this assumption that this right would still be active in 2025. – 0

Yavapai Land Holdings - PrAMA assessement made the assumption that is right would be extinguished by 2010 – 315

2050 AG = 37

Prescott Valley WPA 2006 AG total 55

Maughan – Irrigation acres = 14. Since this is less than 20 acres, assumption that this right will be extinguished by 2050. – 55

2050 AG = 0

Chino Valley WPA 2006 AG total 909 + 782 = 1691

Collier - PrAMA assessement made the assumption that is right would be extinguished by 2010 – 223

Dunbar (2) - PrAMA assessement made the assumption that is right would be extinguished by 2010 – 389

Fletcher - PrAMA assessement made the assumption that is right would be extinguished by 2010 (2006 demand was amended to 46 from 10) – 46

Hoult – Irrigation acres = 17.5. Since this is less than 20 acres, assumption that this right will be extinguished by 2050. – 58

Siegel – This right was fully conveyed to .0012. Irrigation acres = 11.93. Since this is less than 20 acres, assumption that this right will be extinguished by 2050. – 37

Vlachos – This right converted the majority of the right to a Type-1 non-irrigation grandfather right, and leaving just a small portion which was classified as small exempt (not required to report). Water demand associated with this right will go to zero in the 2050 ag column. – 67

West Meadows - PrAMA assessement made the assumption that is right would be extinguished by 2010 – 125

CVID (74-571073.0002) – this need to be moved from the Chino Valley WPA non-exempts into the Chino Valley WPA AG section. The PrAMA decided that only 750 AF of CVID water would still be in use in 2025. Within that irrigation district, they recognized two users that have their own irrigation rights (Coury 58-101191.0002 and Elemental Farms 58-102905.0002). The PrAMA assumed these two would not extinguish by 2025. In the PrAMA assumptions CVID was assumed to use 750 AF in 2025. The assumption by CHYWRMS was that these would continue to 2050. This is how the volumes were determined. Coury's - for the years between '00-'07, the average of the years showing use was calculated and resulted in 207 AF. Element's – for years btw '02-'07, the average of the years showing use was calculated and resulted in 22 AF. The total for these two is 229; it is was subtracted from the 750 that the PrAMA stated remained in 2025. So, 521 AF was removed from the CYHWRMS 2006 demand. – 521

2050 AG = 158

Prescott WPA

2006 AG = 375

The one Ag user is Granite Dells Ranch and the water is SW based on claim 36-65554.0, 36-65554.1 and 38-90493.0. Since it is SW, it was decided that until the claim is adjudicated, that the volume (375 AF) released by COP for this right will continue to 2050. – 0

2050 AG = 375

2006 AG = 578

Paulden WPA – there is one AMA GW right that extends into the Paulden WPA. Wells – PrAMA assessment made the assumption that this right **would not** be extinguished by 2025. – 0

2050 AG = 578 *

2006 AG 176

Prescott CCD - there is one AMA GW right that extends into the Prescott CCD WPA. Wells – PrAMA assessment made the assumption that this right **would not** be extinguished by 2025. – 0

2050 AG 176 *

* Paulden

2006 = 1346 remove 578 = 768 apply reduction by ½ = 384.

384 + 578 back in = 962 AF for 2050 AG in Paulden WPA

* Prescott CCD

2006 = 4936 remove 176 = 4760 apply reduction by ½ = 2380.

2380 + 176 back in = 2556 AF for 2050 AG in Prescott CCD

ARIZONA DEPARTMENT OF WATER RESOURCES
PRESCOTT ACTIVE MANAGEMENT AREA

MEMORANDUM

TO: Lisa Williams

FROM Gerry L. Wildeman

DATE: August 22, 2008

SUBJECT: Agricultural Projections for the Prescott AMA

Your email refers to "...use historic use and historic rates of acreage becoming inactive developed or extinguished..." as a means of making agricultural projections for the Prescott AMA. Due to the unique pattern of development that exists here and some specific rules regarding extinguishment credits (affectionately known as the Young's Farm exemption) I would prefer that we not predict the future exclusively on the past but on our knowledge, as you also indicated. This memo was written to summarize the manner in which we think ag will develop through 2025.

☺ Ag use in the Prescott AMA is already significantly reduced and there are only about 25% of the original IGFR acres remaining. There are also no large planned developments, i.e. master planned communities etc. that we are aware of and the real estate market is in the tank!

☺ There have been two peaks in extinguishment of irrigation rights with only one being somewhat tied to development. However, the actual development (i.e. creation of subdivisions/houses) has not taken place on former irrigated lands, i.e. true urbanization. The first peak in extinguishments was in 2000 and was driven by the Young's Farm exemption. Those that did not qualify wanted to extinguish and get the highest number of credits. The second peak was in 2005 and was driven by a surge in the purchase price of extinguishment credits. This was associated with the upswing in the housing market, but the end use was not associated with formerly irrigated lands.

☺ It is anticipated that there will be another surge in extinguishments in 2010 as the Young's Farm exemption terminates on December 31, 2010. All right holders that do not extinguish by that date will lose 36% of their potential extinguishment credits if they wait until 2011.

☺ For rights less than 10 acres, maintain historic average into the future with average numbers being calculated based on year 2000 and later. Please see spreadsheet for additional information regarding the changes to other Ag use categories. For Exception Users, I projected 900 AF for 2008 and 2009 with a drop to 750 throughout the rest of the projection period. Since 2005, there has been a decreasing trend in CVID water use. As of 2008, the remaining obligation to CVID is approximately 21,000 AF. At this projection rate, there will be this class of water use through 2025 and beyond.

NOTE: Gordon and I were talking and we don't have a good guess right now, but our idea was that there should perhaps be some proportional decrease in ag related to the percentage

increase in population growth due to in-fill of population on lands currently used for agricultural purposes. Since our < 10 AC ag use is so small, it probably doesn't matter, and in the >10 AC ag use group, we really don't think those are going to diminish further, so it would really be in the Exception Users group. Has anyone else thought about/included this in theirs?

☺ Note: Regarding final budget template numbers for 2006 for Exception Users, if these are all CVID water uses, shouldn't the value of recovered effluent be equal to the value for Exception Users? Also, the notation is incorrect as these are not SW Right holders. The remaining surface water rights in CVID are less than 34 AF.

	Right Number	Year of Extinguishment	Name	Change to Demand	Notes:	Acres
Large Rights	58-100544.0002	2010	Yavapai Land, was Young's Farm	759	Currently irrigated	155.7
	58-106507.0000	none	Billy and Betty Wells	0	Won't extinguish	193.9
	58-107000.0001	2020	SLD	0	No current or hist. ir	132.5
	58-120217.0005	2010	West Meadows - Fletcher	0	No current or hist. ir	83.8
Med Rights >20 AC	58-100966.0000	2010	Collier	264	Currently irrigated	62
	58-101191.0002	none	Coury	0	Currently irrigated	50.7
	58-102216.0002	2010	Chino Valley LLC	0	No current or hist. ir	56.6
	58-102755.0001	2010	Dunbar	350	Currently irrigated	71.4
	58-102756.0001	2010	Dunbar	60	Currently irrigated	23
	58-102757.0002	2010	Dunbar	65	Currently irrigated	19
	58-102905.0002	none	Elemental Farms LLC	0	Currently irrigated	23.4
	58-102965.0000	none	Wingfield	0	Currently irrigated	20.9
	58-105220.0001	2010	Myers	0	No current or hist. ir	39.3
	58-105220.0012	2010	Fletcher	0	No current or hist. ir	23
	58-111928.0002	2010	Cain	20	Limited use	60.9
	58-120027.0002	2010	Running W Ranch	0	No current or hist. ir	87.9

Year	Ag Demand Projections (>10AC) (in AF)		Ag Demand Projections (<10AC) (in AF)	(CVID) Exception Users (in AF)
2007	As reported		As reported	1000
2008	Mirror 2007		Maintain at Avg. Historic Value (average beginning with 2000 data)	900
2009	Mirror 2007		same	900
2010	1518	*Subtract this volume *	same	750
2011	Maintain value after 2010 reductions		same	750
2012	Same		same	750
2013	Same		same	750
2014	Same		same	750
2015	Same		same	750

Assessment # for 2025

579 AF

06 = 93 AF hold into future

750

2016	Same	same	750
2017	Same	same	750
2018	Same	same	750
2019	Same	same	750
2020	Same	same	750
2021	Same	same	750
2022	Same	same	750
2023	Same	same	750
2024	Same	same	750
2025	Same	same	750

CYHWRMS 2006 Demands for PrAMA Communities

Description: Most data for the 2006 Demands came from ADWR or ACC records. In some cases the demand number was convoluted due to the need to account for other sources (direct delivery of reclaimed water or recovered water).

City of Prescott – data source ADWR Annual Reports filed and signed by the City
File number: 56-003017.0000

	2005	2006	2007
Groundwater withdrawn (56-003017)	6336.6	7979.0	8397.5
Recovered SW (74-569302)	1547.0	228.7	-
Recovered Effluent (74-569302)	-	153.9	-
Effluent Direct Delivery – Hassayampa	198.1	200.5	223.8
Effluent Direct Delivery – Turf (Antelope)	1283.0	1403.9	1643.9
Effluent Direct Delivery – Other (Hanson's)	107.4	158.9	111.5
74-561500	23.14	26.4	40.61
Total	10,461.84	10,151.3	10,417.31

Town of Prescott Valley – data source ADWR Annual Reports filed and signed by the Town
File number: 56-003012.0000 and 56-003023.0000

	2005	2006	2007
Groundwater (56-003023)	701.7	713.3	658.3
Groundwater (56-003012)	4,402.8	5049.0*	5405.1
Effluent Direct Delivery – Turf, Lakes, Utility (Stoneridge, Mtn Vly Park, WWTP Utility) – as reported on 56-003012	440.3	400.4	401.3
74-590639	6.24	5.9	6.2
Total	5551.04	6168.6	6470.9

*Included in the 5049.0 AF is 184.7 AF deliverd to the following rights, Diamond Valley – 132.7 AF, Bradshaw – 28.4 AF, and PV Muni System – 23.6 AF

Town of Chino Valley – data source ADWR Annual Reports filed by the town
File number: 56-003022.0001

	2005	2006	2007
Groundwater (56-003022.0001)	109.6	156.72	254.71

2050 Commerical and Industrial Demand - Possible Assumptions

TWG working document

Water Planning Area	Non-Exempt Wells	AMA Right Type	2006 Demand[1]	2050 Demand			
				2006 Status Quo[2]	Non-AMA = status quo, AMA GFRs = allotments[3]	Non-AMA and AMA Type 2s = status quo, AMA GFR Type 1s to AWSC[4]	Non-AMA = status quo, PrAMA 2025 assumptions[5]
			(AF/YR)	(AF/YR)	(AF/YR)	(AF/YR)	(AF/YR)
Camp Verde		Not in the AMA					
**	**Yavapai Apache Sand and Rock**		**100**	100	100	100	100
**	**United Metro Materials**		**403**	403	403	403	403
**	**Superior Materials**		**280**	280	280	280	280
	PLANNING AREA TOTAL		**783**	783	783	783	**783**
Dewey-Humboldt							
58-106508.0002	**633842- Yavapai Land Holdings LLC**	Type 1	**0**	0	5.59	72	
58-106509.0001	**633841 – Yavapai Land Holdings LLC**	Type 2	**16**	16	20	16	700
58-110149.0003	**625214 – Yavapai Land Holdings LLC**	Type 2	**0**	0	5	0	
	PLANNING AREA TOTAL		**16**	16	30.59	88	**700**
Clarkdale		Not in the AMA	**0**	**0**	0	0	**0**
Cottonwood							
***	**Pine Shadows GC**	Not in the AMA	**120**	120	120	120	120
***	**Verde Santa Fe GC**		**1313**	1313	1313	1313	1313
**	**Hanson Aggregates**		**320**	320	320	320	320

Water Planning Area	Non-Exempt Wells	AMA Right Type	2006 Demand[1]	2050 Demand			
				2006 Status Quo[2]	Non-AMA = status quo, AMA GFRs = allotments[3]	Non-AMA and AMA Type 2s = status quo, AMA GFR Type 1s to AWSC[4]	Non-AMA = status quo, PrAMA 2025 assumptions[5]
			(AF/YR)	(AF/YR)	(AF/YR)	(AF/YR)	(AF/YR)
	PLANNING AREA TOTAL		**1753**	1753	1753	1753	**1753**
Jerome		Not in the AMA	**0**	0	0	0	**0**
Prescott Valley							
58-108469.0002	**530375 - Prescott Country Club GC**	Type 2	**449**	449	449	449	449
58-111699.0003	**631279 - Humboldt USD**	Type 2	**0**	0	75	0	355
58-111963.0000	**613018 – Fain Land and Cattle Co.**	Type 2	**0**	0	12	0	
58-111966.0001	**613018 - Norman W Fain**	Type 2	**0**	0	21	0	See Mingus
58-115744.0002	**613018 - Fain Land and Cattle Co.**	Type 2	**0**	0	259.2	0	Mtn. CCD
	Stone Ridge GC (PV Water)		**0**	0	?	?	
	Asphalt Paving and Supply, Inc. (SW)		**96**	96	96	96	96
	PLANNING AREA TOTAL		**545**	545	912.2	545	**900**
Chino Valley							
58-106092.0005	**608241 – The Bond Ranch @DRS**	Type 1	**0**	0	1406.13	7572	3500
58-100771.0004	**512905 – J&KA Fletcher**	Type 1	**0**	0	3	15	
58-101428.0007	**571626 - Hines Nursery, Inc**	Type 1	**54**	54	98.67	517.5	
58-101753.0008	**504619 - Town of Chino Valley**	Type 1	**21**	21	13.95	75	
58-102352.0001	**624833 - Josal Enterprises**	Type 1	**95**	95	12	60	
58-111870.0017	**609088 – Vlachos Enterprises LLC**	Type 1	**0**	0	66.68	553.65	150
58-107940.0005	**635256 – Cravath Whole Life LLC**	Type 2	**0**	0	55	0	

Water Planning Area	Non-Exempt Wells	AMA Right Type	2006 Demand[1]	2050 Demand			
				2006 Status Quo[2]	Non-AMA = status quo, AMA GFRs = allotments[3]	Non-AMA and AMA Type 2s = status quo, AMA GFR Type 1s to AWSC[4]	Non-AMA = status quo, PrAMA 2025 assumptions[5]
			(AF/YR)	(AF/YR)	(AF/YR)	(AF/YR)	(AF/YR)
58-108364.0002	**802111 - Town of Chino Valley**	Type 2	**0.3**	0.3	10	0.3	
58-109278.0002	**627269 - Kulmer/Nielsen**	Type 2	**0.02**	0.02	68.6	0.02	
58-111865.0005	**617671 - LDS Church**	Type 2	**10**	10	7	10	
58-111930.0002	**599981 – Silver Mountain Ventures LLC**	Type 2	**0**	0	4.2	0	
58-111958.0001	**504619 – Town of Chino Valley**	Type 2	**0**	0	6.4	0	
58-117267.0000	**606020 – City of Prescott**	Type 2	**0**	0	3169	0	
58-120028.0001	**60629? – Town of Chino Valley**	Type 2	**0**	0	11.2	0	
58-120029.0001	**608241 – The Bond Ranch @DRS**	Type 2	**0**	0	63.44	0	
58-120031.0000	**604449 – Patrick Moore**	Type 2	**0**	0	29.87	0	
59-217097.0000	**635256 – Fletcher Land & Cattle LLC**	Mineral	**0**	0	279	0	
59-538980.0001	**610173 - Gilford Bisjak**	GIU	**6**	6	10	6	
59-566798.0000	**566799 – Del Rio Drill & Pump**	GIU	**0**	0	25	0	
59-570754.0000	**501609 – CV School - Del Rio**	GIU	**73**	73	80	73	
59-570755.0000	**631384 - CVHS**	GIU	**121**	121	120	121	
59-578329.0000	**507356 – R&L Howlett**	GIU	**0**	0	24.5	0	
59-585032.0000	**579607 - Metro Materials**	Mineral	**2**	2	20	2	
59-591433.0000	**606295 - Yavapai College**	GIU	**43**	43	80	43	
59-593403.0001	**593404 - Lonesome Valley LLC**	Mineral	**97**	97	100	97	542
	PLANNING AREA TOTAL		**522**	522	5764	9145	**4192**
Prescott							
58-101244.0000	**602924 - Industrial Dev. Authority**	Type 2	**0.7**	0.7	15	0.7	
56-003017.0000	**Antelope Hills GC (COP Water)**		**0**	0	?	?	

Water Planning Area	Non-Exempt Wells	AMA Right Type	2006 Demand[1]	2050 Demand			
				2006 Status Quo[2]	Non-AMA = status quo, AMA GFRs = allotments[3]	Non-AMA and AMA Type 2s = status quo, AMA GFR Type 1s to AWSC[4]	Non-AMA = status quo, PrAMA 2025 assumptions[5]
			(AF/YR)	(AF/YR)	(AF/YR)	(AF/YR)	(AF/YR)
56-003017.0000	**Prescott Lakes GC (COP Water)**		**0**	0	?	?	
56-003017.0000	**Hassayampa GC (COP Water)**		**0**	0	?	?	
	Type 2 in their Service area in Chino Valley plus potential sub-d						3224
	PLANNING AREA TOTAL		**1**	1	15	1	**3224**
Sedona							
	**** Los Abrigados**	Not in the AMA	**0**	0	?	?	?
	***** Poco Diablo GC**		**33**	33	33	33	33
	PLANNING AREA TOTAL		**33**	33	33	33	**33**
Paulden CDP							
	**** United Metro/Dunbar**	Not in the AMA	**7**	7	7	7	7
	PLANNING AREA TOTAL		**7**	7	7	7	**7**
Big Park CDP							
	Sedona GC	Not in the AMA	**481**	481	481	481	481
	Canyon Mesa GC		**230**	230	230	230	230
	Oak Creek Village GC		**440**	440	440	440	440
	PLANNING AREA TOTAL		**1151**	1151	1151	1151	**1151**
Cornville CDP		Not in the AMA	**0**	0	0	0	**0**

Water Planning Area	Non-Exempt Wells	AMA Right Type	2006 Demand[1]	2050 Demand			
				2006 Status Quo[2]	Non-AMA = status quo, AMA GFRs = allotments[3]	Non-AMA and AMA Type 2s = status quo, AMA GFR Type 1s to AWSC[4]	Non-AMA = status quo, PrAMA 2025 assumptions[5]
			(AF/YR)	(AF/YR)	(AF/YR)	(AF/YR)	(AF/YR)
Lake Montezuma CDP							
*	**B & B Materials**	Not in the AMA	**200**	200	200	200	200
***	**Beaver Creek GC**		**509**	509	509	509	509
	PLANNING AREA TOTAL		**709**	709	709	709	**709**
Ctn-Verde Villages CDP		Not in the AMA	**0**	0	0	0	**0**
Williamson CDP		Not in the AMA	**0**	0	0	0	**0**
Verde CCD							
*	**Out of Africa**	Not in the AMA	**0**	0	0	0	0
***	**Seven Canyons GC**		**276**	276	276	276	276
***	**Sedona National GC**		**414**	414	414	414	414
	PLANNING AREA TOTAL		**690**	690	690	690	**690**
Prescott CCD							
59-561258.0002	**527848 – Camp Tepeyac , Life Teen Inc.**	GIU	**0**	0	10	0	0
	Drake Cement Plant		**0**	0	estimate 8	estimate 8	8
	PLANNING AREA TOTAL		**0**	0	18	8	**8**

Water Planning Area	Non-Exempt Wells	AMA Right Type	2006 Demand[1]	2050 Demand			
				2006 Status Quo[2]	Non-AMA = status quo, AMA GFRs = allotments[3]	Non-AMA and AMA Type 2s = status quo, AMA GFR Type 1s to AWSC[4]	Non-AMA = status quo, PrAMA 2025 assumptions[5]
			(AF/YR)	(AF/YR)	(AF/YR)	(AF/YR)	(AF/YR)
Mingus Mtn. CCD							
**	**Phoenix Cement**		**350**	350	350	350	350
58-111964.0000	**575576 – Heritage Memorial Park**	Type 1	**6**	6	54.7	157.5	
58-111967.0004	**550395 – Fain Family Lmt Part (Quailwood Greens GC)**	Type 1	**344**	344	176.25	881.25	350
58-109214.0001	**202098 - Empire Res. Const.**	Type 2	**0**	0	2.7	0	
59-218233.0000	**558501 – Hanson Aggregate**	Mineral	**0**	0	200	0	
59-585030.0001	**579444 – United Metro Materials**	Mineral	**28**	28	70	28	28
	PLANNING AREA TOTAL		**728**	728	853.65	1416.75	**728**
Humboldt CCD			**0**	0	0	0	**0**
Ashfork CCD		Not in the AMA	**0**	0	0	0	**0**

1. Sources of Water Provider information and 2006 uses are Arizona Corporation Commission Records, Arizona Department of Water Resources – Community Water Plans or Registry of Groundwater Rights, or other existing publications as noted below:
2. All users have the same demand in 2050 as they did in 2006.
3. WPAs outside of the AMA keep status quo. AMA GFRs show their full allotment.

Water Planning Area	Non-Exempt Wells	AMA Right Type	2006 Demand[1]	2050 Demand			
				2006 Status Quo[2]	Non-AMA = status quo, AMA GFRs = allotments[3]	Non-AMA and AMA Type 2s = status quo, AMA GFR Type 1s to AWSC[4]	Non-AMA = status quo, PrAMA 2025 assumptions[5]
			(AF/YR)	(AF/YR)	(AF/YR)	(AF/YR)	(AF/YR)
4. WPAs outside of the AMA keep status quo. AMA GFRs that are a type 1 are converted to AAWS credits. Conversion of Non-Irrigation Type-1 rights to AWSC (without exemption - the parcel was not irrigated 4 of the 6 years prior to 1/1/2000) = # of irrigation acres * 1.5 * (2025 minus Year of Extinguishment). In this example all type -1s extinguish in 2015							
5. WPAs outside of the AMA keep status quo. AMA assumptions developed for the PrAMA assessment were applied. Please see supporting text "CYHWRMS - 2050 Commercial/Industrial Demand based on PrAMA Assessment Assumptions.							
*Data Unavailable – Value assumed to be zero.							
**Data from Verde River Watershed Study ADWR, 2000 Report							
***YCWAC Verde Valley Projection, April 2003							

CYHWRMS – 2050 Commercial/Industrial Demand
based on PrAMA Assessment Assumptions

Background: In the CYHWRMS, 2050 demand has been broken out by the following sectors: Municipal/Domestic, Commercial/Industrial, and Agriculture. Due to this being a future look, the best we can do is look at the past trends as well as what we know is on the horizon to make reasonable assumptions. Since this study has an ADWR defined AMA in it, work developed by AMA staff for the Assessment was reviewed to help in CYHWRMS assumptions. **This paper will only document CHYWRMS assumptions for Commercial and Industrial users which have been identified with Grandfather right numbers** (58s – Irrigation Grandfather Rights, ***Type 1 Non-Irrigation Grandfather Rights, and Type 2 Non-Irrigation Grandfather Right***s), as well as Withdrawal Permits (59 – ***General Industrial Use Permit and Mineral Extraction Permits***). One unique user has also been identified, Asphalt Paving and Supply Inc. who operates with surface water.

Industrial Sector – as described by ADWR

AMA statements

- We do know that there is relatively limited industrial use and it is limited primarily to golf courses and sand and gravel operations. There are some other industrial users that receive water from municipal providers, i.e. Frito Lay in Prescott Valley. Overall, staff believes that much of the future industrial use will either receive water from municipal providers or will use direct delivered effluent or surface water supplies instead of groundwater. (AMA memo – 8/27/2008)
- It is our belief that the majority of future industrial use in the Prescott AMA will not be linked to population, with the exception of sand and gravel operations. It is not anticipated that there will be a linear increase in number of golf courses with population growth. (AMA memo – 8/27/2008)
- For most of the Prescott AMA entities, obtaining LTS credits for effluent is more important than golf courses. The exception is Bond Ranch, a development that is in the very preliminary phases. There has been talk that there will be at least one golf course associated with the Bond Ranch development. (AMA memo – 8/27/2008)
- [The full allotment] proposal is really not feasible, even for a max scenario because there are two large right holders in both the Type 1 and Type 2 categories. With respect to the Type 1, the Bond Ranch at Del Rio Springs holds a right with a 2008 allotment of 1406.13. This equals approximately 69% of the total allotment for Type 1 rights. It is likely that this right will not ever be used in its entirety within the planning period [2025] because the Bond Ranch development will likely not be complete in that time frame. 500 AF of this right was included as a GOLF use in the projections. Examination of the other Type 1's shows that about 150 AF will likely be used for new developments but that growth/demand will fall under the Small Provider demand. There is approximately 100 AF of increased demand that can be attributed to the

remaining Type 1's. With respect to the Type 2's, the City of Prescott holds one large Type 2 with a 2008 allotment of 3169.00 AF which equals approximately 70% of the total Type 2 allotment. It is known that this Type 2 is being held in perpetuity for the Yavapai Prescott tribe and will not be used unless growth dramatically increases on the reservation. Examination of the other Type 2 rights shows a potential for an additional 55 AF that is for new subdivision use that would fall under the Small Provider demand. (AMA memo 3/3/2009)

- With respect to the Mineral Extraction and GIU permits, there really is no allotment cap because new permits can continue to be issued. (AMA memo 3/3/2009)
- Average industrial water use for the time period 2000-2006 is approximately 1,500 AF. If we add an additional golf course at 500 AF and additional S&G at 200 AF, this yields 2,250 AF. In the discussion above, I identified approximately 100 AF of demand that could be attributed to the Type 1's, however, there will likely be approximately 200 AF of demand lost between the three Chino Valley schools moving onto exempt wells as well as Yavapai College. Therefore, 2,250 AF of industrial use seems to be a reasonable projection. (AMA memo 3/3/2009)
- Turf is water applied to an area greater than 10 acres that is not for golf course uses. Review of the uses showed no turf use in Prescott AMA because all cemeteries, memorial park etc. uses are less than 10 acres. Also, no surface water or effluent uses showing up in template because only showing those that have a groundwater right. (AMA memo 3/3/2009)
- The PV sand and gravel that operates solely on surface water is not included because they do not have a gw right. (Letter from Fain 3/9/2009)

AMA projected demand assumptions

- Maintain current golf course use until 2015 and then increase 500 AFA for uses associated with Bond Ranch golf course. Maintain that volume through the planning period. (AMA memo – 8/27/2008)
- Escalate sand and gravel with population in a manner that you're doing for other AMAs as we have no other better estimate. We are currently in the process of approving a mineral extraction permit for 50 years for 250 AFA that should be issued in 2008. (AMA memo – 8/27/2008)
- Include additional regional type parks/turf facilities for each of the municipalities. We anticipate one in Prescott Valley in approximately the 2015 time frame with approximately 350 AFA of landscape irrigation and another in Prescott in the 2018 time frame with approximately 350 AFA of landscape irrigation. Maintain those projections through the planning period. (AMA memo – 8/27/2008)

<u>CYWRMS projected demand assumptions</u>

1. Dewey-Humboldt WPA – Yavapai Land Holding LLC, was Young's Farm. In 2006, the LLC filed paperwork for an Analysis of Assured Water Supply requesting about 700 AF for the development. At this

time the application is still pending. *For CHYWRMS, non-exempt will be held at 22 AF and Yavapai Land will be 700 AF. A total of 722 AF.*

2. Prescott Valley WPA – Maintain Prescott CC GC at 449 AF. The Humboldt USD is a type 2 held by Prescott Valley, it is school landscaping. The AMA determined that regional parks and turf facilities would remain constant until 2015, then about 350 AF should be added for additional landscape/turf. So, for convenience, we could use this type 2 as a placeholder for the 5 AF for the school plus 350 AF = 355 AF. The Fain type 2 rights and associated wells are mixed and matched to meet the Quailwood GC needs. This use is reported on a well that is in the Mingus Mtn. CCD. *For CHYWRMS, non-exempt wells will remain at 6 AF, Prescott CC GC remains at 449 AF, 355 AF will be added for future regional parks and turf facilities, and the Asphalt Paving and Supply Inc averages a use of 96 AF. A total of 906 AF.*
3. Chino Valley WPA – With respect to type 1s this WPA has the most and could carry all the AMA's recommendations. The greatest type 1 allotment is for Del Rio Springs at 1406.13. It is the assumption of the AMA that this community will not be build by the 2025 timeframe. However by 2050, is seems reasonable to that it may. This future development filed a Hydrogeologic Study to ADWR AAWS Program dated 10/2001. In that report the demands for the community were 1406.8 AF for residential, 439.6 AF for commercial, and 2704.0 AF for Irrigation, Golf Course, and Landscape. The total submitted equaled 4550.4 AF. At this time, ADWR has only issued a PAD for 3531.0; note this does not "lock up" the water for this community. Please note that the AMA assumption included 500 AF for a GC. Also, based on AMA examination of the type 1s, about 150 AF will likely be used for new developments. Type 2s are generally small and not considered. *For CYWRMS, it is recommended that we make the assumption Del Rio will be build with a demand at 3500 AF (this includes the GC). An additional 150 AF will also be added to this WPA for the above mentioned PrAMA type 1 assumption. With respect to GIUs and Mineral extraction permits, the AMA held the current use steady but did add in and additional S&G at 200 AF. The GIU/mineral use in 2006 was about 342 AF. This WPA also has a existing nonexempt use of 30 AF. Total equal to 4222 AF in the Chino Valley WPA.*

4. Prescott WPA – With respect to type 2s, the City of Prescott holds one large type 2 with a 2008 allotment of 3169.0 AF which equals approximately 70% of the total type 2 allotment. It is known that this type 2 is being held in perpetuity for the Yavapai-Prescott Tribe and will not be used unless growth dramatically increases on the reservation. When other type 2 are examined, there is potential for an

additional 55 AF this is for a new subdivision. *For CHYWRMS, it is recommended that 3169.0 AF and 55 AF be consider as the 2050 comm/indust. Demand. This WPA has an existing non-exempt use of 7AF. Total equals 3231 AF.* *At this time it is assumed that the 3 GCs in this WPA are already being accounted for in the City of Prescott Municipal System and the demand is housed in the 2050 Muni/Dom.*

5. Prescott CCD WPA – Based on AMA assumptions, GUIs will continue at there current use. *For CHYWRMS, 78 AF for nonexempts, 0 AF for the existing GIU, and 8AF for Drake Cement Plant. Total equals 86 AF.*

6. Mingus CCD WPA – This area will also follow the AMA assumptions for water users who hold a GFR. *For CHYWRMS, nonexempt is 21AF, Phoenix Cement will remain at 350 AF, both type 1 current use is 350 AF, no type 2 use, Hanson's is provided reclaimed water from COP and United Metro used 28 AF in 2006. The total is 749 AF.*

CYHWRMS - Agricultural Demand Method

Discussion: The CYHWRMS needed a method for determining how much agricultural demand was in the study area in 2006. Several documents were available with irrigation acreages and water use. The most recent source of information across the study area was Verde Valley Geospatial Database Project Phase I, by Ross, 2008. This study produced irrigation polygons that had been corrected and simplified from ADWR, 2000 with high-resolution orthorectified aerial photography. In review of this publication it was recognized that the author did not have the manpower to update the 1997 crop codes. In order to do this, ADWR GIS was contacted and NVDI (Normalized Difference Vegetation Index) was performed on a Landsat 5 (2006) satellite image. The first two sets were developed for July and September 2006. When these datasets were shared with the CYHWRMS Ag subgroup, they noticed that the numbers were noticeably low in the Verde Valley. It was determined that the NDVI needed to be set to a finer scale to identify more than just the AG. It needed to pick up the OT Irrigation (irrigation done as pasture around homes, and other small uses of ditch water) shown in ADWR, 2000. Results shown in the "CHYWRMS Irrigated Acres and Irrigation Demand" table (*filename: CYHWRMS_s_AG Acres and Demand Table_11-18-09*) were compiled as follows:

NDVI_July 2006 (adjusted scale) – VV only
The NDVI technique was run a second time. July 2006 Landsat imagery was used again and the NDVI was set to a finer scale. This method also picked up GCs and ballparks. Since a type column was included in the dataset these could be removed because the majority were already had their demands documented with an non-exempt well or as part of a municipal system.

ADWR, 2000
The column titled "Major Crop" was used for querying purposes and the codes for FA=fallow, NA=not applicable and NC=no crop were removed. This data set was only used for comparison.

YCWAC, 2003 – BIC only
The column titled "Investi" was set equal to irrigated or not investigated. Then any fields identified to be in subirrigated areas were removed.

For Irrigation demand to be determined the above three data sets were multipled by the Total Weighted Water Duty as shown in ADWR, 2000. Williamson Valley = 4.0 AF/Acre, Big Chino including Walnut Creek = 4.0 AF/Acre, and Middle Verde = 3.15 AF/Acre.

Little Chino/Upper Agua Fria 2006 (PrAMA)
This portion of the study is the Prescott AMA, where AG uses supplied by groundwater are reported annually. Two areas of AG, supplied by SW were reviewed. This volume was also included in the table. *(filename: CYHWRMS_s_PrAMA AG Demand with SW_11-18-09)*

Data Sources:

1. For determining irrigated acres:
    a. ADWR, 2000

b. YCWAC, 2003
c. NDVI (finer scale) on LandSat 5 imagery (2006)
d. 2006 ADWR PrAMA annual reports

2. For determining volume to apply to the irrigated acres: Verde River Watershed Study, ADWR, 2000. Tables 3-12, 3-13 and 3-16.

TABLE 3-12

WILLIAMSON VALLEY CURRENT CROPPING PATTERNS

CROP	TOTAL WEIGHTED WATER DUTY (AF/AC)	ACRES	PERCENT OF IRRIGATED LAND	CALCULATED WATER SUPPLIED ANNUALLY (ACRE-FEET)
Alfalfa	4.00	61	4.7	244
Pasture		1,190	91.4	4,760
Orchard		23	1.80	92
Vegetables		25	1.9	100
Nursery Trees		2	0.25	8
Total		**1,302**	**100.00**	**5,204**

TABLE 3-13

BIG CHINO VALLEY CURRENT CROPPING PATTERN (INCLUDES WALNUT CREEK)

CROP	TOTAL WEIGHTED WATER DUTY (AF/AC)	ACRES	PERCENT OF IRRIGATED LAND	CALCULATED WATER SUPPLIED ANNUALLY (ACRE-FEET)
Alfalfa	4.00	303	12.2	1,212
Pasture		275	11.1	1,100
Corn		1,357	54.7	5,428
Turf/Landscaping		58	2.3	232
Vegetables		488	19.7	1,952
Total		**2,481**	**100.00**	**9,924**

TABLE 3-16

MIDDLE VERDE CURRENT CROPPING PATTERNS

CROP	TOTAL WEIGHTED WATER DUTY (AF/AC)	ACRES	PERCENT OF IRRIGATED LAND	WATER SUPPLIED ANNUALLY (ACRE-FEET)
Alfalfa	3.15	301	5.60	948
Pasture		3,621	67.30	11,406
Corn		81	1.50	255
Turf/Landscaping		1,081	20.10	3,405
Vegetables		97	1.80	306
Orchard		200	3.70	630
Total		**5,381**	**100.00**	**16,950**

CHYWRMS Irrigated Acres and Irrigation Demand

	Data Source One		*Data Source Two*		*Data Source Three*		*Data Source Four*
	NDVI_July 2006 (adjusted scale) - VV only	**Irrigation Demand for NDVI - VV only[a]**	**ADWR, 2000**	**Irrigation Demand for ADWR, 2000[a]**	**YCWAC, 2003-BIC only**	**Irrigation Demand for YCWAC-BIC only[a]**	**Little Chino/Upper Agua Fria 2006 (PrAMA)[b]**
WPA	Sum acres	Acre-Feet	Sum Acres	Acre-Feet	Sum Acres	Acre-Feet	Acre-Feet
Ashfork CCD			1,694	6,776	699	2,796	
Camp Verde	2,959	9,320	2,738	8,625			
Chino Valley			3,110	12,440			1,691
Clarkdale	10	31	189	595			
Cornville	896	2,823	693	2,183			
Cottonwood	361	1,137	418	1,317			
Humboldt CCD	241	759	315	992			
Lake Montezuma	170	537	234	737			
Mingus Mtn CCD	155	487	193	608			
Paulden			283 (BIC), 140 (LIC)	1132(BIC),560 (LIC)	192	768	578
Prescott			2	8			375*
Prescott CCD			2322 (BIC), 103 (LIC)	9288(BIC), 412(LIC)	1,190	4,760	176
Prescott Valley							55
Sedona	88	278	61	192			
Dewey-Humboldt							569
Verde CCD	420	1,322	500	1,575			
Verde Village	357	1,124	362	1,140			
TOTAL STUDY Irrigated Acres			7,738				
TOTAL STUDY Irrigation Demand (AF)[a]				29,586			
TOTAL BIG CHINO Irrigated Acres			4,299		**2,081**		
TOTAL BIG CHINO Irrig. Demand (AF)[a]				17,196		**8,324**	
TOTAL VERDE VLY Irrigated Acres	**5,657**		5,703				
TOTAL VERDE VLY Irrigation Demand (AF)[a]		**17,818**		17,964			
Total PrAMA 2006 Irrigation Demand (AF)[a]			3,355	13,420			**3,444**

[a]Irrigation Demand will be determined by multiplying the acres by the Total Weighted Water Duty as determined by basin in ADWR, 2000 (except for the PrAMA). Big Chino including Walnut Creek = 4.0 AF/Acre, Williamson Valley = 4.0 AF/Acre, and Middle Verde = 3.15 AF/Acre.

[b]Groundwater pumping associated with IGR in the Prescott AMA (Little Chino and Upper Agua Fria subbasins) is reported annually to ADWR. Those reported volumes will be applied to those subbasins in the study. IGR allotments are legally available for AG purposes. They are not available for municipal/domestic use until they are extinguished or converted.

[*]TWG members were aware of AG associated SW uses. Surface water use is not reported to ADWR. AG at both Del Rio Springs and Granite Dells Ranch were reviewed. Based on imagery and stream gage information, it was determined that irrigation associated with Del Rio springs would not be included on the table. Granite Dells Ranch surface water use would be included based on imagery and confirmation from City of Prescott that they deliver 375 AF/year. COP stated that they have records to that effect from

Leslie Graser

From: Leslie Graser
Sent: Friday, November 13, 2009 1:16 PM
To: 'Meyers, Leslie A'
Subject: FW: Asphalt Paving and Supply - 2006 demand....looking for the 96 = 2050 demand
Attachments: AsphaltPavingAndSupply_2006_SWuse.PDF

Okay, I got the answer for 2050 = 96 AF for the AP&S company. I just took an average (of the years they reported use) in the attached letter and kept them using the same volume. The AMA did not speak to them declining or going away by 2025.

LG

Leslie Graser, Hydrologist
ADWR Regional Strategic Planning
2200 E. Hillsdale Rd.
Prescott, Arizona 86301-4941
ph: 928-778-7202
fax: 928-776-4507
lfgraser@azwater.gov

From: Leslie Graser
Sent: Friday, November 13, 2009 1:09 PM
To: 'Meyers, Leslie A'
Subject: Asphalt Paving and Supply - 2006 demand....looking for the 96 = 2050 demand

Leslie Graser, Hydrologist
ADWR Regional Strategic Planning
2200 E. Hillsdale Rd.
Prescott, Arizona 86301-4941
ph: 928-778-7202
fax: 928-776-4507
lfgraser@azwater.gov

Surface Water for Template

FAIN FAMILY LTD. PTN.
NORMAN W. FAIN II & NANCY L. FAIN R.T.

3001 Main Street, Ste. 2B
Dewey, AZ 86327
(928)772-8844

March 9, 2009

RECEIVED
MAR 20 2009
Prescott AMA

Mr. Jack McCormack, Director
Prescott AMA
Arizona Dept. of Water Resources
2200 E. Hillsdale, Ste. A
Prescott, AZ 86301

Dear Mr. McCormack:

Please accept this letter as notification of water received or diverted from the following decreed and appropriated surface water rights:

CWR 1587	3R - 373.0001 & 4A - 1483.0001
CWR 1588	3R - 484.0001

The surface water received was measured through a weir and was used by Asphalt Paving and Supply, Inc., for mineral extraction purposes.

2001	240.85 AF received
2002	No water received
2003	66.19 AF received
2004	50.37 AF received
2005	54.36 AF received
2006	126.39 AF received
2007	67.61 AF received
2008	62.75 AF received

Yours very truly,

Norman W. Fain II

Norman W. Fain II

NWF:cf

Source: ADWR, 2000 for Big Chino Subbasin
pg 1 of 3

and surface water inflow and outflow components were identified and evaluated for budget analysis in each sub-basin. The water budget components were compiled from field measurements, reported data, ADWR databases, numerous reports, and calculated estimates. The Big Chino has not been studied extensively and consequently there is a limited amount of current information and data available for regional precipitation, streamflow data, and groundwater conditions. The Little Chino sub-basin was recently reviewed and evaluated by ADWR in the Preliminary Determination Report on the Safe-Yield Status of the Prescott Active Management Area, dated August 28, 1998. The water budget in the Safe-Yield status report showed the Little Chino to be in an overdraft condition due to the outflows exceeding the inflows. The components of their 1997 budget are discussed in the section of this chapter that describes the Little Chino sub-basin.

Sub-Basin Water Budgets

Reach 1 - Big Chino Sub-basin to the Verde River near Paulden

For the period of record studied, the Big Chino sub-basin may have been in a near equilibrium condition and for budgetary purposes that assumption has been made. However, it is possible that were additional water level, gaging data, and recharge estimates available we might in fact find a non-equilibrium condition. The components of the Big Chino water budget are as follows:

Big Chino Sub-basin Water Budget (1997)
Figures based on 1996 and 1997 calculated data and estimates.

Inflows	
Natural Recharge	
Mtn. Front & Streams	15,700 AF
Underflow from Little Chino	1,500 AF
Unmeasured Tributary Flows, Groundwater and Springs	9,560 AF
	26,760
Incidental Recharge	
Agriculture	7,570 AF
Industrial	100 AF
Septic	340 AF
Total Inflows	**34,770 AF**

C:\HWRMS_s_Budget Reference Docs_11-18-09

Source: ADWR, 2000
Pg 2 of 3

Outflows

Natural Discharge

Verde near Paulden	19,050 AF

Groundwater Pumpage

Small Providers	140 AF
Domestic (Exempt) Wells	250 AF
Agriculture	15,130 AF
Industrial	200 AF

15,720

Total Outflows	**34,770 AF**

Change in Groundwater Storage = Inflows – Outflows:
0 AF = 34,770 AF – 34,770 AF.

The inflows for this reach of the study area consist of the gaging station at Williamson Valley Wash near Paulden, the gaging station at Walnut Creek near Ash Fork, natural recharge from mountain fronts and streams, recharge from agriculture and septic systems, unmeasured tributary flows, groundwater, and springs.

The inflow components that contribute to the groundwater supply in the Big Chino are comprised of incidental and natural recharge, unmeasured streams, and springs. Incidental recharge is the estimated excess water that has returned to the aquifer from agriculture, industrial uses, and septic recharge. Natural recharge is the mountain front recharge and streamflow that infiltrates to the aquifer as a result from precipitation and snowmelt. Incidental recharge from agriculture was estimated to be 7,570 acre-feet per year, based upon estimates of irrigated acres, the consumptive use value for the irrigated crops, and the estimated irrigation efficiency described in Chapter 3, Section 3. Industrial recharge was estimated to be 100 acre-feet per year based on an estimate of pumpage by the users. Septic recharge was estimated at 340 acre-feet per year. Natural recharge from mountain front runoff and streamflow was estimated to be 15,700 acre-feet per year based on the best available, average annual, streamflow data. A tentative analysis of natural recharge based on the median annual flow resulted in estimates that ranged from 7,500 to 8,500 acre-feet, depending upon the estimated watershed area and the amount of precipitation (Chapter 4, Section 4.2). The volume of unmeasured streams, springs, and groundwater is assumed to be the residual component of inflow in the Big Chino water budget and was added in to balance the difference between the total outflows and total inflows. This was determined after total inflow and outflow components were calculated. Unmeasured waters, the residual component in the Big Chino, were estimated to be about 9,560 acre-feet.

Source: ADWR, 2000
pg 3 of 3

This number may include higher than realized estimates of natural and incidental recharge. The total inflows (34,770) less unmeasured waters (9,560) in the Big Chino sub-basin were estimated to be approximately 25,210 acre-feet.

The outflows for this reach of the study area are separated into surface water and groundwater. The surface water outflows include the Verde River flows recorded at the USGS gaging station near Paulden and agriculture. A normalized annual budget for the period 1990-1996, excluding 1993, was used to calculate the average annual surface water outflows exiting the Big Chino at the Paulden gaging station. Average annual outflows for this period were 19,050 acre-feet. Groundwater outflows also include agriculture, municipal/industrial, and domestic wells. Estimated groundwater pumpage was obtained from surveys and records from the Abra Water Company, Ashfork Water Service, Granite Mountain, and Inscription Canyon Ranch, as described in Chapter 3, Section 3.2. The estimated total municipal outflow for 1997 is 140 acre-feet. Agriculture demand for groundwater and surface water was estimated to be approximately 15,130 acre-feet, based on estimates of irrigated acres and the estimated crop consumptive use described in Chapter 3, Section 3.4. Domestic use was estimated to be 250 acre-feet for approximately 990 domestic wells registered in the ADWR Wells Registry database. Industrial water use for sand and gravel operations was estimated to be 200 acre-feet per year, based on pumpage estimates provided by the users. The estimated total outflow in 1997 for the Big Chino sub-basin was 34,770 acre-feet.

Based on available data and taking into consideration an estimated 9,560 acre-feet of unmeasured tributary flow, groundwater, springs, and/or higher estimates of natural and incidental recharge, there appears to be no change in groundwater storage in the Big Chino.

Reach 2 - Little Chino Sub-basin to the Verde River near Paulden

The Verde River Watershed Study compiled the Little Chino sub-basin water budget based on 1997 data and on data presented by ADWR in the 1998 Report on the Safe-Yield Status of the Prescott AMA. Modifications from the original Safe-Yield Report were a result of the availability of additional data. The Little Chino sub-basin water budgets in the Safe-Yield Status Report and in this study both indicated that outflows exceeded inflows and there was an overdraft condition. The components of the 1997 Little Chino sub-basin water budget for this study were as follows:

Source: Blasch, 2006 pg 1 of 1 for Big Chino + Verde Vly

Table 22. Average annual water budgets for regional aquifers in the upper and middle Verde River watersheds, central Arizona, 1990–2003

[Values are in acre-feet per year. Negative values indicate water is removed from or leaves the subbasin. Terms in parentheses refer to terms in water-budget equations. Terms in brackets are estimated error as ± percent. Detailed annual water budgets are included in appendix 9; NC, not calculated]

Water-budget component	Big Chino subbasin	Little Chino subbasin[1]	Verde Valley subbasin
Total inflow	**30,300**	**12,620**	**167,470**
Base flow in[2] (BF_{in})	[2a]180[0.23]	0	17,900[0.23]
Natural recharge[3] (R)	23,420	5,070	130,270
Incidental and artificial recharge[4] (IR)	4,300	7,550	[4a]19,300
Ground water in[5] (GW_{in})	[5a]2,400	0	NC [5b]
Total outflow	**-30,300**	**-16,720**	**-167,470**
Agricultural irrigation[6] (WU)	-7,900	-4,900	-120
Agricultural subirrigation	[7]-3,400[25]	0	0
Domestic (WU)	-300	-1,300	-1,900
Water providers	-200	-6,600	-7,800
Golf course irrigation (WU)	-30	0	-1,500
Industrial use (WU)	-10	-140	-1,150
Base flow out[8] (BF_{out})	-17,900[0.23]	[8a]-1,800[1]	[8b]-144,100
Vegetation evapotranspiration[9] (ET)	-560	[9a]0	[9b]-10,800
Ground water out[10] (GW_{out})	NC[10a]	[10b]-1,980	[10c]-100
Change in storage (ΔS)	**NC**	[11]**-4,100**	**NC**

[1]The Little Chino subbasin is considered a tributary subbasin to the Big Chino subbasin.

[2]Base-flow separation calculated by using HYSEP; 14-year average values (1990–2003).

[2a]Base flow from Del Rio Springs minus diversions, channel infiltration, and evapotranspiration.

[3]Natural recharge is estimated as a residual in this equation. Includes components such as mountain-block, mountain-front, basin, and channel recharge. This value does not consider storage losses in the system.

[4]Calculated on the basis of incidental recharge factors and water use; 14-year average values (1990–2003).

[4a]Includes recharge from diverted surface water applied as irrigation.

[5]14-year average values (1990–2003).

[5a]Nelson (2002) simulated 1,800 acre-ft/yr of ground-water flow from the Little Chino subbasin to the Big Chino Subbasin. About 600 acre-ft/yr is derived from recharge of base flow downstream from the streamflow-gaging station at Del Rio Springs. This value was applied to the conceptual budget for 1990–2003. Possible ground-water inflow on the northern boundary of the subbasin not calculated.

[5b]Ground-water inflow that may occur along the Mogollon escarpment not calculated.

[6]Ground-water use values detailed in appendix 9; 14-year average values (1990–2003).

[7]Includes approximately 3,400 acre-ft of water evapotranspired from subirrigated agriculture.

[8]Base-flow separation calculated by using HYSEP; 14-year average values (1990–2003).

[8a]Base flow from Del Rio Springs including diversions, channel infiltration, and evapotranspiration.

[8b]Base-flow values based only on winter base-flow values.

[9]Calculated by using gaging-station data and HYSEP base-flow separation; 43-year average values (1961–2003).

[9a]Evapotranspiration near Del Rio springs is included in base flow out.

[9b]Sum of Wet Beaver Creek, West Clear Creek, Oak Creek, and Verde River near Camp Verde.

[10]14-year average values (1990–2003).

[10a]Ground-water flow out of the subbasin through the northern boundary not calculated.

[10b]Nelson (2002) simulated 1,800 acre-ft/yr of ground-water flow from the Little Chino subbasin to the Big Chino Subbasin. This GW_{out} value includes the water that leaves the Little Chino subbasin as base flow from Granite Creek. Wirt and others (2005) reported a base flow of 360 acre-ft/yr; however, the base flow can vary. In order to determine the flows across the subbasin boundary, the Arizona Department of Water Resources did a Zone Budget (Harbaugh, 1990) analysis of the 1998 model results (Frank Corkhill, hydrologist, Arizona Department of Water Resources, written commun., 2005).

[10c]Ground-water flow out of the southern boundary calculated. Ground-water flow out of the northern and eastern boundaries not calculated.

[11]Nelson (2002) simulated an average 4,000 acre-ft/yr of ground-water storage change from 1990 to 2003.

Source: ADWR, 1999 pg 1 of 1 for PrAMA

Prescott Active Management Area 1990-1997 Groundwater Budget

Table 2

	1990	1991	1992	1993	1994	1995	1996	1997	Avg
GROUNDWATER DEMAND									
MUNICIPAL GROUNDWATER WITHDRAWALS	**8289**	**8667**	**8756**	**9595**	**10044**	**10303**	**11635**	**11594**	9,860
City of Prescott	5014	5221	5056	5633	5656	5664	6352	6509	
Shamrock Water Company	1795	1854	2019	2232	2615	3010	3439	3353	
Small Provider	279	335	364	464	493	463	537	521	
Exempt Wells	1201	1257	1317	1266	1280	1166	1307	1211	
AGRICULTURAL GROUNDWATER WITHDRAWA	**6032**	**5943**	**4613**	**6460**	**6134**	**5316**	**6629**	**6260**	5,923
Irrigation Grandfathered Rights	6032	5943	4613	6460	6134	5316	6629	6260	
INDUSTRIAL GROUNDWATER WITHDRAWALS	**444**	**486**	**443**	**500**	**533**	**555**	**688**	**626**	534
Turf Facilities	349	399	313	343	357	391	502	434	
Non-Turf Facilities	95	87	130	157	176	164	186	192	
NATURAL SYSTEM DISCHARGES	**4850**	**4850**	**4850**	**4850**	**4850**	**4850**	**4850**	**4850**	Σ = 16,317
Del Rio Springs Underflow from AMA	1500	1500	1500	1500	1500	1500	1500	1500	
Del Rio Springs Baseflow from AMA	2100	2100	2100	2100	2100	2100	2100	2100	
Upper Agua Fria Baseflow from AMA	1250	1250	1250	1250	1250	1250	1250	1250	
GROUNDWATER RECHARGE									
INCIDENTAL RECHARGE	**4578**	**8128**	**7640**	**9744**	**4512**	**7988**	**4942**	**4651**	
Agricultural Incidental Recharge	2413	3396	2756	3967	2875	4053	2906	2669	
CVID Canal Losses	0	2548	2277	3449	1053	3001	635	412	
Industrial Incidental Recharge	35	56	48	56	53	59	72	60	
Effluent Discharged into Agua Fria	0	0	0	0	531	875	1329	1510	
Effluent Recharged with No Credits	2131	2128	2559	2272	0	0	0	0	
NATURAL SYSTEM RECHARGE	**4600**	**4600**	**4600**	**23320**	**4600**	**8920**	**4600**	**4600**	7,480
Upper Agua Fria Natural Recharge	2550	2550	2550	2550	2550	2550	2550	2550	
Little Chino Natural Recharge	2050	2050	2050	2050	2050	2050	2050	2050	
Granite Creek Flood Recharge	0	0	0	18720	0	4320	0	0	
CHANGE IN STORAGE									
TOTAL GROUNDWATER DEMAND	19615	19946	18662	21405	21561	21024	23802	23330	14,003
TOTAL GROUNDWATER RECHARGE	9178	12728	12240	33064	9112	16908	9542	9251	
TOTAL GROUNDWATER OVERDRAFT	**-10437**	**-7218**	**-6422**	**11659**	**-12449**	**-4116**	**-14261**	**-14079**	
City of Prescott Effluent Recharge Credits	0	0	0	0	1940	2098	1688	2270	
CHANGE IN GROUNDWATER STORAGE	**-10437**	**-7218**	**-6422**	**11659**	**-10509**	**-2018**	**-12573**	**-11809**	

Arizona Department of Water Resources Hydrology Division. For further information see Arizona Department of Water Resources Preliminary Determination Report on the Safe-Yield Status of the Prescott Active Management Area, August 28, 1998, Appendix C, Exhibit 1 for Prescott Active Management Area Water Budget which includes renewable supplies (surface water and effluent), as well as a list and discussion of assumptions and references used in developing this budget.

Source: ADWR, 2009 (memo) pg 1 of 1 for PrAMA

Year: Period (yrs)	MFR (acre-feet/year)	Flood Recharge (acre-feet/year)			Total (acre-feet/year)
		Granite Creek	Agua Fria/ Lynx Creek	Mint Wash	
1940-1977: 38 yrs	5,800	0	0	0	5,800
1978	5,800	4,320	780	49	10,949
1979	5,800	0	0	0	5,800
1980	5,800	6,240	1,120	71	13,231
1981-1982: 2 yrs	5,800	0	0	0	5,800
1983	5,800	1,920	350	22	8,092
1984-1992: 9 yrs	5,800	0	0	0	5,800
1993	5,800	18,720	3,370	213	28,103
1994	5,800	0	0	0	5,800
1995	5,800	4,320	780	49	10,949
1996-2002: 7 yrs	5,800	0	0	0	5,800
2003	5,800	850	0	0	6,650
2004	5,800	0	0	0	5,800
2005	5,800	18,690	2,850	185	27,525
2006-2007: 2 yrs	5,800	0	0	0	5,800
2008	5,800	4,800	740	54	11,394
Average 1940-2008	**5,800**	**868**	**145**	**9**	**6,822**
No. of years: 69		**1,022**			
[1]Average 1978-2008	**5,800**	**1,931**	**322**	**21**	**8,074**
No. of years: 31		**2,274**			
Total/Sum (AF)	**400,200 AF**	**59,860 AF**	**9,990 AF**	**643 AF**	**470,693 AF**
1940-2008		**70,493 AF**			

[1]Assumed to be a more reliable estimate of flood recharge based on correlation of high-flow events to nearby streamflow gauge, active since 1963; see text above. Long-term average precipitation records show little difference between 1940-1977 (18.0") and 1978-2004 (18.1"), Arizona Climate Summary (2009) {Note - years with missing precipitation periods were omitted from statistics}. The number of significant digits presented for the different recharge categories above, does not necessarily reflect the reliability of the recharge rates.

Conclusion and Future Recharge Estimates

The average long-term (natural) recharge rate for the LIC and UAF sub-basins in the Prescott AMA was estimated to be 6,820 acre-feet/year for the period between 1940 and 2008. Another long-term recharge rate, based on a shorter - yet more reliable - streamflow record (1978-2008), was estimated to be 8,070 acre-feet/year. While it is appropriate to consider ranges of natural recharge due to uncertainty and climatic variability, if a single (long-term) natural recharge rate is required, the more recent estimate of 8,070 acre-feet/year is better supported by available data.

Although quantifying natural recharge is inherently difficult, the MFR and flood recharge rates listed herein represent the best estimates to date, based on available data and modeling analysis. In the future the ADWR hopes to improve estimates (and quantify the uncertainty) of natural recharge through both model calibration and data acquisition. Historic estimates of flood recharge may also be re-examined for both model calibration purposes, and to provide recharge information for projective purposes. For example streamflow data exists along the Upper Agua Fria near Mayer which could potentially be used to infer flood recharge, prior to the mid-1960s. See below. It is hoped that a better understanding of the

Source: Timmons, 2006 pg 1 of 1 for PrAMA + mint wash

Table 10
Simulated Transient Water Budgets for the Updated Prescott AMA Groundwater Flow Model (1999-2004)
(Figures rounded to the Nearest 100 acre-feet)

	Inflow	Simulated 1999 AF/YR	Simulated 2000 AF/YR	Simulated 2001 AF/YR	Simulated 2002 AF/YR	Simulated 2003 AF/YR	Simulated 2004 AF/YR
Avg 5,800	Natural Recharge[1]	5,800	5,800	5,800	5,800	5,800	5,800
	Recharge: Incidental and Artificial Recharge[2,3,4]	6,000	7,800	7,400	6,400	7,200	7,600
	Flood Recharge[5]	0	0	0	0	900	21,700
16,633	**Total Inflow**	**11,800**	**13,600**	**13,200**	**12,200**	**13,900**	**35,100**
	Outflow	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
	Pumpage[6]	18,100	20,600	21,100	23,800	21,500	23,000
	Del Rio Springs (LIC)[7]	1,700	1,700	1,600	1,500	1,400	1,300
	Agua Fria River (UAF)[7]	1,300	1,300	1,300	1,200	1,200	1,400
	Subsurface Flow (LIC)[7]	1,700	1,500	1,500	1,400	1,600	1,400
	Total Outflow	**22,800**	**25,100**	**25,500**	**27,900**	**25,700**	**27,100**
	Change in Storage	**-11,000**	**-11,500**	**-12,300**	**-15,700**	**-11,800**	**8,000**

[1] Estimates for long-term average mountain front recharge (Nelson, 2002). Actual annual volumes may vary significantly from the long-term average.

[2] Incidental agriculture recharge estimated at 50% of agricultural water use. (Corkhill and Mason 1995) (Nelson 2002).

[3] City of Prescott artificial recharge includes treated effluent and surface water. City of Prescott Annual Underground Storage Facility Reports - Schedule 71.

[4] Town of Prescott Valley artifical recharge data provided by John Munderloh - Town of Prescott Valley (09/27/2006)

[5] Flood recharge for Granite Creek, Lynx Creek and Mint Wash estimated based on wetted-area approach (Nelson 2002). Flood recharge for 2003 was simulated based on a release from Watson Lake into Granite Creek (ADWR 2004). Other drainages were not affected.

[6] Pumpage includes reported pumpage from ADWR Registry of Groundwater Rights Database as well as estimated domestic and exempt well pumpage for the active model area. See pumpage section of this report for further details.

[7] Model simulated discharge.

[8] Flood recharge includes flooding from January - March 2005

Source: ADWR, 2000 pg 1 of 5 for Verde Vly

CHAPTER 5: WATER BUDGET ANALYSIS

5.1 INTRODUCTION

The purpose for developing a water budget is to evaluate the hydrologic components of a watershed, such as inflows, outflows, and change in groundwater storage. Through analysis of these components, determinations regarding their relative importance and the impacts they have on each other and on the system as a whole can be made. This type of analysis also helps in understanding the relative certainty or uncertainty of each component.

To better understand the dynamics of the hydrologic system, particularly to help address the difficult questions of the effect of pumping and the timing and location of diversions and return flows, the preliminary water budgets developed in this report will ultimately need to be more detailed and cover a longer period of time.

A balanced water budget for a regional aquifer occurs when there is no net change in the amount of water stored and the inflows equal the outflows. The *Upper Verde River Area* report, written in 1983 by Owen-Joyce and Bell, included a water budget that focused on a portion of the study area referred to in this report as the Middle Verde (Verde River near Clarkdale to the Verde River near Camp Verde). Their water budget was based on the assumption that the inflows and outflows of the system were in balance, with no change in storage for the regional aquifer. The components of the water budget section of their report were as follows:

Owen-Joyce & Bell Water Budget (1983)

Inflows		
1-	Infiltration of precipitation and streamflow	169,000 AF
2-	Baseflow of the Verde River near Paulden	16,000 AF
	Total Inflows	**185,000 AF**
Outflows		
1-	Baseflow of Verde River near Camp Verde	80,000 AF
2-	Fossil Springs	31,150 AF
3-	Evapotranspiration	35,000 AF
4-	Irrigation- Consumptive Use	31,000 AF
5-	Groundwater Withdrawal	8,000 AF
	Total Outflows	**185,000 AF**

74,000

Source: ADWR, 2000 pg 2 of 5 for Verde Vly

In the Owen-Joyce and Bell water budget, the inflow component of precipitation and streamflow accounted for all flows into the Verde River. This component was derived by first determining the total outflows, and then computing the recharge percentage needed to balance the system, which compared favorably with the 8 percent recharge factor that was originally developed and proposed by Twenter and Metzgers in 1963. Fossil Springs was treated as an outflow because the mouth of the spring was outside the study area, but the contribution to the system was taken into account through the precipitation and streamflow component.

For the current report, the water budget study area is divided into two regions: 1) the Upper Verde, which is comprised of the area above the USGS gaging station #09503700 (Verde River near Paulden) including Williamson Valley and Big and Little Chino Valleys; and 2) the Middle Verde, which encompasses the area between the USGS gaging station #09503700 to the gaging station #09508500 (Verde River below Tangle Creek).

The Upper Verde water budget was divided into two sub-budgets: the Big Chino and Little Chino sub-basins. The annual water budget for the Upper Verde River Watershed discussed in this section includes the amounts of water recharged to and withdrawn from the aquifers of the Big Chino and Little Chino. The inflow and outflow components of the groundwater budget for the Big and Little Chino sub-basins upstream of the USGS stream gage on the Verde River near Paulden were determined from area streamflow data, precipitation data, studies and reports, field investigations, water use data analysis, and estimates of groundwater and surface water conditions. Figure 5.1 shows components that are representative of the water budget for the Upper Verde region.

For the Middle Verde, this study developed a number of water budgets in order to explore the behavior of the hydrologic system on an annual and seasonal basis and during wet and dry years. In order to concentrate on the area with the highest demands, the Middle Verde section was examined from the USGS gaging station #09504000 (Verde River near Clarkdale) to the USGS gaging station #09506000 (Verde River near Camp Verde), labeled Reach 2. Two additional sub-budgets were developed for the reaches between the USGS gaging stations #09503700 (Verde River near Paulden) and #09504000 (Verde River near Clarkdale), labeled as Reach 1, and the USGS gaging stations #09506000 (Verde River near Camp Verde) to the USGS gaging station #09508500 (Verde River below Tangle Creek), labeled as Reach 3.

For the Middle Verde, a normalized budget for each reach was developed in order to calculate seven-year averages. Seasonal water budgets and annual water budgets were

Source: ADWR, 2000 pg 3 of 5 for Verde Vly

developed to explore the system behavior. The seasonal water budgets were designed to reflect the month to month changes in water availability and demand due to agriculture and municipal use as well as seasonal streamflow fluctuations. The annual budget reveals the total yearly water usage based upon the inflows and outflows of the system and is essential in evaluating long-term effects to the overall water budget and groundwater storage in particular.

Seasonal and annual water budgets were developed for the years 1992 and 1996 for the Middle Verde region. The year 1992 was a wet year, with monthly precipitation levels consistently greater than the 30-year monthly average precipitation levels. The year 1996 was considered a drought year, with monthly and annual precipitation totals having been lower than the 30-year monthly and annual precipitation averages. Both seven-day low flow and total flow analyses of the main budget, as well as the two sub-budgets, for both 1992 and 1996, were prepared for this report. Seven-day low flows were used as surrogates for baseflows, although they are influenced somewhat by precipitation. Figure 5.2 lists the components that comprise the water budget for the Middle Verde region.

The annual and seasonal budgets, as well as the normalized budget for all three reaches, were presented in the following format:

- 1992 - 7 Day Low Flow
- 1992 - Total Flow
- 1996 - 7 Day Low Flow
- 1996 - Total Flow

5.2 UPPER VERDE WATER BUDGET

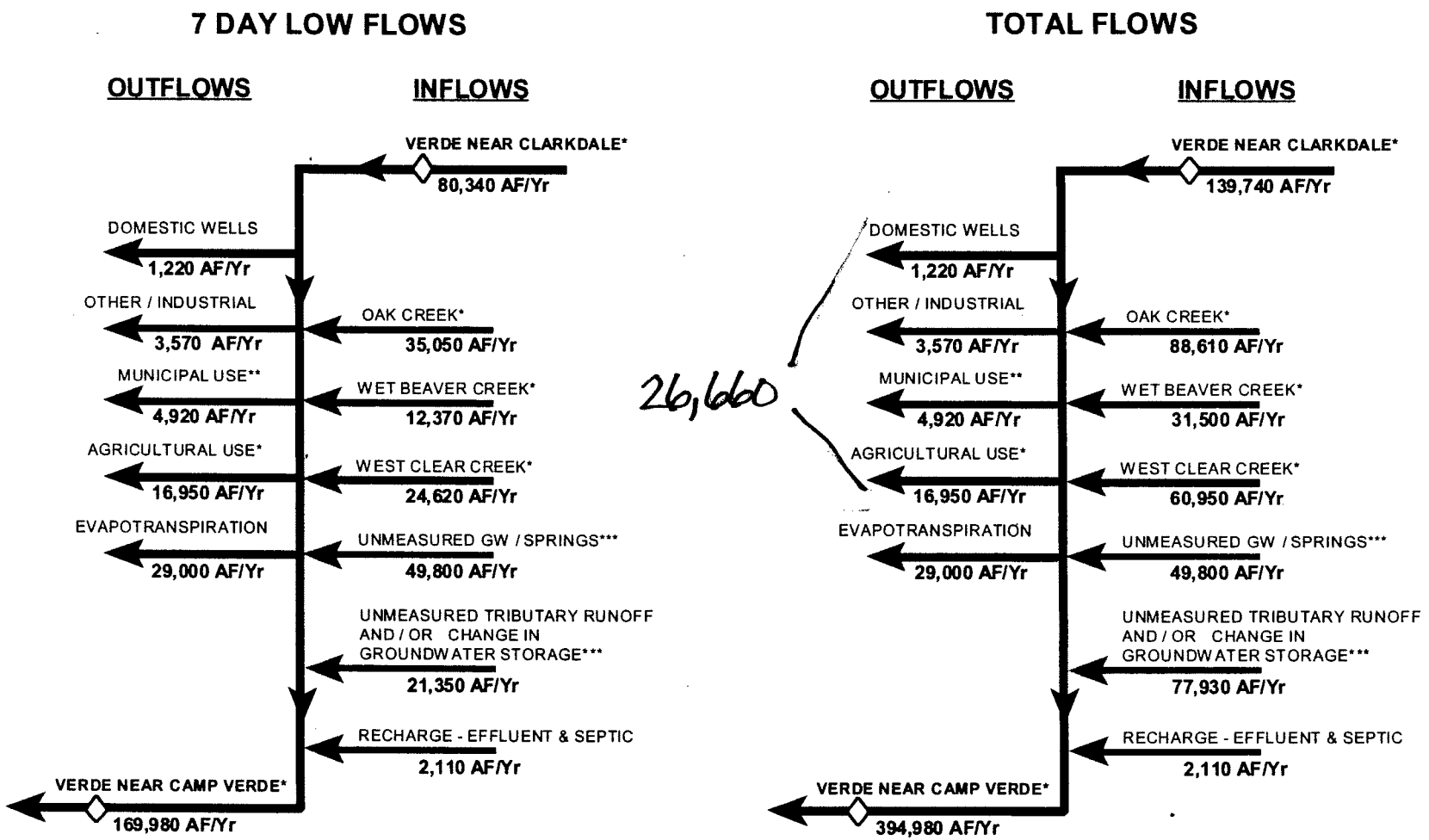
Introduction

The Upper Verde section of the study area was divided into two sub-budget sections: Reach 1 - the Big Chino sub-basin that includes Big Chino Wash, Williamson Valley and Walnut Creek; and Reach 2 - the Little Chino sub-basin that includes Granite Creek and Little Chino Wash. The annual water budgets were compiled using yearly totals of inflows and outflows for each sub-basin.

The Big Chino and Little Chino groundwater budgets are based on the best available data for a one-year analysis of the water demands and supplies between 1996 and 1997. Groundwater

Source: ADWR, 2000 pg 4 of 5 for Verde Vly

Figure 5.7 - 1992 Wet Year - Reach 2: Verde River Near Clarkdale to Verde River Near Camp Verde, 7 Day Low and Total Flows.



TOTAL OUTFLOWS = 225,640 AF/Yr TOTAL INFLOWS = 225,640 AF/Yr

NET GAIN IN REACH: 169,980 - 80,340 = 89,640 AF/Yr

89,640 AF/Yr = 124 CFS

TOTAL OUTFLOWS = 450,640 AF/Yr TOTAL INFLOWS = 450,640 AF/Yr

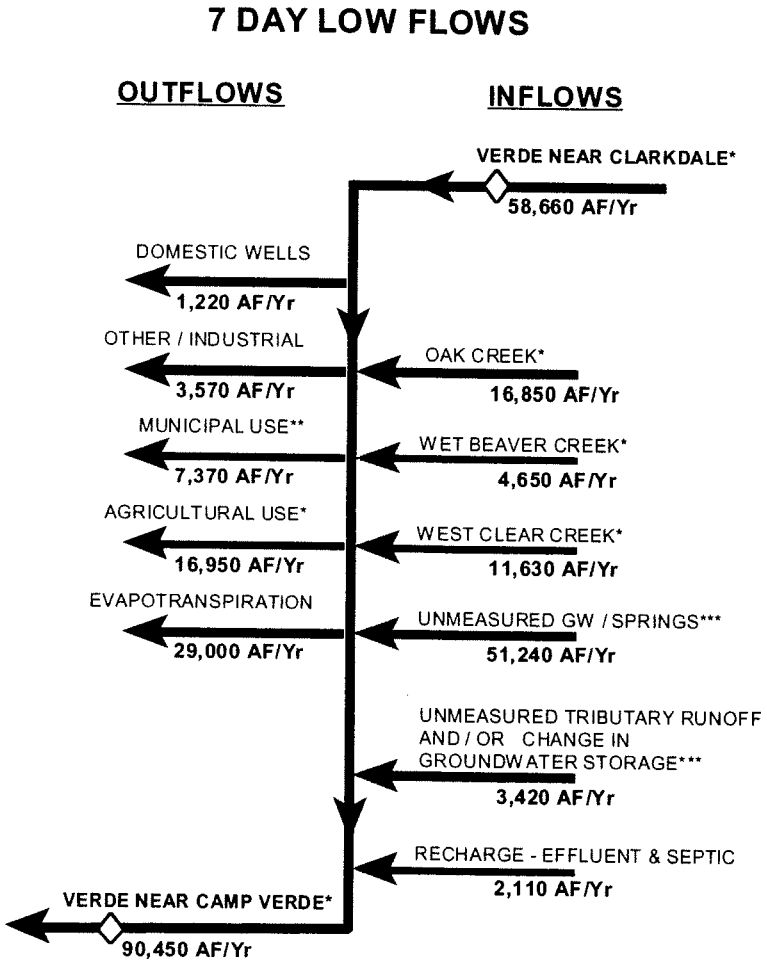
NET GAIN IN REACH: 394,980 - 139,740 = 255,240 AF/Yr

255,240 AF/Yr = 353 CFS

◇ USGS Gaging Station *Measured **Reported ***Residual

Source: ADWR, 2000 pg 5 of 5 for Verde Vly

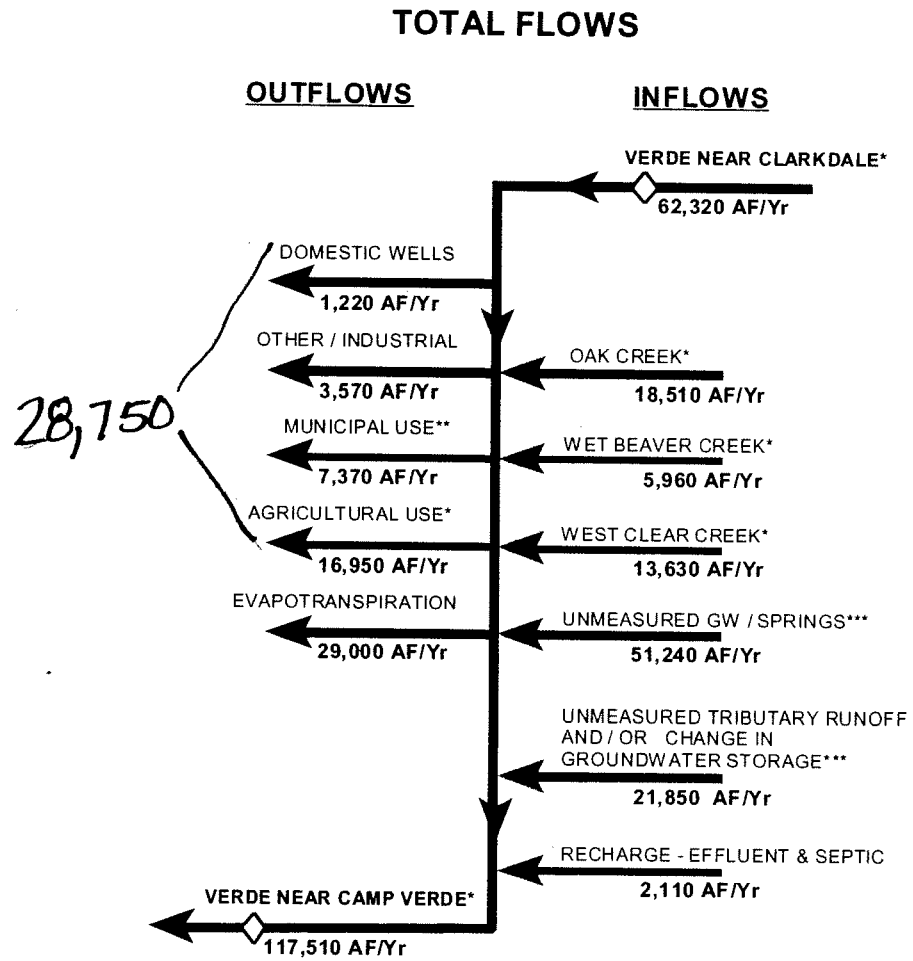
Figure 5.8 - 1996 Dry Year - Reach 2: Verde River Near Clarkdale to Verde River Near Camp Verde, 7 Day Low and Total Flows.



TOTAL OUTFLOWS = 148,560 AF/Yr TOTAL INFLOWS = 148,560 AF/Yr

NET GAIN IN REACH: 90,450 - 58,660 = 31,790 AF/Yr

31,790 AF/Yr = 44 CFS



TOTAL OUTFLOWS = 175,620 AF/Yr TOTAL INFLOWS = 175,620 AF/Yr

NET GAIN IN REACH: 117,510 - 62,320 = 55,190 AF/Yr

55,190 AF/Yr = 76 CFS

◇ USGS Gaging Station *Measured **Reported ***Residual

Options for Estimated Available Water Supplies using Components from Existing Water Budgets

BIG CHINO SUB BASIN

Option #	Source	Description	Volume (in AF)
1	ADWR, 2000 page 5-8	1997 Demands (sum of sm. providers, domestic (exempt) wells, ag, and industrial)	15,720
2	ADWR, 2000 page 5-7	1997 Natural Recharge	26,760
3	Blasch, 2006 page 82	1990-2003 Avg. Demand (sum of ag, domestic, water providers, golf courses and industrial)	8,440
4	Blasch, 2006 page 82	1990-2003 Avg. Natural Recharge (no incidental or artificial)	23,420

ADWR, 2000 Verde River Watershed Study

Blasch, 2006 Hydrogeology of the Upper and Middle Verde River Watersheds, Central Arizona

*Natural recharge is estimated as a residual in this equation. Includes components such as mountain-block, mountain-front, basin and channel recharge. This value does not consider storage losses in the system.

LITTLE CHINO AND UPPER AGUA FRIA SUB BASIN (PrAMA)

Option #	Source	Description	Volume (in AF)
1	ADWR, 1999 table 2	1990-1997 Avg. AMA Demands (sum of muni (includes exempt wells), ag, and industrial)	16,317
2	ADWR, 1999 table 2	1990-1997 Avg. Natural Recharge	7,480
3	ADWR, 1999 table 2	1990-1997 Avg. Total Recharge (natural and incidental)	14,003
4	ADWR, memo (Hydrology) 2009	1978-2008 estimate including flood recharge in AMA.	8,070
5	Timmons, 2006 page 43	1999-2004 Avg. Simulated Natural Recharge (no incidental, artificial or flood)	5,800
6	Timmons, 2006 page 43	1999-2004 Avg. Simulated Total Inflow (includes natural, incidental, artifical and flood)	16,633

ADWR, 1999 *ADWR Report on the Final Decision and Order That the Prescott AMA Is No Longer At Safe-Yield*

Timmons and Springer, 2006 Prescott AMA Groundwater Flow Model Update Report

VERDE VALLEY SUB BASIN

Option #	Source	Description	Volume (in AF)
1	ADWR, 2000 page 5-1	1983 Owen-Joyce & Bell Demands (sum of ET, Irrigation CU, and GW withdrawals)	74,000
2	ADWR, 2000 page 5-23	1992 Wet Year Outflows, Reach 2 Clarkdale to Camp Verde (sum of domestic wells, industrial, muni, and ag)	26,660
3	ADWR, 2000 page 5-24	1996 Dry Year Outflows, Reach 2 Clarkdale to Camp Verde (sum of domestic wells, industrial, muni, and ag)	28,750
4	Blasch, 2006 page 82	1990-2003 Avg. Natural Recharge (no incidental or artificial)*	130,270
5	Blasch, 2006 page 82	1990-2003 Avg. Demand (sum of ag, domestic, water providers, golf courses, and industrial)	12,470

ADWR, 2000 Verde River Watershed Study

Blasch, 2006 Hydrogeology of the Upper and Middle Verde River Watersheds, Central Arizona

*Natural recharge is estimated as a residual in this equation. Includes components such as mountain-block, mountain-front, basin and channel recharge. This value does not consider storage losses in the system.

CYHWRMS - Comprehensive Water Provider List

Description: The TWG recommended that water usage be looked at for the three year '05-'07 and the most complete data set would be used in the study. It was decided that 2006 was the most complete.

Name	Source	Reporting ID#	Water Source[1]	AF in 2005[2]	AF in 2006[2]	AF in 2007[2]	Comment (all comments in red pertain to water quantity info)	Water Planning Area (based on GIS)
Camp Verde Water System	ACC -query by Fuente of Yavapai Cnty	W-01419A	GW	457 (gp)	502 (gp)	533 (gp)	Note CV files use on two sheets showing two systems 13-015 and 13-072.	Camp Verde
Rainbow Acres	ADWR CWP - query by Ford of Yavapai Cnty	91-000852.0000	GW	no info	17 (qw) - see comments	no info	Added to RGR in 2008, SWP due Jan. 2, 2009. Received but not yet reviewed. First annual report due 6/2009. Wells 630281,629001. 10/09 - checked CWP again the 2008 report had been submitted by the water provider. 2008 = 16.98 AF (qw). This will be a surrogate for the 2006 demand.	Camp Verde
Lake Verde Water Company	ADWR CWP - query by Ford of Yavapai Cnty	91-000627.0000	GW	no info	19 (e)	not filed		Camp Verde
Verde Lakes Water Corporation	ACC -query by Fuente of Yavapai Cnty	W-02372A	GW	237 (gp)	241 (gp)	254 (gp)		Camp Verde
Verde West Irrigation	ACC -query by Fuente of Yavapai Cnty	W-02274A	SW	no info	See comments, it will be assumed we caught this in the study's AG work.	no info	LGraser personal communication with ACC - Del Smith on 1/16/2009, "Verde West doesn't meter the water delivered to its customers this sort of data was not collected by Staff during Verde's recent rate case. However, the Company can probably give you a rough fig. 10/09 L. Graser called Peggy Larson. They use 2- 25HP pumps and run about 6-8 hrs/day. 6"and 8" pipes. They turn off in Nov/Dec and start up again about Feb/Mar. No system expansion expected. 186 customers.	CampVerde
Yavapai-Apache - Middle Verde System	YCWAC Verde Valley Projection, April 2003 (draft)	none	GW	37 (e)	no info	no info		Camp Verde

Yavapai-Apache - Casino System	YCWAC Verde Valley Projection, April 2003 (draft)	none	GW	21 (e)	no info	no info		Camp Verde
Humboldt Water Co.	ADWR RGR 2006 (56 prefix only)	56-003010.0000	GW	77.59 (qw)	83.08 (qw)	85.88 (qw)		Dewey-Humboldt
Soft Winds MHP	ADWR CWP - query by Ford of Yavapai Cnty	91-000666.0000	GW	no info	7 (e)	50 (e) (qw)		Dewey Humboldt
Wilhoit Water Co. [Blue Hills]	ADWR RGR 2006 (56 prefix only)	56-003005.0000	GW	12.83(qw)	9.18 (qw)	9 (qw)	This provider is in the D-H area	Dewey-Humboldt
Clarkdale Municipal Water Utility	ADWR CWP - query by Ford of Yavapai Cnty	91-000617.0000	GW	no info	405 (qw)	487 (qw)	6/19/08 it was mentioned that once Clarkdale drills a new well, this system will be isolated from City of Cottonwood system.	Clarkdale
Bent River Apartments	ADWR CWP - query by Ford of Yavapai Cnty	91-000850.0000	GW	no info	6 (e) - See comments	no info	Added to RGR in 2008, system water plan due Jan. 2, 2009. Received, but not reviewed. First annual report due June 2009. 10/2009 an annual report was not filed, but ADEQ records show that 100 people are served by the provider. Rough estimate using an ADWR standard multi-family gpcd of 57 will be used as an estimate for 2006.	Clarkdale
Cottonwood Municipal Water System	ADWR CWP - query by Ford of Yavapai Cnty	91-000812 (Verde Santa Fe), 91-000613 (Clemenceau), 91-000618 (Cottonwood Waterworks), 91-000645 (Cordes Lakes I), 91-000657 (Cordes Lakes II), 91-000658 (Cordes Lakes III), and 91-000659 (Cordes Lakes VI, VII, and VIII)	GW	no info	3145 (qw)	2963 (qw)	*06/19/08 B. Hardy said Cottonwood could be represented as one line. 7/31/08 - email from Bob stated the system name as shown on this line. Based on City of Cottonwood's SWP, they have multiple systems see reporting ID column.*	Cottonwood

On the Greens	ADWR CWP - query by Ford of Yavapai Cnty	91-000851.0000	GW	no info	11.9 (e) - see comments	no info	Added to RGR in 2008, system water plan due Jan. 2, 2009. Not yet received. First annual report due June 2009. 10/2009 - the provider submitted a report in 2008 showing 11.9 AF of water withdrawn. This will be a surrogate for 2006 demands.	Cottonwood
Town of Jerome	ADWR CWP - query by Ford of Yavapai Cnty	91-000626.0000	SPRING	no info	90 (e)	430.2 (qw)	Note: this is not a system of wells, the water is from springs. Town of Jerome provided their own number see communications from Jane Moore. 282 AF	Jerome
Prescott Valley Municipal Water System	ADWR RGR 2006 (56 prefix only)	56-003012.0000 and 56	GW, reclaimed water - direct delivery and recovered	5551	6169	6471	6/19/08 John M. stated that the ToPV can be respresented with one row. The two systems that were merged (Prescott Valley Water District and Prescott Valley Municipal Water System) are now known as Prescott Valley Municipal Water System. See support file CHYWRMS_s_2006DemandsforAMAcommunities_11-18-09	Prescott Valley
Hanely Park	ADWR RGR 2006 (56 prefix only)	56-003018.0000		1.7 (qw)	2.03 (qw)	1.76 (qw)		Prescott Valley
Diamond Valley Water Users Corp. (Triangle Dev. Corp)	ADWR RGR 2006 (56 prefix only)	56-003014.0001	GW	124.31 (rcvd)	132.53 (rcvd)	127.07 (rcvd)	This company receives water from ToPV.	Prescott Valley
Bradshaw Water Co. Inc.	ADWR RGR 2006 (56 prefix only)	56-003019.0000	GW	4.14 (qw) and 29.3 (rcvd)	2.4 (qw) and 28.4 (rcvd)	4 (qw) and 37 (rcvd)	This company receives water from ToPV, but also reports pulling some water from their well.	Prescott Valley
Mingus West Water System	ADWR CWP - query by Ford of Yavapai Cnty	no info					Note: served by ToPV	Prescott Valley
Viewpoint SubD	ADWR CWP - query by Ford of Yavapai Cnty	91-000688.0000		no info			Note: served by ToPV	Prescott Valley
Appaloosa Water Co.	ADWR RGR 2006 (56 prefix only)	56-003021.0000	GW	63 (qw)	78 (qw)	72 (qw)		Chino Valley
Chino Valley Irrigation							This was handled in the AG study section	
Mountain View MHP							No data found	Chino Valley

H & R Enterprises	ADWR RGR 2006 (56 prefix only)	56-003025.0000	GW	2.5 (qw)	3.34 (qw)	2.69 (qw)		Chino Valley
Chino Meadows II Water Co.	ADWR RGR 2006 (56 prefix only)	56-003003.0000	GW	206 (qw)	211 (qw)	211 (qw)		Chino Valley
PacWest Properties (Mountain View MHP)	ADWR RGR 2006 (56 prefix only)	56-003002.0002	GW	7.48 (qw)	25.6 (qw)	42.25 (qw)		Chino Valley
Town of Chino Valley	ADWR RGR 2006 (56 prefix only)	56-003022.0001	GW	110 (qw)	157 (qw)	255 (qw)	See support file CHYWRMS_s_2006DemandsforAMAcommunities_11-18-09	Chino Valley
Manneken Apartments LLC	ADWR CWP - query by Ford of Yavapai Cnty	91-000849.0000	GW	no info	3 AF (qw) - see comment	no info	Added to RGR in 2008, system water plan due Jan. 2, 2009. Received but not yet reviewed. First annual report due June 2009. 10/2009 annual report was received and in 2008 the provider showed 2.8 AF of use. This will be used as an estimate for 2006 demand.	Chino Valley or Prescott
Frank & Eva Margini/ Sunset Village Mobile Home Park	ADWR RGR 2006 (56 prefix only)	56-003001.0001	GW	2.39 (qw)	2.48 (qw)	2.21 (qw)	635185 and 635184	Chino Valley
Roadrunner Mobile Home Park	ADWR RGR 2006 (56 prefix only)	56-003016.0000	GW	13.86 (qw)	15.55 (qw)	16.36 (qw)	637989	Chino Valley or Prescott
City of Prescott	ADWR RGR 2006 (56 prefix only)	56-003017.0000	GW, Recovered SW, and reclaimed - direct delivery and	10462	10151	10417	See support file CHYWRMS_s_2006DemandsforAMAcommunities_11-18-09	Prescott
Dell's Water Co.	ADWR RGR 2006 (56 prefix only)	56-003004.0000	GW	27.7 (qw)	23.65 (qw)	22.8 (qw)		Prescott
Granite Dells Water Co.	ADWR RGR 2006 (56 prefix only)	56-003007.0000	GW	3.79 (qw)	5.2 (qw)	4.22 (qw)		Prescott
Holiday Hills DWID	ADWR RGR 2006 (56 prefix only)	56-003009.0000	GW	14.82 (rcvd)	13.70 (rcvd)	12.52 (rcvd)	They receive their water from City of Prescott.	Prescott

Wilhoit Water Co. (Chino/Yavapai)	ADWR RGR 2006 (56 prefix only)	56-003006.0000	GW	22	27	20	This provider is in the Chino Valley area	Prescott
Beverly Gardens Trailer Park	ADWR CWP - query by Ford of Yavapai Cnty	91-000697.0000	GW	no info	5 (rcvd)	13 (rcvd)	Due to a low producing well, this user receives water from the City of Prescott.	Prescott
Highland Pines DWID	ADWR RGR 2006 (56 prefix only)	56-003008.0000	GW	29.8 (rcvd)	32 (rcvd)	32.19 (rcvd)	The water is received from City of Prescott.	Prescott
Arizona Water Co. - Sedona Water System	ADWR CWP - query by Ford of Yavapai Cnty	91-000093.0000	GW	no info	3332 (qw)	3396 (qw)		Sedona
Oak Creek Water Co. #1	ADWR CWP - query by Ford of Yavapai Cnty	91-000630.0000	GW	no info	309 (qw)	317 (qw)		Sedona
Sedona Venture Water Co.	ADWR CWP - query by Ford of Yavapai Cnty	91-000660.0000	GW	no info	110.7 (qw)	112.1 (qw)		Sedona
Sunset Mobile Home Park	ADWR CWP - query by Ford of Yavapai Cnty	91-000695.0000	GW	no info	10.38 (qw)	10 (qw)		Sedona
Abra Water Co.	ADWR CWP - query by Ford of Yavapai Cnty	91-000605.0000	GW	no info	163 (qw)	169 (qw)		Paulden CDP
Antelope Lakes Water Company	ACC -query by Fuente of Yavapai Cnty	W-02740A	GW	187 (gs)	157 (gs)	247 (gp)		Paulden CDP
Gilpins Trailer Park	ADWR CWP - query by Ford of Yavapai Cnty	91-000705.0000	GW	no info	11.01 (qw)	not filed		Paulden CDP
Arizona Water Co. - Valley Vista	ADWR CWP - query by Ford of Yavapai Cnty	91-000663.0000	GW	no info	420 (qw)	423 (qw)		Big Park CDP
Big Park Water Co.	ADWR CWP - query by Ford of Yavapai Cnty	91-000609.0000	GW	no info	880 (qw)	925.26 (qw)		Big Park CDP
Pine Valley Water Co.	ADWR CWP - query by Ford of Yavapai Cnty	91-000656.0000	GW	46.74 (qw)	47 (qw)	no info		Big Park CDP
Oak Creek Public Service LLC	ADWR CWP - query by Ford of Yavapai Cnty	91-000631.0000		no info	66 (e)	66.22 (qw)		Cornville CDP

Oak Creek Valley	ADWR CWP - query by Ford of Yavapai Cnty	91-000665.0000	GW	no info	479.13 (qw)	567.44 (qw)		Cornville CDP
Arizona Water Co. - Rimrock	ADWR CWP - query by Ford of Yavapai Cnty	91-000635.0000	GW	no info	326 (qw)	337 (qw)		Lake Montezuma CDP
Montezuma Rimrock Water Co.	ADWR CWP - query by Ford of Yavapai Cnty	91-000648.0000	GW	no info	42 (qw)	46 (qw)	This is the new co. name for Montezuma Estates POA, verified with 55 records	Lake Montezuma CDP
Beaver Creek Store (Cactus Petes Mex Restaurant)	ADWR CWP - query by Ford of Yavapai Cnty	91-000694.0000	GW	no info	7.62 (e)	8 (e)		Lake Montezuma CDP
Boynton Canyon Enchantment Homeowners Association	ACC -query by Fuente of Yavapai Cnty	W-02510A	GW	55 (gp)	63 (gp)	68 (gp)		Verde CCD
Cathedral Vista Water Co.	ADWR CWP - query by Ford of Yavapai Cnty	91-000611.0000	GW	no info	19 (qw)	20 (qw)		Verde CCD
Clear Creek Mobile Home	ADWR CWP - query by Ford of Yavapai Cnty	91-000700.0000	GW	no info	3.89 (qw)	4 (qw)		Verde CCD
C-Oasis Park	ADWR CWP - query by Ford of Yavapai Cnty	91-000702.0000	GW	no info	3 (e)	2.8 (e)		Verde CCD
Cup of Gold Water Co.	ADWR CWP - query by Ford of Yavapai Cnty	91-000621.0000	GW	no info	no info	20.22 (e)		Verde CCD
Little Park Water Co.	ADWR CWP - query by Ford of Yavapai Cnty	91-000651.0000	GW	no info	44.61 (qw) +0.31 (rcvd)	44.6 (qw) + 0.46 (rcvd)	They do pump their own water, but they also receive some water from Big Park.	Verde CCD
Michaels Ranch WUA (Juniper Meadows)	ADWR CWP - query by Ford of Yavapai Cnty	91-000661.0000	GW	no info	12.75 (qw)	13 (qw)	Well no.518864.	Verde CCD
Montezuma Heights WC	ADWR CWP - query by Ford of Yavapai Cnty	91-000677.0000	GW	no info	24.5 (qw)	21.7 (qw)		Verde CCD
Red Rock Crossing Mobile	ADWR CWP - query by Ford of Yavapai Cnty	91-000650.0000	GW	no info	5.6 (e)	4.8 (e)		Verde CCD

Seven Canyons Water Company	ACC -query by Fuente of Yavapai Cnty	W-03388A	GW	8 (gs)	27 (gp)	35 (gp)	Note 2007 volumes were adjusted to account for vandalism as noted by the company.	Verde CCD
Verde Valley Manor	ADWR CWP - query by Ford of Yavapai Cnty	91-000667.0000	GW	no info	37.2 (qw)	36.2 (qw)		Verde CCD
White Hills Trailer Park	ADWR CWP - query by Ford of Yavapai Cnty	91-000696.0000	GW	no info	no info	47 (qw)		Verde CCD
American Ranch DWID	ADWR CWP - query by Ford of Yavapai Cnty	91-000684.0000	GW and effluent	no info	no info	22.6 (qw) + 2.24 effluent		Prescott CCD
Buffalo Run MHP	ADWR CWP - query by Ford of Yavapai Cnty	91-000693.0000	GW	no info	12 AF(qw) - see coomment	not filed	ADWR has never received anything from this system. ADEQ shows them as an active CWS. 10/2009 annual report filed for 2008 stating a use of 12 AF in 2008 with 150 served. This number will be used as a surrogate for 2006 demand.	Prescott CCD
Cactus Mobile Ranch	ADWR CWP - query by Ford of Yavapai Cnty	91-000690.0000	GW	no ino	1.0 (qw)	2 (qw)		Prescott CCD
Chino Mobile Home Ranch	ADWR CWP - query by Ford of Yavapai Cnty	91-000699.0000	?	no info	no info	no info	SWP submited in '08, did not meet requirements. Not sure if they have submitted a revised plan yet - not all of those have been logged in. We've never received an annual report. 10/2009 checked back with CWP and their 2008 annual report was not filed. No estimate will be made for this provider.	Prescott CCD

Dells View WC	ADWR CWP - query by Ford of Yavapai Cnty	91-000698.0000	GW	no info	no info	no info	ADWR has not received anything from this system. ADEQ shows them as an active CWS. 10/2009 checked back with CWP and their 2008 annual report was not filed. No estimate will be made for this provider	Prescott CCD
Double G TP	ADWR CWP - query by Ford of Yavapai Cnty	91-000704.0000	GW	no info	7.3 (e)	0.1 (e)		Prescott CCD
Granite Mountain Water Co.	ADWR RGR 2006 (56 prefix only)	56-003024.0000	GW	33.65 (qw)	56.28 (qw)	31.48 (qw)		Precott CCD
Granite Oaks WUA	ADWR RGR 2006 (56 prefix only)	56-003020.0000	GW	197.68 (qw)	206.5 (qw)	233.8 (qw)		Prescott CCD
INSCRIPTION CANYON RANCH SYSTEM	ADWR CWP - query by Ford of Yavapai Cnty	91-000687.0000	GW	no info	101 (qw)	96.9 (qw)	These numbers do not compare well to the ACC's. Maybe some confusion with first year of reporting, call Melanie. Talking Rock's website mentions that reclaimed water is used on the GC, I don't see it noted in the CWP AR.	Prescott CCD
ICR Talking Rock	ADWR CWP - query by Ford of Yavapai Cnty	91-000686.0000	GW	no info	177.5 (qw)	471.5 (qw)	The report shows that the majority of this water goes to turf @ 401.4 AF/year.	Prescott CCD
Jackson Acres Water Co.	ADWR CWP - query by Ford of Yavapai Cnty	91-000625.0000	GW	no info	5.29 (qw)	5 (qw)		Prescott CCD
Lakeside Water Co.	ADWR CWP - query by Ford of Yavapai Cnty	91-000619.0000	GW	no info	5.65 (e)	6.85 (e)		Prescott CCD
Pinehurst Water Co.	ADWR CWP - query by Ford of Yavapai Cnty	91-000632.0000	GW	no info	no info	28.86 (e)	900790, 518401, 639666	Prescott CCD
Quail Ridge DWID	ADWR RGR 2006 (56 prefix only)	56-003015.0000	GW	53.04 (qw)	64.98 (qw)	74.44 (qw)		Prescott CCD
Sherman Pines HOA	ADWR RGR 2006 (56 prefix only)	56-003013.0000	GW	4.18 (qw)	4.05 (qw)	4.03 (qw)		Prescott CCD

[1] GW = Groundwater and SW = Surface Water

[2] In this column (p) = a projected value, (gp) = vol. pumped, (gs) = vol. sold, (qw) = quantity withdrawn, (e) = estimated, (rcvd) = received

Arizona Subcounty Population Projections
July 1, 2006 to July 1, 2055
by County, Census County Division, Place, and Reservation
http://www.azcommerce.com/doclib/econinfo/FILES/2006YavapaiProjectionsSC.xls

DRAFT NUMBERS PROVIDED TO THE POPULATION TECHNICAL ADVISORY COMMITTEE
December 2006

	2006	2007	2008	2009	2010	2050
Yavapai County	212,722	220,170	227,468	234,626	241,667	418,671
Ashfork CCD	2,254	2,314	2,372	2,430	2,487	3,908
Ash Fork CDP	457	457	457	457	457	457
Seligman CDP	456	456	456	456	456	456
Remainder of Ashfork CCD	1,341	1,401	1,459	1,517	1,574	2,995
Congress CCD	10,339	10,651	10,957	11,256	11,551	18,967
Black Canyon City CDP (part)	3,224	3,311	3,396	3,479	3,561	5,624
Congress CDP	2,272	2,364	2,453	2,541	2,628	4,802
Cordes Lakes CDP (part)	17	17	18	18	19	33
Mayer CDP (part)	5	5	5	5	5	5
Peeples Valley CDP	491	511	530	548	567	1,027
Peoria city (part)	12	14	15	17	19	61
Spring Valley CDP	1,332	1,384	1,434	1,484	1,533	2,759
Wilhoit CDP	853	884	914	944	973	1,712
Yarnell CDP	645	645	645	645	645	645
Remainder of Congress CCD	1,488	1,517	1,546	1,574	1,602	2,299
Humboldt CCD	6,647	6,869	7,087	7,301	7,512	12,804
Black Canyon City CDP (part)	0	0	0	0	0	0
Camp Verde town (part)	0	0	0	0	0	0
Cordes Lakes CDP (part)	2,860	2,994	3,126	3,255	3,382	6,574
Dewey-Humboldt CDP (part)	719	773	826	879	930	2,222
Mayer CDP (part)	1,597	1,631	1,665	1,697	1,730	2,538
Remainder of Humboldt CCD	1,470	1,470	1,470	1,470	1,470	1,470
Mingus Mountain CCD	29,316	30,124	30,915	31,691	32,454	51,642
Camp Verde town (part)	0	0	0	0	0	0
Clarkdale town	3,732	3,783	3,833	3,883	3,931	5,146
Cottonwood city (part)	11,201	11,534	11,860	12,180	12,495	20,411
Cottonwood-Verde Village CDP (part)	11,328	11,592	11,850	12,104	12,353	18,625
Dewey-Humboldt CDP (part)	11	12	13	14	14	32
Jerome town	330	330	330	330	331	334
Prescott Valley town (part)	1,027	1,130	1,231	1,329	1,427	3,870
Remainder of Mingus Mountain CCD	1,687	1,743	1,797	1,851	1,903	3,224
Prescott CCD	126,068	131,026	135,884	140,648	145,335	263,156
Bagdad CDP	1,578	1,578	1,578	1,578	1,578	1,578
Chino Valley town	13,235	14,125	14,996	15,851	16,692	37,836
Dewey-Humboldt CDP (part)	3,404	3,450	3,496	3,541	3,585	4,689

Mayer CDP (part)	19	20	21	23	24	52
Paulden CDP	5,342	5,659	5,969	6,273	6,573	14,099
Prescott city	42,154	43,508	44,835	46,136	47,416	79,588
Prescott Valley town (part)	34,582	36,469	38,318	40,131	41,914	86,750
Williamson CDP	5,228	5,468	5,702	5,932	6,158	11,845
Remainder of Prescott CCD	20,525	20,749	20,969	21,184	21,396	26,720
Verde CCD	38,098	39,186	40,253	41,299	42,328	68,194
Big Park CDP	6,566	6,783	6,996	7,205	7,411	12,582
Camp Verde town (part)	11,779	12,163	12,539	12,908	13,270	22,387
Cornville CDP	4,075	4,197	4,317	4,434	4,549	7,448
Cottonwood city (part)	0	0	0	0	0	0
Cottonwood-Verde Village CDP (part)	1,244	1,303	1,361	1,418	1,474	2,881
Lake Montezuma CDP	4,237	4,385	4,529	4,670	4,809	8,308
Sedona city (part)	7,958	8,078	8,196	8,311	8,424	11,278
Remainder of Verde CCD	2,239	2,278	2,316	2,353	2,389	3,309
Reservations						
Hualapai (part)	0	0	0	0	0	0
Yavapai-Apache	838	854	869	884	899	1,270
Yavapai-Prescott	187	187	188	189	189	207
Total Reservation	1,024	1,041	1,057	1,073	1,088	1,478
Total Non-Reservation	211,698	219,129	226,411	233,553	240,579	417,193
Coconino County	**132,826**	**135,070**	**137,261**	**139,388**	**141,457**	**198,149**
Coconino CCD	85,058	86,495	87,898	89,260	90,585	126,887
Sedona city (part)	3,122	3,144	3,165	3,185	3,205	3,752

Source: Arizona Department of Economic Security, Research Administration, Population Statistics Unit, 12/01/06.

Estimated Available Water Supplies – Using ADWR Assured and Adequate Water Supply (AAWS) Records

(Prepared 8/26/2009)

Background: Since about February 2009, the study team has worked on and off to address estimated available water supplies for the demand table by using ADWR AAWS records. The AAWS program applies when subdivisions are being developed, and thus are driven by the definition of a subdivision from the Arizona Department of Real Estate:

> A subdivision is six or more parcels with at least one parcel having an area less than 36 acres. This includes residential or commercial subdivisions, stock cooperatives, condominiums, and all lands subdivided as part of a common promotional plan (including golf courses, parks, schools, and other amenities). Short-term leases (12 months or less) and subdivisions where all parcels are greater than 36 acres in size do not fall under this definition.

Based on AAWS definitions for determinations, only Designations, Certificates, Water Reports and Analyses, "locked up" water and were selected from the AAWS DB. The latter determination is "locked up" for only 10 years. Before recording plats or selling parcels in AMAs, developers must demonstrate all of the following criteria: physical water availability, legal water availability, continuous water availability, financial capability, water quality, and consistency with AMA management goal and management plan. This holds true for areas outside of the AMA without the need for consistency with management goal and plan. (Source: http://www.azwater.gov/AzDWR/WaterManagement/AAWS/default.htm)

Methods:

1. ADWR ARM (intranet based) was queried using the "Issued Determination of assured or adequate water". In this query the following can be set by the user: AMA, Status (Issued, Denied, or Pending) and Sub basin. The query was set by sub basin or AMA of interest, and status equal to issued since we were looking at determination through 2006. Due to results not always being shown by water provider it was difficult to sum a total volume for each WPA.
2. Next, ADWR Atlas GIS point files for AAWS were reviewed and clipped to each WPA. This gave the TWG another format to assess the AAWS data. It also brought up discussion on whether inadequate determinations (outside AMAs) should be included in the volumes. By using Yavapai County GIS with imagery, it was seen in many cases that subdivisions had been completed with inadequate determinations.
3. Last, some of the TWG membership were not certain that their available supply (in AF) based on Atlas GIS and AAWS records was correct. In some cases TWG members felt their volume was either too low or too high when compared to 2006 reported demands. A test case was done with one WPA by cross-checking the data in the AAWS DB with the platted lots provided by the community representative.

Results: Due to the study timeframe, it has been determined that it will not be possible to complete Method 3 for all WPAs in the study. Estimated available supply will be determined with one or both of the other two approaches developed by the TWG, Status Quo (setting available supplies = 2006 demands) or using a water balance approach by sub basin. Initial findings can be found in the main study document, *Planning Area Water Use Summary Table.*

Query structure for exempt wells in the CYHWRMS

Data Source: ADWR Wells 55DB CD (version 6/2008)

WELLTYPE = Domestic/Stock/Exempt OR Exempt OR Non-Domestic Exempt OR Replacement Well in New Location
WELLSITEUS = Water production OR Null
WELLSITE_1 = Water production OR Null
WATERUSE1 = Null OR **WATERUSE1** =Domestic OR **WATERUSE2** = Domestic OR **WATERUSE3** = Domestic
WELL_CANCE = N or Null
APPROVED > 12/31/06 remove from the data set, keep null records
INSTALLED > 12/31/06 remove from the data set, keep null records

Information on the data source: It contains all registered wells in the State. The DB was created in 1980 to store registration information submitted by well owners and drillers. This project used a static clip from the Wells 55DB that was produced in CD format in June 2008.

Information on the query structure:

1. Setting well type as shown above removes wells coded as air sparging, cathodic, exploration, geotechnical, heat pump, injection, mineral exploration, monitor, monitor or piezometer, non-exempt, non-service, other, piezometer, service, soil vapor extraction, vadose zone or withdrawal permit.
2. Setting well site use as shown above removes wells coded as abandoned, capped destroyed, drainage, mineral exploration, monitor, no site use code listed, observation, piezometer, or test.
3. Setting well site 1 as shown above removes wells coded as abandoned, anode, capped, recharge or recovery.
4. Setting water use 1, 2, and 3 as shown above removes wells coded as commercial, drainage, industrial, irrigation, mining, municipal, no water use code listed, none, other-production, recharge, recreation, stock, subdivision, unknown, or utility (water co.). **Note: These other uses stay in the data set if at least one of the three columns has domestic in it. Also, if Water use 1 is not set with Null and an OR operator then about 282 exempt wells are lost from the study boundary.**
5. Setting well cancelled as shown above removes all wells coded with a Y = yes.
6. Setting approved and installed greater than 12/31/2006 removes wells that came in after this time. So that would be 2007 and 2008 wells.

Outcome: At the January 22nd 2009 TWG meeting, the stakeholders agreed that this query structure was good, with one exception. It was requested that we see if the addition of a "NULL" in the well type category would include additional wells that would other

wise be dropped from the query. On February 2nd 2009, L. Graser checked for this condition in all 55DB wells that are clipped to the study boundary. Only one well came up as NULL for well type, it was 55-588542. Fortis records were checked. The party who filed the paperwork stated well type to be exempt. This looked like a data entry error by ADWR records division. This item was forwarded and corrected in the 55DB by the NOI supervisor, L. Cason. At the 3/5/2009 TWG meeting the information about the "null" was shared with the group and the query structure will stand as shown above.

CYHWRMS – Golf Courses

Planning Area	**Golf Course**	**2006 Demand (in AF)**	**Information Source**
Camp Verde	None		
Dewey-Humboldt	None		
Clarkdale	None		
Cottonwood	Pine Shadows	120 (GW)	YCWAC Verde Valley Projection, April 2003 (draft)
	Verde Santa Fe (N and S)	1139(GW) 174 (eff)	YCWAC Verde Valley Projection, April 2003 (draft)
Jerome	None		
Prescott Valley	Prescott Country Club	448.51 (GW)	58-108469.0002 55-530375
	StoneRidge	280 (eff)	58-003012.0000 Direct delivery
Chino Valley	None		
Prescott	Antelope Hills (N and S)	968.10 (eff)	56-003017.0000 Direct delivery
	Prescott Lakes	425.6 (eff-2005)	56-003017.0000 Direct delivery
	Hassayampa	200.5 (eff)	56-003017.0000 Direct delivery
Sedona	Poco Diablo	33 (SW)	YCWAC Verde Valley Projection, April 2003 (draft)
Paulden CDP	None		
Big Park CDP	Sedona Golf Resort	481(GW)	Big Park Water Company's Modified Designation - ADWR record number 41-400325.0001
	Canyon Mesa	230(GW)	Big Park Water Company's Modified Designation - ADWR record number 41-400325.0001
	Oak Creek Village	440(GW)	Big Park Water Company's Modified Designation - ADWR record number 41-400325.0001
Cornville CDP	None		
Lake Montezuma CDP	Beaver Creek	509 (SW)	YCWAC Verde Valley Projection, April 2003 (draft)
Ctn-Verde Villages CDP	None		
Verde CCD	Seven Canyons Golf Club	69 (GW) 207 (eff)	YCWAC Verde Valley Projection, April 2003 (draft)
	Sedona National	414 (GW)	YCWAC Verde Valley Projection, April 2003 (draft)
Prescott CCD	Talking Rock	441 (GW and eff)	**Big Chino Subbasin Historical and Current Water Uses and Water Use Projections, 2004**
Mingus Mtn. CCD	Quailwood Greens	344 (GW)	58-111967.0004, 58-111966.0001 55-613018, 613021 and 550395. Note only the first well was used in 2006
Humboldt CCD	None		
Ashfork CCD	None		

Non-Exempt Well Count
by Water Planning Area

Note: Non-Exempt wells were queried for the study area using the attached query structure. Well listings were reviewed and verfied by representatives from each of the Water Planning Areas. It was assumed that Municipal and Utility wells were already accounted for by water providers, Commercial/Industrial wells were also accounted for individually per WPA, and Irrigated Acreage and irrigation water use was estimated for the entire planning as noted on the CYHWRMS Agricultural Demand Table.

	#	AF/yr/well	AF/yr
Camp Verde			
Domestic	91	0.5	45.5
Other/Domestic	58	1	58
Municipal	0		0
Commercial/Industrial	13		0
Irrigation	11		0
Stock	3	0.3	0.9
	176		104.4
Dewey Humboldt			
Domestic	10	0.5	5
Other/Domestic	17	1	17
Municipal	0		0
Mining	4		0
Commercial/Industrial	3		0
Irrigation	12		0
Stock	0	0.3	0
	46		22
Clarkdale (7)			
Domestic	4	0.5	2
Other/Domestic	1	1	1
Municipal	2		0
Commercial/Industrial	1		0
Irrigation	4		0
Stock	0	0.3	0
	12		3
Cottonwood (32)			
Domestic	27	0.5	13.5
Other/Domestic	15	1	15
Municipal	0		0
Commercial/Industrial	12		0
Irrigation	2		0
Stock	1	0.3	0.3
	57		28.8

Prescott Valley			
Domestic	3	0.5	1.5
Other/Domestic	4	1	4
Municipal	1		0
Commercial/Industrial	3		0
Irrigation	10		0
Stock	1	0.3	0.3
	22		5.8

Chino Valley			
Domestic	23	0.5	11.5
Other/Domestic	18	1	18
Municipal	3		0
Commercial/Industrial	1		0
Irrigation	13		0
Stock	4	0.3	1.2
	62		30.7

Prescott			
Domestic	9	0.5	4.5
Other/Domestic	2	1	2
Municipal	1		0
Commercial/Industrial	0		0
Irrigation	0		0
Stock	0	0.3	0
	12		6.5

Sedona			
Domestic	9	0.5	4.5
Other/Domestic	2	1	2
Utility	1		0
Commercial/Industrial	0		0
Irrigation	1		0
Stock	0	0.3	0
	13		6.5

Paulden			
Domestic	168	0.5	84
Other/Domestic	57	1	57
Municipal	0		0
Commercial/Industrial	4		0
Irrigation	47		0
Stock	8	0.3	2.4
	284		143.4

Big Park			
Domestic	2	0.5	1
Other/Domestic	1	1	1
Municipal	0		0
Commercial/Industrial	0		0
Irrigation	3		0
Stock	1	0.3	0.3
	7		2.3
Cornville			
Domestic	42	0.5	21
Other/Domestic	10	1	10
Municipal	0		0
Commercial/Industrial	2		0
Irrigation	2		0
Stock	2	0.3	0.6
	58		31.6
Lake Montezuma			
Domestic	30	0.5	15
Other/Domestic	27	1	27
Municipal	1		0
Commercial/Industrial	2		0
Irrigation	6		0
Stock	2	0.3	0.6
	68		42.6
Ctn Verde Villages			
Domestic	2	0.5	1
Other/Domestic	0	1	0
Municipal	0		0
Commercial/Industrial	0		0
Irrigation	0		0
Stock	0	0.3	0
	2		1
Williamson			
Domestic	23	0.5	11.5
Other/Domestic	10	1	10
Municipal	1		0
Commercial/Industrial	0		0
Irrigation	13		0
Stock	6	0.3	1.8
	53		23.3

Verde CCD			
Domestic	37	0.5	18.5
Other/Domestic	22	1	22
Municipal	1		0
Mining	1		0
Commercial/Industrial	4		0
Irrigation	11		0
Stock	3	0.3	0.9
	79		41.4
Prescott CCD			
Domestic	84	0.5	42
Other/Domestic	14	1	14
Utility	0		0
Commercial/Industrial	4		0
Irrigation	10		0
Stock	17	0.3	5.1
	129		61.1
Mingus Mtn CCD			
Domestic	18	0.5	9
Other/Domestic	12	1	12
Municipal	2		0
Mining	1		0
Irrigation	5		0
Stock	12	0.3	3.6
	50		24.6
Humboldt CCD			
Domestic	10	0.5	5
Other/Domestic	0	1	0
Municipal	0		0
Commercial/Industrial	0		0
Irrigation	2		0
Stock	0	0.3	0
	12		5
Ashfork CCD			
Domestic	12	0.5	6
Other/Domestic	2	1	2
Municipal	3		0
Commercial/Industrial	0		0
Irrigation	3		0
Stock	1	0.3	0.3
	21		8.3

Total CYHWRMS Area		
Total Domestic	876	574
Total Municipal/Utility	16	0
Total Commercial/Indus	49	0
Total Irrigation	155	0
Total Mining	6	0
Total Stock	61	18.3
Total N/E Wells	**1163**	**592.3**

Query structure for Non-exempt in the CYHWRMS

Data Source: ADWR Wells 55DB CD (version 6/2008)

WELLTYPE = Non-exempt OR Non-service OR Withdrawal Permit (last two only show up in the AMA)
WELL_CANCE = N or Null
APPROVED > 12/31/06 remove from the data set, keep null records
INSTALLED > 12/31/06 remove from the data set, keep null records

Information on the data source: It contains all registered wells in the State. The DB was created in 1980 to store registration information submitted by well owners and drillers. This project used a static clip from the Wells 55DB that was produced in CD format in June 2008.

Information on the query structure:

1. Setting well type as shown above removes wells coded as air sparging, cathodic, domestic/stock/exempt, exempt, exploration, geotechnical, heat pump, injection, mineral exploration, monitor, monitor or piezometer, other, piezometer, replacement well in new location, service, soil vapor extraction, or vadose zone.
2. Setting well cancelled as shown above removes all wells coded with a Y = yes.
3. Setting approved and installed greater than 12/31/2006 removes wells that came in after this time. So that would be 2007 and 2008 wells.

Outcome: Leslie M. you many want to summarizes the outcome on this one from the meeting minutes. I know that there was not objection to the query. It launched us into a process that helped eliminate well that were already accounted for, volume assignments, etc.

Central Yavapai Highlands Water Resources Management Study - Phase I
Population Comparison

Water Planning Area[1]	2006 DES Population (not WPAs)	DES 2050 Population (not WPAs)	DES Annual Growth Rate	2006 DES modified for WPAs [1]	2006[2] Yavapai County Parcel Population	2006[2] Population - Yavapai County Estimates	2006[3] Population	2050 County Estimates 2.25% Growth [2,4]	2050[1,3] Assumed Population	Annual Growth Rate	Pop. Change
	not WPAs	not WPAs		WPAs	WPAs	WPAs	WPAs		WPAs		
			%							%	
Camp Verde	11,779	22,387	1.5%		-9,826		12,497		23,277	1.4%	10,780
Dewey Humboldt	4,134	6,943	1.2%		-4,041		4,134		6,943	1.2%	2,809
Clarkdale	3,732	5,146	0.7%	3999	-3,568		3,999		22,460	4.0%	18,461
Cottonwood	11,201	20,411	1.4%	20400	-17,872		20,400		77,630	3.1%	57,230
Jerome	330	334	0.0%	510	-429		510		800	1.0%	290
Prescott Valley	35,609	90,620	2.1%	41610	-42,182	20,400	41,610		146,000	2.9%	104,390
Chino Valley	13,235	37,836	2.4%	12690	-7,874		12,690		63,690	3.7%	51,000
Prescott	42,154	79,588	1.5%	49072	-43,418		49,072		100,000	1.6%	50,928
Sedona	11,080	15,030	0.7%		-8,271		11,080		16,300	0.9%	5,220
Paulden CDP	5,342	14,099	2.2%		-5,890		5,342		14,099	2.2%	8,757
Big Park CDP	6,566	12,582	1.5%	7731	-7,252		7,731		8,810	0.3%	1,079
Cornville CDP	4,075	7,448	1.4%		-3,747		4,075		7,448	1.4%	3,373
Lake Montezuma CDP	4,237	8,308	1.5%		-4,679		4,237		8,308	1.5%	4,071
Ctn-Verde Village CDP	12,572	21,506	1.2%	3373	-1,928		3,373		11,706	2.9%	8,333
Williamson CDP	5,228	11,845	1.9%		-5,107		5,228		11,845	1.9%	6,617
Verde CCD	2,239	3,309	0.9%		-1,644	-2,239	1,644	4,377	4,377	2.3%	2,733
Prescott CCD	20,525	26,720	0.6%		-11,012	-25,573	11,012	29,312	29,312	2.2%	18,300
Mingus Mtn CCD	1,687	3,224	1.5%		-2,741	-1,687	1,700	4,525	4,525	2.2%	2,825
Humboldt CCD	1,470	1,470	0.0%		-230	-287	230	612	612	2.2%	382
Ashfork CCD	1,341	2,995	1.8%		-471	-500	471	1,251	36,250	10.4%	35,779
Total	198,536	391,801	1.6%		-182,182		201,035		594,392	2.5%	393,357

1. Modifications to 2006/2050 DES populations based on differences between water service area boundaries and city/town boundaries.
1. Modifications to 2006/2050 DES populations based on input from town/water provider.
2. See Phase I - Data Sources and Documentation for methods and assumptions used to estimate CCD populations.
3. Populations for Camp Verde and Clarkdale include Yavapai-Apache Nation reservations located with each Water Planning Area.
4. Ashfork CCD 2050 Population includes 1,250 plus 35,000 growth for CVCF and Yavapai Ranches.

CYHWRMS - Populations determined using YC Parcel Data (intented for CCDs)

Water Planning Area	Total Res. Parcels	Census' per Occupied Housing Unit (POHU)	Total Population Res. Parcels * POHU
Ashfork	193	2.44	470.9
Big Park WPA	3608	2.01	7252.1
Camp Verde WPA	3899	2.52	9825.5
Clarkdale WPA	1493	2.39	3568.3
Cornville WPA	1517	2.47	3747.0
Cottonwood WPA	7873	2.27	17871.7
Humboldt	95	2.42	229.9
Jerome WPA	237	1.81	429.0
Lake Montezuma WPA	2061	2.27	4678.5
Mingus Mountain	1147	2.39	2741.3
Paulden WPA	1970	2.99	5890.3
Prescott CCD	4686	2.35	11012.1
Prescott Valley WPA	16224	2.6	42182.4
Prescott WPA	20577	2.11	43417.5
Sedona WPA	4015	2.06	8270.9
Town of Chino Valley WPA	3052	2.58	7874.2
Town of Dewey-Humboldt WPA	1796	2.25	4041.0
Verde	724	2.27	1643.5
Verde Village WPA	762	2.53	1927.9
Williamson WPA	2173	2.35	5106.6
Totals	78102		182180.3

*Parcel data from the Yavapai Co. parcel GIS database.
The database was queried for Usage_Type = "Res" Or "Res/IPR"
Res = Residential
Res/IPR = Residential with no permanent structures such as mobile homes
Kevin Blake, GIS Manager for Yavapai Co. explained the field definitions
Leslie Graser looked up the Census' "per occupied housing unit" number for each WPA

Prescott AMA AG Demand with Surface Water

Discussion: TWG members recognized that there may be some agriculture that relied on surface water supplies. These uses are not accounted for by the ADWR annual reports. Two locations in particular needed to be researched, agriculture associated with Del Rio Spring, and the SW releases off of Watson Lake (Granite Dells Ranch).

Del Rio Springs: The identified parcel and nearby lands were reviewed using 2005 and 2007 imagery. Neither year showed a strong vegetation pattern. *See file: DelRioBond_AgwithSW.pdf.* It was somewhat patchy. The GIS file NDVI July17_2006 which was completed by ADWR staff was also referenced. In that file the blue line polygons were ones that were digitized into the dataset because it looked like the field may be idle. The red line polygons were fields identified by the NDVI due to their strong vegetation signal. Since the ploygons in blue were so patchy, it was thought that Del Rio spring discharge records should be checked. There is a USGS gage at Del Rio near Chino Valley (09502900), *see table to right.* ADWR, 2002 also stated, 'The generalized decrease in hydraulic head throughout the LIC sub-basin is projected to further decrease the groundwater discharge rate near Del Rio Springs (spring flow at the surface and subsurface flow)."

Water Year	Discharge, cubic feet per second
1997	2.10
1998	1.96
1999	1.95
2000	1.91
2001	1.76
2002	1.56
2003	1.50
2004	1.32
2005	1.31
2006	1.08
2007	1.05
2008	1.04

Based in this evidence and discussions at the July 2009 TWG meeting, water supplies used at Del Rio would not be included in the CYHWRMS demand table. *See July 2009 TWG meeting minutes.*

Granite Dells Ranch: The same imagery and GIS data sets were reviewed. The NDVI showed two fields that had strong signatures. Three others were in blue (hand digitized as potential AG polygons). ADWR, 2000 GIS coverage was applied to determine the historic cope type(s) field checked back in 1997-98. Both red line polygons were pasture. The other three were identified to be 2 alfalfas and 1 native pasture. The two red polygon areas totaled approximately 19 acres. If the ADWR, 2000 irrigation requirement for pastures is applied, 3.65 AF/acre, it can be estimated that the agricultural demand is 69 AF. *See files: GraniteDellsRanch_AGwithSW and GraniteDellsRanch_AgwithSW_zoom*

Connie Tucker was contacted by email on 8/14/2009. She stated that once Granite Creek flows, GD Ranch can make the call for releases off of Watson Lake. COP generally releases about 375 AF/year for irrigation and stock water. This volume was chosen for the study.

CYHWRMS PrAMA 2006 Non-Exempt Type I, Type II and 59s					
WPA	**Owner**	**Right**	**Well Reg. #**	**Amount**	**Allotment**
Dewey Humboldt	Yavapai Land Holdings	58-106508.0002	633842	0.00	5.59
Dewey Humboldt	Yavapai Land Holdings	58-106509.0001	633841	15.55	20.00
Dewey Humboldt	Yavapai Land Holdings	58-110149.0003	625214	0.00	5.00
Total DeweyHumboldt				**15.55**	**30.59**
Prescott Valley	PrescottCountryClubGC	58-108469.0002	530375	449.00	469.00
Prescott Valley	TownofPrescottValley	58-111699.0003	631279	0.00	75.00
Prescott Valley	Fain Land & Cattle	58-111963.0000	613018	0.00	12.00
Prescott Valley	Norman W. Fain II	58-111966.0001	613018	0.00	201.00
Prescott Valley	Fain Land & Cattle	58-115744.0002	613018	0.00	259.20
Total Prescott Valley				**449.00**	**1016.20**
Chino Valley	J&KA Fletcher	58-100771.0004	512905	0.00	3.00
Chino Valley	Hines Nursery, Inc	58-101428.0007	571626	54.21	98.67
Chino Valley	Town of Chino Valley	58-101753.0008	504619	21.00	13.95
Chino Valley	Josal Enterprises	58-102352.0001	624833	94.67	12.00
Chino Valley	The Bond Ranch @DRS	58-106092.0005	608241	0.00	1406.13
Chino Valley	VlachosEnterprises LLC	58-111870.0017	609088	0.00	102.25
Chino Valley	CravathWholeLife LLC	58-107940.0005	635256	0.00	55.00
Chino Valley	Town of Chino Valley	58-108364.0002	802111	0.32	10.00
Chino Valley	Kulmer/Nielsen	58-109278.0002	627269	0.02	68.60
Chino Valley	LDS Church	58-111865.0005	617671	10.00	7.00
Chino Valley	SilverMountainVentures	58-111930.0002	599981	0.00	4.20
Chino Valley	Town of Chino Valley	58-111958.0001	504619	0.00	6.40
Chino Valley	City of Prescott	58-117267.0000	606020	0.00	COP)3169
Chino Valley	Town of Chino Valley	58-120028.0001	60629?	0.00	11.20
Chino Valley	The Bond Ranch @DRS	58-120029.0001	608241	0.00	63.44
Chino Valley	Patrick Moore	58-120031.0000	604449	0.00	29.87
Chino Valley	Fletcher Land & Cattle	59-217097.0000	635256	0.00	279.00
Chino Valley	Gilford Bisjak	59-538980.0001	610173	6.00	6.00
Chino Valley	Del Rio Drill & Pump	59-566798.0000	566799	0.00	25.00
Chino Valley	CV School - Del Rio	59-570754.0000	501609	73.24	80.00
Chino Valley	CVHS	59-570755.0000	631384	121.20	120.00
Chino Valley	R&L Howlett	59-578329.0000	507356	0.00	24.50
Chino Valley	Metro Materials	59-585032.0000	579607	2.37	20.00
Chino Valley	Yavapai College *	59-591433.0000	606295	43.00	80.00
Chino Valley	Lonesome Valley LLC	59-593403.0001	593404	97.00	100.00
Total Chino Valley				**523.03**	**2626.21**
Prescott	Industrial Devel Auth	58-101244.0000	602924	0.70	15.00
Prescott	City of Prescott	59-218227.0000	212087	0.00	10.00
Total Prescott				**0.70**	**25.00**
Prescott CCD	Camp Tepeyac	59-561258.0002	527848	0.00	10.00

Total Prescott CCD				**0.00**	**10.00**
Mingus Mtn CCD	Heritage Memorial Park	58-111964.0000	575576	6.39	54.70
Mingus Mtn CCD	Fain Limited Partnership	58-111967.0004	550395	334.00	176.25
Mingus Mtn CCD	Empire Res. Constr.	58-109214.0001	202098	0.00	2.70
Mingus Mtn CCD	Hanson Aggregate	59-218233.0000	558501	0.00	200.00
Mingus Mtn CCD	United Metro Materials	59-585030.0001	579444	28.00	70.00
Total Mingus Mtn CCD				**368.39**	**503.65**

* Adjusted based on personal communication with Mark Holmes, Town of Chino Valley.
See ToCVandCOPmeeting_021809_outcome.doc

Volumes to assign to exempt wells in the CYHWRMS

Description: Source documents brought to the TWG in 1/2009 in order to select a volume to assign to exempt wells.

<u>Outcome:</u> During the January 22nd 2009 meeting, the stakeholders agreed that the wells identified with the exempt well query should have a 0.3 AF/year demand associated with them. In order to cite existing publications for exempt well use, the study team applied 0.33 AF/year to exempt well.

Supervisor Springer asked for a comparison to be done with residential use only volumes from the various providers in the study area. This was to check the 0.33 number in the event it may be too high for rural areas in the county. Please see the table in this document. Outcome was that 0.33 AF was still acceptable.

Source info for 1/22/09 TWG workshop

Previous Reports

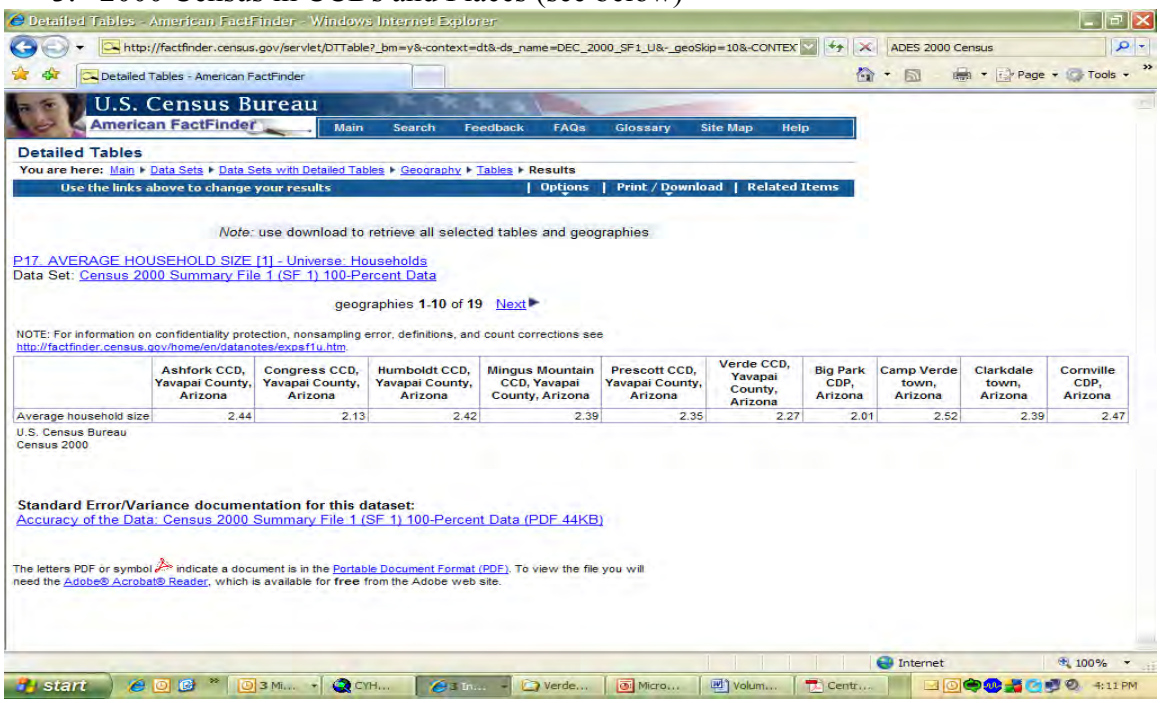
	Report	Volume	Area it was applied to:
1	Prescott AMA Model, 1995	0.5 AF/year/well	GW basin area in the Prescott AMA
2	Verde River Watershed Study, 2000	97 gpcd (0.24 AF/year *2.35 pph = **<u>0.56 AF/yr/well)</u>**	Upper Verde
		133 (0.33 AF/year*2.35 pph = **<u>0.78 AF/yr/well)</u>**	Middle Verde
3	Prescott AMA Hydrologic Monitoring Report, 2002	0.5 AF/year/well	Prescott AMA groundwater basin
		0.33 AF/year/well	Prescott AMA marginally productive areas
4	Domestic Well GPCD Rates for the Upper San Pedro Basin, 2005	0.55 af/person/year	Benson Sub-Area
		0.35 af/person/year	Sierra Vista Sub-Area
5	Prescott AMA Model Update, 2006	Same as report 3 in this table	Same as report 3 in this table
6	Hydrogeology of the Upper and Middle Verde, 2006	Same as report 2 in this table	Same as report 2 in this table
7	Long-Term Scenario Development #1	Same as reports 3 and 5 in this table	Same as reports 3 and 5 in this table

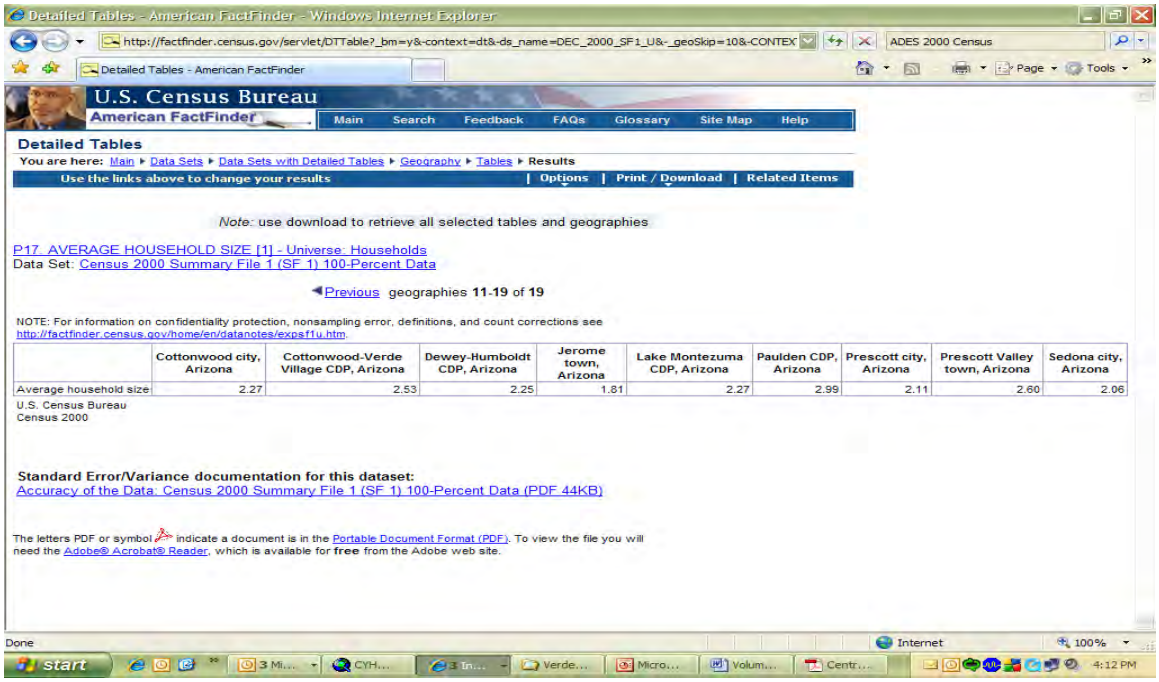
1. Corkhill and Mason, 1995, PrAMA Modeling Report pg 77. Pumpage for exempt wells is estimated to average about **<u>0.5 AF/year/well/year</u>** (Foster, 1993b)

2. ADWR, 2000, Verde River Watershed Study, pgs. 3-6 to 3-8. The average residential GPCD for the Upper Verde and Middle Verde water providers that delivered in excess of 20 AF of water in 1997 is 97 (0.24 AF/year *2.35 pph = **0.56 AF/yr/well in Upper Verde**) and 133 (0.33 AF/year*2.35 pph = **0.78 AF/yr/well in Middle Verde**) respectively. The residential GPCDs are also used to calculate the annual volume of water pumped by the active domestic wells in both the Upper Verde and Middle Verde regions.
3. ADWR, 2002, pg. 17. Average annual pumpage for exempt wells located within the **groundwater basin area** of the AMA has been estimated at **.5 AF/year per well**. Pumpage for exempt wells located in the **marginally productive area** that surround the groundwater basin portion of the AMA has been estimated by Remick (2002) to be about **.33 AF/year per well.**
4. ADWR, 2005, Calculation of Domestic Well GPCD Rates for the Upper San Pedro Basin Active Management Area Review Report.
   Benson sub-area's total domestic well use = .12 + .435 = **.55 af/person/year**
   Sierra Vista sub-area's total domestic well use = .12 + .23 = **.35 af/person/year**
   A **New Mexico** study estimated domestic well use at **.35 acre-feet per residence per year** assuming 114 GPCD and 2.74 pphu.[1]
5. Timmons, 2006, PrAMA model update, pg 17. Followed ADWR, 2002, see item 3.
6. Blasch, 2006, Hydrogeology of Upper and Middle Verde, pg. 87. Followed ADWR, 2000, see item 2.
7. H3J Consulting, 2008, Long Term Scenario Development #1, pg 30. Same as items 3 and 5.

Census Person Per Household (pph)

1. 1990 Census in Yavapai County = 2.35 pph
2. 2000 Census in Yavapai County = 2.33 pph?
3. 2000 Census in CCDs and Places (see below)





Detailed Tables - American FactFinder - Windows Internet Explorer

http://factfinder.census.gov/servlet/DTTable?_bm=y&-context=dt&-ds_name=DEC_2000_SF1_U&-_geoSkip=10&-CONTEX

U.S. Census Bureau
American FactFinder

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Detailed Tables

You are here: Main ▸ Data Sets ▸ Data Sets with Detailed Tables ▸ Geography ▸ Tables ▸ Results

Use the links above to change your results | Options | Print / Download | Related Items

Note: use download to retrieve all selected tables and geographies

P17. AVERAGE HOUSEHOLD SIZE [1] - Universe: Households
Data Set: Census 2000 Summary File 1 (SF 1) 100-Percent Data

Previous geographies **11-19** of **19**

NOTE: For information on confidentiality protection, nonsampling error, definitions, and count corrections see http://factfinder.census.gov/home/en/datanotes/expsf1u.htm.

	Cottonwood city, Arizona	Cottonwood-Verde Village CDP, Arizona	Dewey-Humboldt CDP, Arizona	Jerome town, Arizona	Lake Montezuma CDP, Arizona	Paulden CDP, Arizona	Prescott city, Arizona	Prescott Valley town, Arizona	Sedona city, Arizona
Average household size	2.27	2.53	2.25	1.81	2.27	2.99	2.11	2.60	2.06

U.S. Census Bureau
Census 2000

Standard Error/Variance documentation for this dataset:
Accuracy of the Data: Census 2000 Summary File 1 (SF 1) 100-Percent Data (PDF 44KB)

The letters PDF or symbol indicate a document is in the Portable Document Format (PDF). To view the file you will need the Adobe® Acrobat® Reader, which is available for **free** from the Adobe web site.

Done | Internet | 100%

Comparison using residential volumes from water provider for Supervisor Springer.

Discussion: On 6/3/09, John and Leslie G. met with Supervisor Springer to discuss the basics of the study and the current draft documents (Four - Phase I products). In that meeting Sup. Springer ask for a comparison of the 0.33 AF/year, which was chosen for exempt well demand by the TWG in 01/09 (TWG workshop), to water providers who serve residential customers. The following looks at this question in two ways:

1. Single Family Connections and the Quantity Delivered in AF/year

WPA	*System*	*Data Source*	*Single Family (residential) Connections*	*Quantity Delivered (AF/year)*	*AF/connection*
Camp Verde	Camp Verde Water System	ADWR CWS AR, 2007	1190	250	0.2
Clarkdale	Clarkdale Public Water System	ADWR CWS AR, 2007	1432	361	0.3
Cottonwood	Verde Santa Fe	ADWR CWS AR, 2007	890	177	0.2
Jerome	Jerome	ADWR CWS AR, 2007	230	64	0.3
Prescott Valley	Prescott Valley Municipal Water System	ADWR AMA AR, 2007	1937	462	0.2

Chino Valley	Town of Chino Valley	ADWR AMA AR, 2007	392	69	0.2
Prescott	City of Prescott	ADWR AMA AR, 2007	17605	4251	0.2
Sedona	Az Water Co. - Sedona	ADWR CWS AR, 2007	4449	1835	0.4
Sedona	Oak Creek Water No. 1	ADWR CWS AR, 2007	586	168	0.3
Paulden	Abra Water Co.`	ADWR CWS AR, 2007	633	152	0.2
Big Park CDP	Big Park Water Co.	ADWR CWS AR, 2007	2749	630	0.2
Big Park CDP	Az Water Co. - Valley Vista	ADWR CWS AR, 2007	665	266	0.4
Cornville	Oak Creek Valley	ADWR CWS AR, 2007	185	567	3.1
Lake Montezuma CDP	Az Water Co. - Rimrock	ADWR CWS AR, 2007	1098	261	0.2
Verde CCD	Little Park Water Co.	ADWR CWS AR, 2007	69	44	0.6
Verde CCD	Cup of Gold Water Co.	ADWR CWS AR, 2007	26	20	0.8
Prescott CCD	American Ranch DWID	ADWR CWS AR, 2007	43	16	0.4
Average:					0.5
Average (if Cornville is removed from the set):					0.3
Mode:					0.2

2. Converting 0.33 acrefeet to gpcd (0.33 = 128 GPCD):

0.33 acft * 325,851 gallons per acft = 107,531 gallons per year per well
107,531 divided by 365 = 294.61 gallons per day per well
294.61 divided by **2.3 people per household** = 128 gallons per person per day (GPCD)

Residential Use by Providers:

Prescott Valley = 102 GPCD

Clarkdale = 83 GPCD

(Reported to John Ras by Town Reps (JM, DvG) with note that 0.33 is appropriate for wells for the study)

NOTE: Also See Column I in "Draft TWG Table" (1st on this file)

Column I is a similar calculation based on municipal residential use (removal of agriculature and commercial/industrial from total)
Column I includes miscellaneous restaurant and business use that is not included in industrial/commercial. Thus PV, for instance, shows 136 instead of 102.

Central Yavapai Highlands Water Resource Management Study (CYHWRMS)

Appendix B

Phase 2: Water Resources Inventory Report

- **Water Resources Inventory Study Report Final 11-15-11**

Central Yavapai Highlands Water Resources Management Study
Phase II
Water Resources Inventory
Report

November 2011

I. Introduction

The Central Yavapai Highlands Water Resource Managements Study (CYHWRMS) is proceeding as per the original Plan of Study to assess future water supply needs and alternatives for meeting those needs within the study area (see Figure 1). The CYHWRMS is an appraisal level study funded through a cost share agreement between the Bureau of Reclamation (Reclamation), the Arizona Department of Water Resources (ADWR) and the Yavapai County Water Advisory Committee (WAC). In addition to the contributions of the study partners, many other stakeholders have contributed to the study through significant in-kind services such as data sets, research, report preparation and review.

The first phase of the study, the Demand Analysis, identified future unmet water demands for the study planning areas (see Figure 1). The second phase is the Water Resources Inventory and is the subject of this report. The purpose of this inventory is to identify potential sources of water to satisfy unmet demands in the study's planning areas. This report documents the Phase II findings by describing data and conclusions regarding availability of surface water, groundwater, wastewater, flood water, storm water, and effluent. The potential water sources are divided into those that are within the study area and those that are outside of the study area.

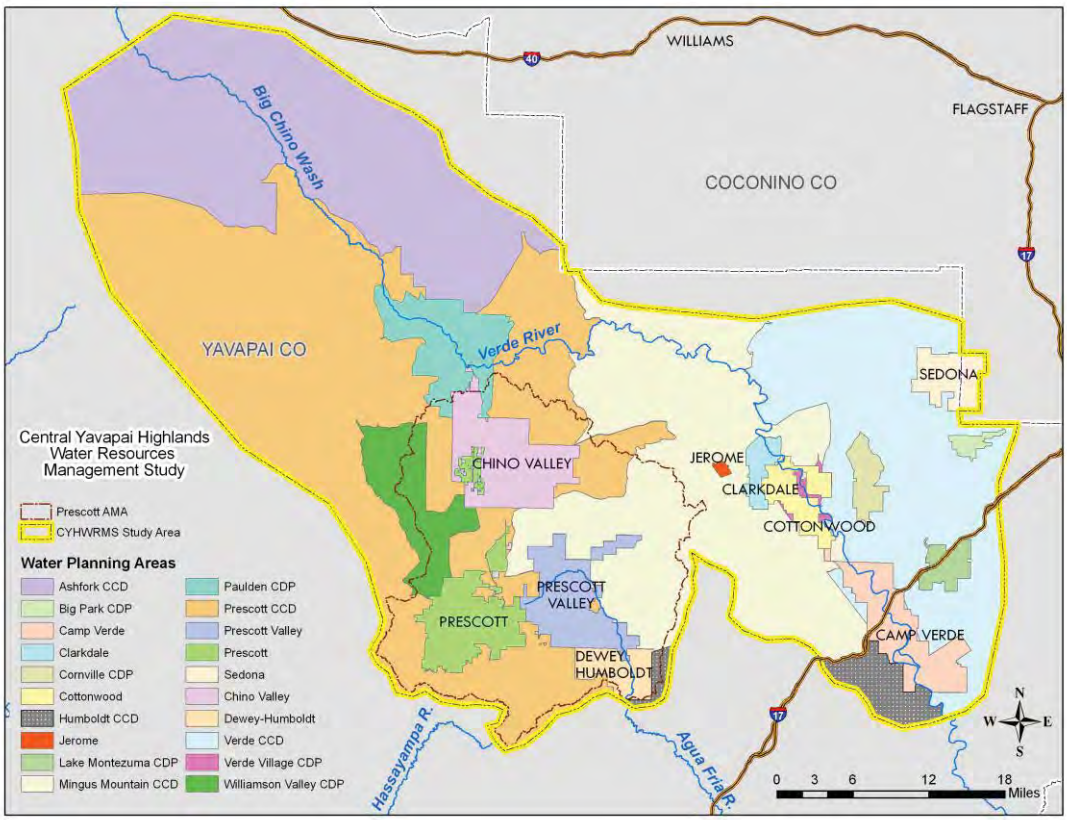

Figure 1. CYHWRMS Study Area Map showing Water Planning Areas

II. Summary of Findings

Tables 1, 2 and 3 are a summary of the conclusions of the Water Resources Inventory. Table 1 identifies sources located within the study area and tables 2 and 3 show results for sources located outside of the study area. The tables represent appraisal level analysis based on available information and input from the CYHWRMS Technical Working Group. The text that follows the tables also summarizes the Phase II findings. More detailed information on the assumptions and analysis for each source is in the sections that follow the Summary of Findings.

A. Sources of Water Within the Study Area

Table 1. Water Resource Availability within Study Area

	Big Chino Sub-Basin	Little Chino and Upper Agua Fria Sub-Basin (Prescott AMA)	Verde Valley Sub-Basin
Surface Water	No	No	No
Groundwater	Yes	Yes	Yes
Wastewater			
Septic	Yes	Yes	Yes
Mine Drainage	No	No	No
Brackish/Saline	No	No	No
Flood Water	Yes	Yes	Yes
Storm Water	Yes	Yes	Yes
Effluent	Yes	Yes	Yes

1. Surface Water

a. Rivers and Streams
The analysis of Statements of Claimant (SOCs) and surface water filings in the Verde and Agua Fria Watersheds concludes that existing claims for surface water far exceed available supply. Therefore, with the exception of major flood events (see Flood water section); new sources of surface water are not available within the study area to meet new water demands.

b. Springs
As with other surface water claims, the amount of water claimed for beneficial use from each spring exceeds the amount physically available. Additionally, it is assumed that all surface water produced from springs in the study area today is either fully consumed or contributes to stream flow, therefore, it may be concluded that there is no new surface water available in the study area from springs.

c. Lakes and Reservoirs
Water supply from the larger lakes and reservoirs is quantified; however, data is very limited for smaller reservoirs. Willow Creek Reservoir and Watson Lake are the largest lakes in the study area. All water from these two lakes is claimed for use and already accounted for in the CYHWRMS Demand Analysis by the city of Prescott. Based on the best available data, it is assumed that no new water is available within the study area from lakes and reservoirs.

2. Groundwater

a. Basin-Fill Aquifers
Based on referenced information and specific yield calculations, the Big Chino sub-basin aquifer has between 6 and 15 million acre feet (maf) of water available for pumping. The Prescott AMA aquifer has approximately 3.0 maf, and the Verde Valley has between 4.5 and 11 maf in places beneath the Big Chino and Verde Valley.

Some of the available supply may be of poor quality or subject to other limitations imposed by aquifer properties, legal, environmental, or economic issues. Additionally, groundwater use in amounts greater than the net recharge results overdraft of the aquifer. The Prescott AMA and the Verde Valley are currently in a state of overdraft.

b. Paleozoic age rock Aquifers
There may be additional water in Paleozoic aquifers, but it is not well understood. Some of the available supply may be of poor quality or subject to other limitations imposed by aquifer properties, legal, environmental, or economic issues.

3. Wastewater

a. Septic
The volume of water estimated to be available in urban areas (water served by a provider) from septic tank storage is 3,368 afy. An additional 2,766 afy of wastewater may be available in rural areas. This source of water would require high levels of treatment and the construction of a significant infrastructure system, both sewer and WWTFs, to make this water supply available to incorporate into any water supply budget.

b. Mine Drainage
While there are many mines in the study area; there appears to be little or no data to quantify mine drainage water volumes available for use anywhere in the study area. Drainage from mines does not appear to be a viable option as source water for local or regional supply.

c. Brackish/Saline
There is little or no brackish/saline water within the study area, therefore, brackish/saline waters are not considered to be available for development as either a local or regional water supply.

4. Flood Water

Flood water is generated in tributaries in each of the sub-basins and is available to be developed as an additional supply in the study area. Water supply developed from the collection and storage of unappropriated flood water is dependent on high flow events

and will be relatively unreliable. Additionally, this supply will likely be quite expensive and may have many issues associated with location of diversion and potential exchanges on the Verde River.

5. Storm Water

Storm water may have the potential to produce large volumes of surface runoff within any given developed community and, potentially, on a larger landscape scale, however, information relating to storm water runoff volumes is limited.

6. Effluent

There are three sources of effluent development in the study area. The first is the conversion of existing septic to sewer systems. This alternative could produce more than 3,000 afy. The second effluent development alternative assumes that all new growth would be provided access to a sewer system. This assumption could produce 30,000 afy of new supply within the study area by 2057. The third alternative is effluent not currently utilized by treatment facilities. There are almost 1,896 afy of unutilized effluent within the study area in 2010.

B. Sources Outside of the Study Area

For the purpose of this study, it is assumed that wastewater, storm water and effluent are localized alternatives and are not feasible for development and importation into the study area. Therefore, only surface water, including flood water, and groundwater were examined for development outside of the study area. Tables 2 and 3 summarize the findings for sources outside of the study area.

1. Surface Water

There are six (6) Arizona Surface Water Basins surrounding the Verde River Basin (equivalent to a portion of the CYHWRMS area). The surface water basins are: Agua Fria River, Colorado River, Little Colorado River, Salt River, Middle Gila River, and Bill Williams River. As with surface water availability in the study area, surface water availability in the surrounding basins is likewise limited. With ongoing general stream adjudications and Indian waters rights settlements it is difficult to quantify surface water available, in excess of existing appropriations, to meet the future water supply needs in the study area. For the purpose of this study, it is assumed that the most likely sources of surface water outside of the study area are the Colorado and Bill Williams Rivers. Although the Verde River has many SOCs, legal and environmental concerns, unappropriated flood water may be available for development outside of the study area (i.e. Horseshoe and Bartlett Dams).

Table 2. Surface Water Resource Availability outside the Study Area

River Basin	Surface Water
Agua Fria	No
Colorado	Yes
Little Colorado	No
Salt	No
Middle Gila	No
Bill Williams	Yes
Verde	No

2. Groundwater

There are 12 groundwater basins that touch one or more sub-basins of the study area. Groundwater is the main source of water supply in the Yavapai County Water Resources Management Study area and throughout much of rural Arizona.

Although there are sources outside of the study area, those immediately to the east and north of the study area have been investigated in other water resources planning studies (i.e. Mogollon Rim Water Resources Management Study and North Central Water Supply Study) and in most cases have been found to be unsustainable as a renewable supply. It is possible that groundwater may be available for development in the study area from basins to the west (i.e. Bill Williams Basin) or in any basin on a groundwater mining basis. Due to the relative proximity and potential sustainability of groundwater development, the Agua Fria, Upper Hassayampa, Big Sandy and Bill Williams basins were identified as potential sources of groundwater development outside of the study area.

Table 3. Water Resource Availability outside the Study Area

Groundwater Basins	Groundwater
Coconino Plateau	No
Little Colorado Plateau	No
Agua Fria	Yes
Salt River	No
Tonto Creek	No
Upper Hassayampa	Yes
Verde River	No
Phoenix AMA	No
Prescott AMA	No
Big Sandy	Yes
Bill Williams	Yes
Peach Springs	No
Shivwits Plateau	No

III. Analysis of Potential Sources of Water

This section documents the analyses used as a basis for the conclusions presented in Tables 1, 2 and 3 and the Summary text.

A. Water Resources Available Within the Study Area

1. Surface Water

Arizona Revised Statues § 45-101 defines surface water as "waters of all sources, flowing in streams, canyons, ravines or other natural channels, or in definite underground channels, whether perennial or intermittent, floodwaters, wastewaters, or surplus water, and of lakes, ponds and springs on the surface." For purposes of this report, this definition of surface water will be divided into rivers/tributaries, springs, and lakes/reservoirs. Floodwaters and wastewaters are addressed in other sections of the report.

In the sections that follow each category of surface water is discussed and quantified if possible, followed by an analysis of water availability. The discussion supports the overall conclusion that new surface water is not available within the study area to satisfy future unmet demands.

a. Rivers/Tributaries

Water Supply

There are two major river systems in the study area; the Verde River and the Agua Fria River. The Verde River watershed in the study area contains the Big Chino, Little Chino and Verde Valley sub-basins. The Verde river runs 94 miles through the study area. The Agua Fria River begins in the Prescott Active Management Area (PrAMA) and runs approximately 20 miles through the study area.

Within or near the study area the Verde River is measured at five gages, while the Agua Fria River is measured at one gage. Table 4 shows the median and mean annual flow for the two rivers in afy. Both measuring stations located just outside the study area. As a result, the measurements include the accumulated flow from tributaries upstream. Figure 2 shows the location of the gages.

Table 4. Median and Mean Annual Flow of Verde and Agua Fria Rivers within the Study Area

River	USGS Station Number	Median Annual Flow (afy)	Mean Annual Flow (afy)	Years of Annual Flow Record
Agua Fria River	09512450	3,257	4,102	10
Verde River	09506000	222,679	293,299	33

Source: USGS Water Data(http://waterdata.usgs.gov/az/nwis/current/?type=flow)

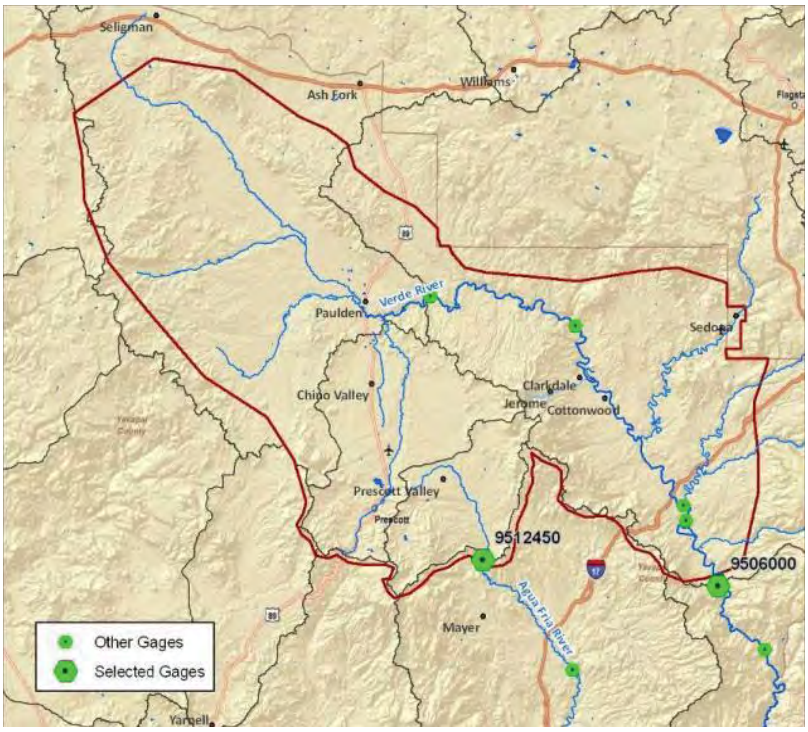

Figure 2. Location of USGS gages used to report annual flow of Verde and Agua Fria Rivers within (or just downstream) from the study area (study area boundary is shown)

Significant tributaries with measured flow to the Verde River include Williamson Valley Wash, Sycamore Creek, Oak Creek, Beaver Creek, West Clear Creek and Granite Creek. Table 5 shows USGS flow measurements for these tributaries. Note that not all the tributaries have measurement gages. Figure 3 illustrates that the locations of streams with the highest flows are located in the southeast portion of the Verde Valley sub-basin and, therefore, included in flows represented by the USGS gage "Verde River near Camp Verde" (gage #09506000).

Table 5. Median and Mean Annual Flow of Verde River Tributaries

Stream	USGS Station	Median Annual Flow (afy)	Mean Annual Flow (afy)	Years of Annual Flow Record
Beaver Creek	09505500	64,072	70,274	6
Granite Creek	09503000	3,133	5,036	26
Oak Creek	09504500	51,402	61,972	56
Williamson Valley Wash	09502800	2,064	5,199	20
Willow Creek	09503500	422	631	4

Source: ADWR Water Atlas
http://www.azwater.gov/AzDWR/StatewidePlanning/WaterAtlas/CentralHighlands/documents/volume_5_VRB_final.pdf
http://www.azwater.gov/azdwr/StatewidePlanning/WaterAtlas/ActiveManagementAreas/documents/Volume_8_PRE_final.pdf

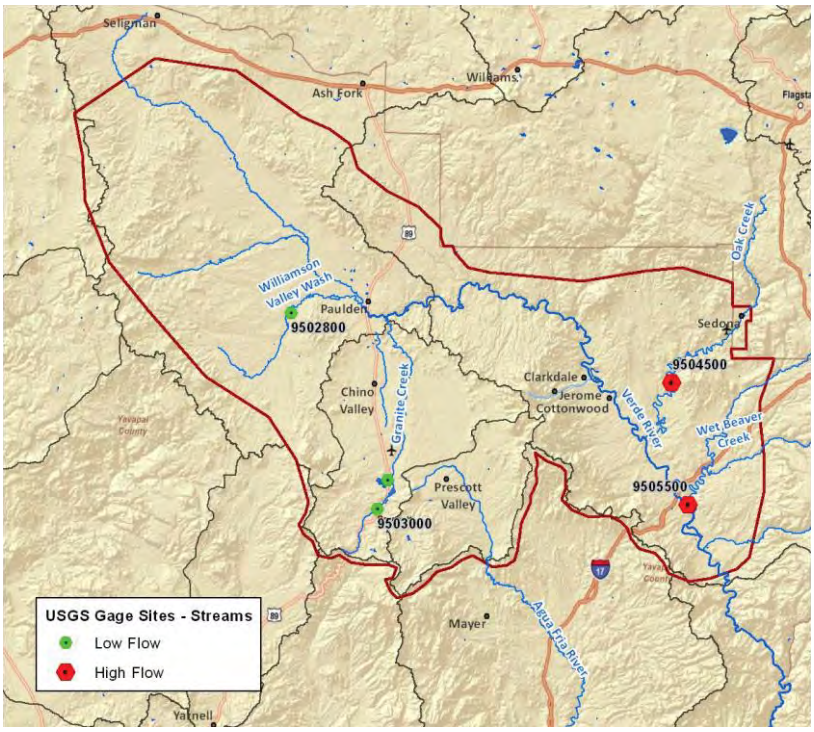

Figure 3. Location of USGS Gage Sites measuring Tributaries

Available Water

Since 1974, the ADWR has been completing a general stream adjudication for the Gila River System, which includes the rivers and streams in the study area.

A general stream adjudication is a judicial proceeding to determine or establish the extent and priority of water rights in the Gila River system. Thousands of claimants and water users are joined in these proceedings that will eventually result in the Superior Court issuing a comprehensive final decree of water rights for the Gila system. Adjudications are conducted pursuant to Arizona Revised Statutes sections 45-251 to 45-264.

On April 26, 1974, the Salt River Valley Water Users' Association (SRP) filed a petition with the Arizona State Land Department to determine the water rights in the Salt River above Granite Reef Dam. SRP filed a similar petition on February 24, 1976 for the Verde River and its tributaries. Petitions for other watersheds within the Gila River system followed and on December 24, 1980, the Buckeye Irrigation Company filed a motion to intervene and a petition to enlarge the scope of the adjudication with respect to all areas of the Gila River watershed not included in the previously filed petitions. This motion and petition were granted on March 17, 1981, and included the Agua Fria River watershed and portions of the Lower Gila River watershed.

In November 1981, the Arizona Supreme Court consolidated these petitions into one proceeding assigned to the Maricopa County Superior Court under the caption In re the General Adjudication of All Rights to Use Water in the Gila River System and Source, Nos. W-1, W-2, W-3 & W-4 (Consolidated).

This case continues today and will extend well beyond the end of this appraisal study. Due to this legal proceeding, it is evident that conclusively determining a quantity of available surface water is beyond the scope of this appraisal study, however, there are opportunities to use ADWR SOC and Surface Water Filing data to demonstrate the likelihood of available surface water.

Adjudication Statements of Claimant

An SOC is an official claim of a water right and will be used in the court adjudication proceedings. ADWR houses all the SOCs filed in the Adjudication. ADWR has also developed a Geographical Information Systems (GIS) database that includes a spatial layer representing the locations of the SOCs claiming surface water in the State of Arizona (Statement of Claimant 12/2008). Of the over 82,600 SOCs have been filed in the Gila River System, 22,306 SOCs have use locations within the Verde and Aqua Fria Watersheds. Figure 4 shows the study area in relation to the Verde and Agua Fria Watersheds. There are 11,998 SOCs within the study area. Typical fields in ADWR data set include water source, water volume claimed, file date, type of water use, location of use and location of diversion. Many of the SOCs are missing key data. Less than 40% of the SOCs include a water volume entry. However, the data that is available does provide a perspective on the potential number of SOCs and volumes for particular water sources.

The Verde Watershed is comprised of three primary sub-watersheds; the Big Chino sub-watershed, the Upper Verde sub-watershed and the Lower Verde sub-watershed. The study area is located within the Big Chino and Upper Verde sub-watersheds. Even though the Lower Verde sub-basin is outside the study area, the number of SOCs has bearing on water availability because early priority claims in the lower reaches of the watershed have senior rights to be fulfilled by stream flows moving through the study area. Some of the more notable claimants in the Lower Verde sub-basin are the Gila River Indian Community, the Salt River Project, the Fort McDowell Yavapai Nation and the City of Phoenix.

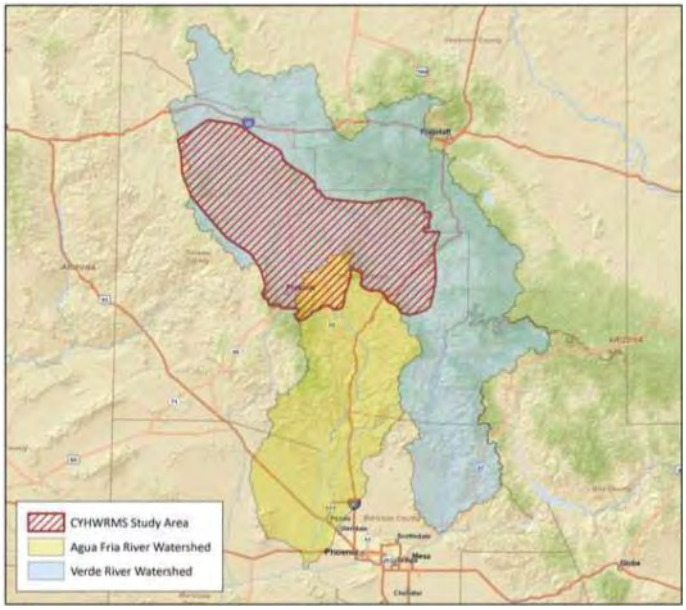

Figure 4. Location of the Study Area relative to the Verde and Agua Fria River Watersheds

The tables (Table 6, 7, 8) below identify the number of SOCs claiming surface water for uses located within drainage areas identified by USGS hydrologic units (or tributaries)[1] within each sub-basin (See Figure 5). Recognizing that sub-flow is a significant issue in the Adjudication, for purposes of this analysis, SOCs claiming wells as the only point of diversion have not been included. Groundwater is discussed later in this report.

[1] The Watershed and Sub-basin hydrologic units were developed by the USGS to provide a uniquely identified and uniform method of subdividing large drainage areas. The smaller sized 6th level sub-watersheds (up to 250,000 acres) are useful for numerous application programs supported by a variety of local, State, and Federal Agencies and used as a tool for water-resource management and planning activities, particularly for site-specific and localized studies requiring a level of detail provided by large-scale map information. The dataset is seamless and, for the most part, a nationally consistent geospatial database.

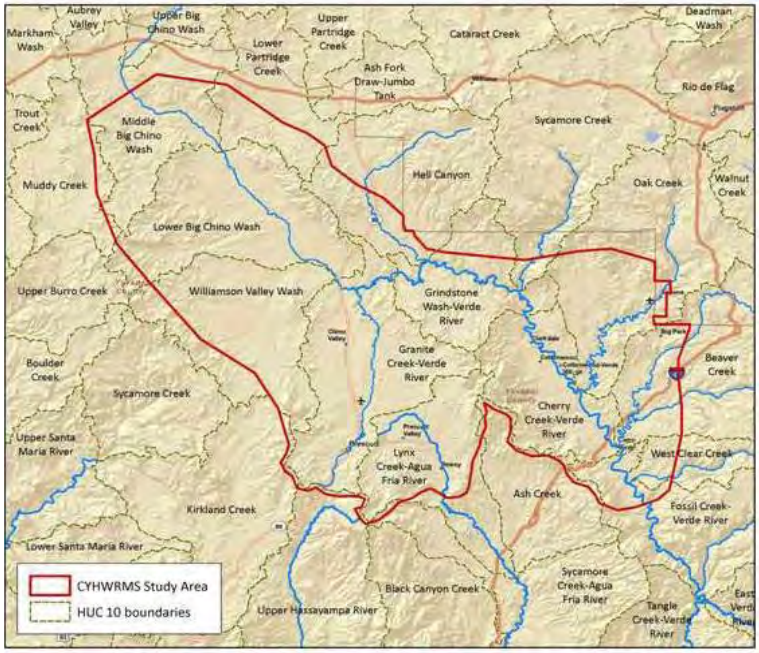

Figure 5. Study Area in relation to the HUC 10 Hydrologic Units as identified by the USGS.

Table 6. Big Chino Sub-Basin Statement of Claims

Tributary	# of SOCs	Volume (acre feet)
Aubrey Valley	0	0
Upper Big Chino Wash	16	154
Upper Partridge Creek	109	1,036
Lower Partridge Creek	74	2,072
Middle Big Chino Wash	186	1,053
Ash Fork Draw	106	412
Lower Big Chino Wash	360	1,604
Williamson Valley Wash	407	1,048
Total	**1,258**	**7,379**

Table 7. Upper Verde Sub-Basin Statement of Claims

Tributary	# of SOCs	Volume(acre feet)
Granite Creek	1,569	18,015
Hell Canyon	248	656
Grindstone Wash	160	9,195
Sycamore Canyon	481	2,034
Oak Creek	1,061	10,530
Cherry Creek	1,377	54,908
Beaver Creek	631	1,551
Total	**5,527**	**96,889**

Table 8. Lower Verde Sub-Basin Statement of Claims

Tributary	# of SOCs	Volume (acre feet)
West Clear Creek	390	19,507
Fossil Creek	681	59,528
East Verde River	445	3,733
Tangle Creek	203	79
Horseshoe-Bartlett Reservoirs	218	533[2]
Sycamore Creek	109	54
Camp Creek	110	2,011,775
Total	**2,156**	**2,095,209**

As indicated in the tables above, almost 2.2 million acre feet of surface water is being claimed in 8,941 SOCs on the Verde Watershed. The amount of water claimed far exceeds the mean annual flow of the Verde River by several times (mean annual Verde Flow at gage 0950600 is approximately 293,000 acre feet).

Table 9 below depicts the number of SOCs and claimed volume in the Agua Fria Watershed, which is much smaller in size than the Verde Watershed but still contains several tributaries.

Table 9. Agua Fria Watershed Statement of Claimants

Tributary	# of SOCs	Volume (acre feet)
Lynx Creek	721	3,373
Ash Creek	287	1,520
Black Canyon Creek	400	454
Sycamore Creek	620	2,693
Agua Fria River	541	11,593
Trilby Wash	91	854
New River	297	44,580
Cave Creek/ACDC	186	206,291
Agua Fria below Lake Pleasant	216	2,805,448
Total	**3,359**	**3,076,806**

Again, the amount of surface water being claimed in SOC's on the Agua Fria Watershed exceeds the mean annual flow of the river by many times (mean annual Agua Fria flow at gage 09512450 is 4,102 Acre feet).

[2] SRP's claims for its Verde Reservoirs are included in the Camp Creek subtotal.

Surface Water Filings

A similar analysis (excluding volumes) was made for the various surface water filings that will provide the foundation for the water rights being claimed by the SOCs. Rights and claims are utilized as the basis of claim for an SOC. The ADWR surface water rights database includes rights and claims established under the Public Water Code of June 12, 1919 (filing prefix 4A, 3R, 33); the 1974 Water Rights Registration Act (prefix 36) and the 1977 Stockpond Registration Act (prefix 38). Water filings with the prefix "4A" or "3R" are likely to have high priority rights because of the doctrine of "first in time, first in right".
Tables 10, 11, 12 and 13 below depict the number of surface water filings in each of the sub-basins in the study area.

Table 10. Big Chino Sub-Basin Surface Water Filings

Tributary	**# of 4A, 3R, 33**	**# of 36 claims**	**# of 38**
Aubrey Valley	0	0	0
Upper Big Chino Wash	29	32	11
Upper Partridge Creek	24	80	80
Lower Partridge Creek	37	33	22
Middle Big Chino Wash	54	114	36
Ash Fork Draw	9	57	48
Lower Big Chino Wash	41	261	82
Williamson Valley Wash	50	243	112
Total	**244**	**820**	**391**

Table 11. Upper Verde Sub-Basin Surface Water Filings

Tributary	# of 4A, 3R, 33	# of 36 claims	# of 38
Granite Creek	63	225	449
Hell Canyon	35	44	95
Grindstone Wash	5	31	100
Sycamore Canyon	102	140	222
Oak Creek	100	578	221
Cherry Creek	45	751	42
Beaver Creek	72	145	309
Total	**422**	**1,914**	**1,438**

Table 12. Lower Verde Sub-Basin Surface Water Filings

Tributary	# of 4A, 3R, 33	# of 36 claims	# of 38
West Clear Creek	39	98	301
Fossil Creek	51	524	256
East Verde River	47	201	146
Tangle Creek	37	108	76
Horseshoe-Bartlett Reservoirs	28	184	33
Sycamore Creek	17	55	27
Camp Creek	20	52	29
Total	**239**	**1,222**	**868**

Table 13. Agua Fria Watershed Surface Water Filings

Tributary	# of 4A, 3R, 33	# of 36 claims	# of 38
Lynx Creek	50	265	136
Ash Creek	61	141	109
Black Canyon Creek	73	218	63
Sycamore Creek	117	306	198
Agua Fria River	90	459	138
Trilby Wash	9	60	51
New River	30	115	111
Cave Creek/ACDC	39	99	43
Agua Fria below Lake Pleasant	19	130	20
Total	**488**	**1,793**	**869**

Due to the structure of the data set for the surface water filings it was beyond the scope of this study to sum the various volumes for each filing. That will be a manual process that ADWR will eventually accomplish as part of the Adjudication. Just the sheer number of surface water filings (7,258 total filings on the Verde Watershed and 3,153 filings in the Agua Fria Watershed) further supports the magnitude of potential surface water being claimed.

Summary

This analysis of SOCs and surface water filings of the Verde and Agua Fria Watersheds concludes that existing claims for surface water far exceed available supply. Therefore, with the exception of major flood events, new sources of surface water are not available to meet new water demands in the study area

(note: In the CYHWRMS Phase I – Demand Analysis, surface water, currently used for agriculture, is assumed to be completely used by other sectors in each planning area as agricultural uses diminish (see Phase I assumptions: "CYHWRMS_m_datasources and documentation_4_10.pdf"). Therefore, there is no new surface water available from this source considered as a part of this analysis.).

b. Springs

Water Supply

According to USGS National Water Information System data a total of 33 major springs are found in the study area. Major springs are defined as having a discharge of greater than 10 gallons per minute (gpm). Major springs are largely concentrated in the Verde Valley sub-basin, which includes 30 of 33 major springs. Figure 6 illustrates the distribution of major springs in the study area.

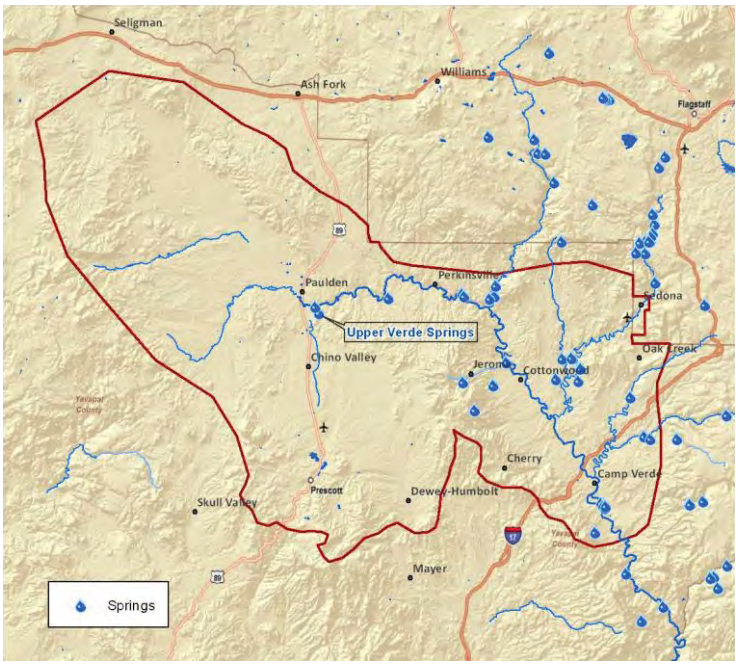

Figure 6. Major Springs in the CYH Study Area

Table 14 shows the discharge of major springs in the study area. The spring that produces the largest annual flow, Upper Verde Springs, is located in the Big Chino sub-basin and is in the Verde River flow channel.

Table 14. USGS Major Springs Discharge Data

SPRING NAME	GALLONS PER MINUTE	DATE MEASURED	AFY
Upper Verde Springs	8,941	During or prior to 1997	14,421
Bubbling Pond	3,879	5/20/1968	6,252
Unnamed	2,917	7/4/1991	4,702
Page	2,693	1/20/1975	4,341
Summers	2,100	10/12/2003	3,385
Parson	1,600	11/27/1999	2,579
Montezuma Well	916	During or prior to 1990	1,476
Del Rio Springs	874	1999	1,410
Haskell	600	10/24/1958	967
Lower Newell3	520	2/4/1959	838
Duff	449	During or prior to 1997	723
Sullivan Lake	448	During or prior to 1997	723
Lolo-Mai	300	7/10/1974	483
Tree Root	264	7/9/1952	425
Blue	230	6/11/1981	370
Unnamed3	220	11/6/1980	354
Spring Creek	207	10/12/2003	333
Unnamed3	190	6/9/1981	306
Spider John	15	10/27/1999	24
Turtle Pond	160	12/10/1952	257
Sheepshead Canyon	111	3/1/1974	178
Unnamed	90	11/6/1980	145
Beaverhead	85	6/4/1974	137
Unnamed	75	6/8/1977	120
Page area # 1	60	7/10/1974	96
Gravel Plant3	60	10/29/1958	96
Walnut	52	5/10/1978	83
Twin springs	40	5/10/1978	64
Catfish	22	6/11/1981	35
Mine	20	1/27/1982	32
Soda	15	2/6/1959	24
Unnamed3	13	11/6/1980	20
Frey Ranch	10	7/10/1974	16

Source: USGS National Water Information System http://waterdata.usgs.gov/nwis

In this analysis, five spring data sets were reviewed (Figure 7); along with the ADWR surface water filings. Nomenclature of springs varied among the data sets, spring discharge information was old or incomplete, and the amount of water claimed for beneficial use from each spring exceeded the amount physically available. The lack of current data is a concern with assessing the water supply from springs. Most measurements of discharge were taken prior to 1981. It is also impossible to determine the reliability of the water source using a single point in time measurement. Given the limitations of the data it is very difficult to assess the contribution from minor springs (discharge less than 10 gpm). Therefore, minor springs are not included in determining water supply.

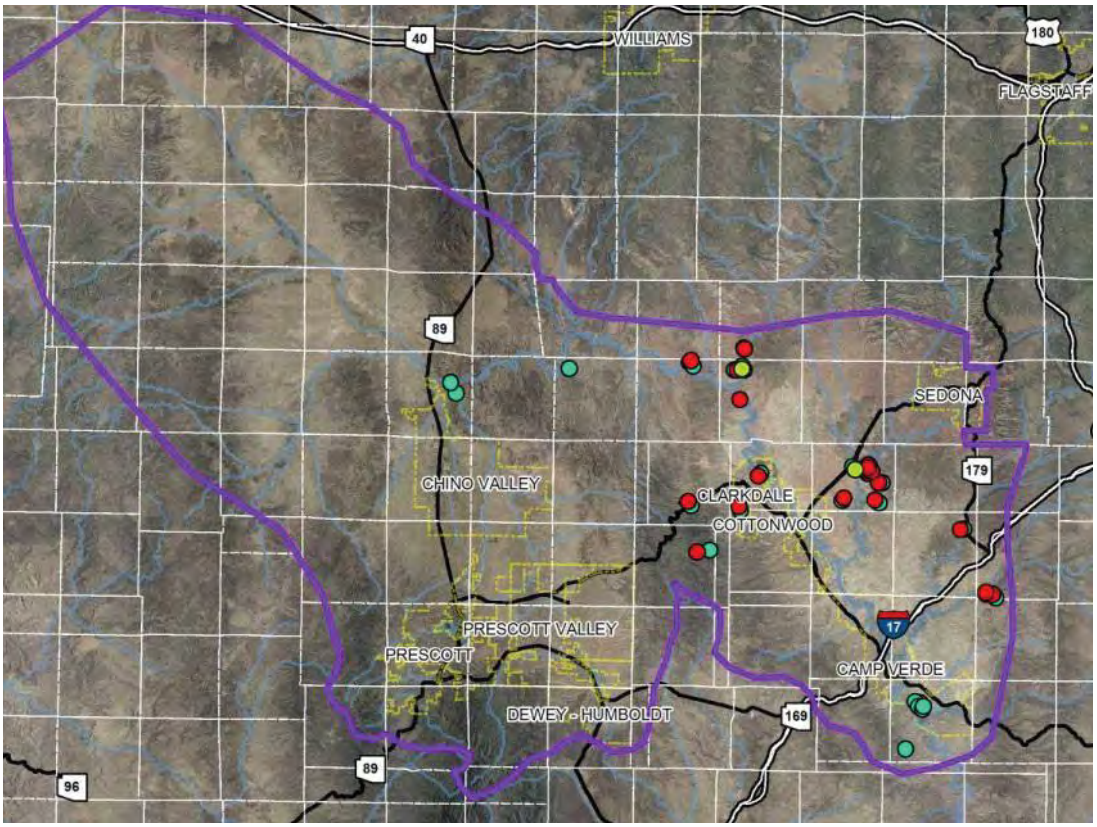

Figure 7. CYHWRMS Study Area; Springs > 10 GPM

Verde Watershed Data Sets

OwenJoyceBell_springs

- Source: Appraisal of Water Resources in the Upper Verde River Area, Yavapai and Coconino counties, 1983
- Abstract: Springs in the Verde Valley, includes discharge estimates

ADWR_springs

- Source: Arizona Department of Water Resources
- Abstract: ADWR springs in the Central Yavapai Highlands Water Resource Management Study. Includes discharge estimates, date measured.

Springs_NAU2002

- Source: Stephen Flora Thesis; Hydrogeological Characterization and Discharge Variability of Springs in the Middle Verde River Watershed, Central Arizona
- Abstract: Springs in the Verde Valley, comprehensive data set on measured springs; 160 springs total, although only a few within the CYHWRMS study area. Includes discharge data, dates measured.

Statewide Data Sets

ALRIS_springs

- Source: Arizona State Land Department, Arizona Land Resources Information System (ALRIS)
- Abstract: This data set consists of spring locations in Arizona and incorporates information extracted from both the USGS Geonames database and the USGS Digital Line Graphs (DLG)s.

- No discharge data
- Publication Date: 1993, Last Update: 12/4/2006

NHD_springs

- Source: U.S. Geological Survey, USEPA, USDA Forest Service, and other Federal, State and local partners.
- Abstract: This data set represents springs in Arizona. The Arizona State Land Department downloaded the NHD data from the USGS NHD website (http://nhd.usgs.gov/) in 2008. Since then, ASLD have made minor modifications to the data set (See Process Steps for details). Please note: This is a modified version of the NHD. For a comprehensive and more current version please visit the USGS NHD at http://nhd.usgs.gov/.
- No discharge data
- Publication Date: 2008, Last Update: 1/17/2008

In lieu of evaluating each major spring (discharges more than 10 gpm) individually, the Page Spring area was assessed as an Example Area using on a few basic assumptions: any springs that discharge on the surface are either fully consumed; or where they are not fully consumed, contribute to base flow of the river which will be accounted for in gage measurements.
Area of Analysis (Page Springs); Findings (Figure 8, Table 15)

- Names and numbers of springs are not consistent between the spring data sets and the ADWR surface water filings.
- Spring names and locations are not consistent among the data sets; data varies on discharge and is typically a single measurement in time.
- Claimed amounts for surface water filings exceed water available from spring sources.
- In many areas, including our Example Area of Analysis (Page Springs), springs feed ditches mixed with water from the river, which then serve irrigated areas; irrigated areas are not always in the immediate vicinity of the springs. Identifying which springs irrigate which acres would require extensive field work.
- Identifying the location of each spring, ensuring we have a comprehensive list of all springs, and estimating discharge available for future use would require extensive field work.

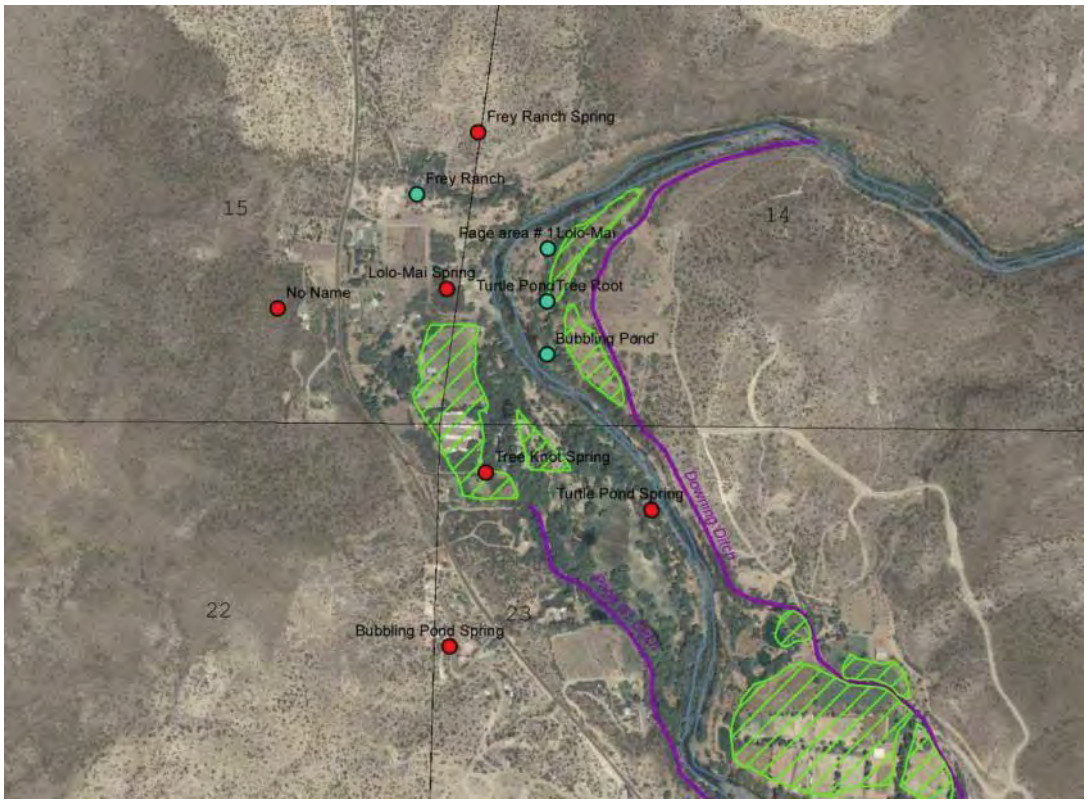

Figure 8. Example Area of Analysis; Page Springs T16N R4E; Springs > 10 GPM

Table 15. DWR Surface Water Filings; T16N R4E

PRG	APP NO	NAME	WATER SOURCE	USE1
4A	2811	WILLBANKS, E B	BATES SPRING	using 182,500.0 GALLONS PER ANUM for DOMESTIC
36	40278	PATTERSON, ALTON & SYLVIA	BLUFF	using 10.0 ACRE FEET PER ANUM for ANNUAL USE
36	13452	ASHER, ALAN	BLUFF SPRING	using 2.0 ACRE FEET PER ANUM for ANNUAL USE
36	33071	FREY, CALVIN R	BLUFF SPRINGS	using 5.8 ACRE FEET PER ANUM for ANNUAL USE
36	45609	GRABE, EARL	HOME	using 70.2 ACRE FEET PER ANUM for ANNUAL USE
36	60773	BEEBE, JAMES D	HOME SPRING	using 20.5 ACRE FEET PER ANUM for ANNUAL USE
36	33070	FREY, CALVIN R	HOME SPRING	using 12.0 ACRE FEET PER ANUM for ANNUAL USE
36	45413	DURNEZ, RALPH	LO LO MAI	using 3.0 ACRE FEET PER ANUM for ANNUAL USE
36	59851	BENTLY WRIGHT TRUST	MASON LANE DITCH	using 10.9 ACRE FEET PER ANUM for ANNUAL USE
36	62237	WEISMAN FAMILY TRUST	NO NAME	using 50,000.0 GALLONS for STOCK
36	64176	FLICK, WILLIAM A	OAK CREEK DITCH	using .1 ACRE FEET PER ANUM for ANNUAL USE
36	64176	FLICK, WILLIAM A	OAK CREEK DITCH	using .1 ACRE FEET PER ANUM for ANNUAL USE
36	66960	KINSELLA, YVON B	OAK CREEK DITCH	using 1.0 ACRE FEET PER ANUM for ANNUAL USE
4A	3430	AZ GAME & FISH DEPT	PAGE SPRING NO 2A	using 724.0 ACRE FEET PER ANUM for WILDLIFE
36	62420	AZ GAME & FISH DEPT	PAGE SPRING NO 2A	using 723.0 ACRE FEET PER ANUM for ANNUAL USE
36	102237	ASHER, ELEANOR A	PAGE SPRINGS	using 182.0 ACRE FEET PER ANUM for ANNUAL USE
4A	3417	AZ GAME & FISH DEPT	PAGE SPRINGS	using 7,963.0 ACRE FEET TOTAL for WILDLIFE

36	62423	AZ GAME & FISH DEPT	PAGE SPRINGS	using 7,226.0 ACRE FEET PER ANUM for ANNUAL USE
36	45285	BOYNTON, MACK M	PAGE SPRINGS	using .1 ACRE FEET PER ANUM for ANNUAL USE
36	46546	BROWN, JOHNNY A	PAGE SPRINGS	1.0 ACRES using 3.0 ACRE FEET PER ANUM for IRRIGATION
4A	3417	CAVE, BRUCE W & CLAUDETTE A	PAGE SPRINGS	2.0 ACRES using 24.7 ACRE FEET PER ANUM for IRRIGATION
36	35821	CHURCHILL, MARJORIE C	PAGE SPRINGS	3.0 COWS / HORSES using for STOCK
4A	3417	EVANS, JOHN C & DOROTHY G	PAGE SPRINGS	7.6 ACRES using 107.6 ACRE FEET PER ANUM for IRRIGATION
4A	3417	EVANS, JOHN C & DOROTHY G	PAGE SPRINGS	COWS / HORSES using .2 ACRE FEET PER ANUM for STOCK
36	59852	FLETCHER, ROBERT L AND MARY K	PAGE SPRINGS	COWS / HORSES using .1 ACRE FEET PER ANUM for STOCK
36	59852	FLETCHER, ROBERT L AND MARY K	PAGE SPRINGS	COWS / HORSES using .3 ACRE FEET PER ANUM for STOCK
36	45010	FOGARTY, MARY K	PAGE SPRINGS	3.0 COWS / HORSES using for STOCK
36	59852	FREY, HENRY L AND JOHN	PAGE SPRINGS	1.0 ACRES using 10.0 ACRE FEET PER ANUM for IRRIGATION
36	59852	FREY, JOHN S	PAGE SPRINGS	3.0 ACRES using 30.0 ACRE FEET PER ANUM for IRRIGATION
36	62264	GANNAM, NASIB	PAGE SPRINGS	16.7 ACRES using for IRRIGATION
36	45010	HILDEBRAND, JOHN & REBECCA	PAGE SPRINGS	3.0 COWS / HORSES using for STOCK
36	39692	JEKEL, MARGARET R	PAGE SPRINGS	2.0 COWS / HORSES using for STOCK
36	59852	JOEL A HENRY LLC	PAGE SPRINGS	1.1 ACRES using 11.0 ACRE FEET PER ANUM for IRRIGATION
36	58933	MERKIN TRUST, HARRY	PAGE SPRINGS	3.9 ACRES using 5.6 MINERS INCHES TOTAL for IRRIGATION
36	58933	PARKER, LYNDA	PAGE SPRINGS	2.0 ACRES using 2.8 MINERS INCHES TOTAL for IRRIGATION
36	45010	POWELL, DOUGLAS & BETTY	PAGE SPRINGS	3.0 COWS / HORSES using for STOCK
36	62264	SCHIFFNER, CHARLES & ADRIENNE	PAGE SPRINGS	using ACRE FEET PER ANUM for ANNUAL USE
4A	3417	TANNER, JANICE K	PAGE SPRINGS	COWS / HORSES using .2 ACRE FEET PER ANUM for STOCK
4A	3417	VAUGHN, WILLIAM S. & JOHNNIE N	PAGE SPRINGS	.8 ACRES using 7.2 ACRE FEET PER ANUM for IRRIGATION
36	38935	WASBOTTEN, LUTHER B	PAGE SPRINGS	3.0 COWS / HORSES using for STOCK
36	35177	WEISMAN FAMILY TRUST	PAGE SPRINGS	3.0 COWS / HORSES using for STOCK
36	62421	AZ GAME & FISH DEPT	POND SPRING AREA - Cave Spring	using 12,300.0 ACRE FEET PER ANUM for ANNUAL USE
36	61476	C W CORPORATION	SPRING	using .6 ACRE FEET PER ANUM for ANNUAL USE
36	25731	WADDELL, JOHN H	SPRING	using 22.0 ACRE FEET PER ANUM for ANNUAL USE
36	67977	SPRING HILL RANCH LLC	SPRING CREEK	using 146.3 ACRE FEET PER ANUM for ANNUAL USE
36	102236	ASHER, ELEANOR A	TURTLE	using 463.5 ACRE FEET PER ANUM for ANNUAL USE
36	13453	ASHER, ALAN	TURTLE SPRING	using 2.0 ACRE FEET PER ANUM for ANNUAL USE
36	28445	GREEN, HUGH E	TURTLE SPRING	20.0 COWS / HORSES using .3 ACRE FEET PER ANUM for STOCK
36	36937	PAGE, JAMES E	WILLARD	25.0 COWS / HORSES using for STOCK
36	36936	PETERSON, MELVIN F	WILLARD	20.0 COWS / HORSES using for STOCK
36	59143	VAUGHN, WILLIAM S	WILLARD	using 7.2 ACRE FEET PER ANUM for ANNUAL USE

36	62422	AZ GAME & FISH DEPT	Willard - PAGE SPRING NO 2	using 7,950.0 ACRE FEET PER ANUM for ANNUAL USE
4A	3417	PAGE, JAME E & FANITA	Willard - PAGE SPRING NO 2	9.5 ACRES using 104.0 ACRE FEET PER ANUM for IRRIGATION
36	62213	BAKER, BALDWIN	WILLARD SPRING	using 2,363.1 ACRE FEET PER ANUM for ANNUAL USE
36	100138	GOETTL, DON	Willard-BUBBLING POND	using 150.0 ACRE FEET PER ANUM for ANNUAL USE

Available Water

As with other surface water claims, the amount of water claimed for beneficial use from each spring exceeds the amount physically available. Additionally, it is reasonable to assume that surface water currently produced from springs in the study area is either fully consumed or contributes to stream flow.

Summary

A review of spring data shows the existence of 33 major springs, mostly in the Verde Valley sub-basin. However, spring discharge measurements are not current and do not provide a long-term indicator of reliability. Inconsistent spring names, inconsistent spring locations and outdated discharge measurements hampered the overall spring analysis. A significant amount of field work would be necessary to correct data discrepancies. Because it is assumed that any current reliable spring discharge is either fully consumed or if not fully consumed, contributes to the base flow of a river and included in those flow measurements, it may be concluded that there is no new surface water available in the study area from springs.

c. Lakes/Reservoirs

Water Supply

Several large capacity reservoirs exist within the study area. (A large capacity reservoir is defined as having a capacity of 500 acre feet or greater). The Prescott AMA has four large reservoirs while the remaining sub-basins include two. Table 16 shows the available data for these reservoirs. The largest reservoir is Willow Creek Reservoir in the Prescott AMA. The reservoir is used for City of Prescott water supply and is filled by Willow Creek. Watson Lake is also used primarily for City of Prescott water supply. Granite Creek is the main water source.

Table 16. Large Reservoirs within the CYH Study Area

NAME	SUB-BASIN	OWNER/OPERATOR	MAXIMUM STORAGE (AF)	USE
Willow Creek Reservoir	Prescott AMA	City of Prescott	7,800	Water supply, Recreation
Watson Lake	Prescott AMA	City of Prescott	4,900	Water supply, Recreation
Lynx Lake	Prescott AMA	Arizona Game and Fish	2,763	Recreation
Hells Canyon Tank	Verde	AZ Dept of Transportation	1,545	Fire Protection
Wineglass Ranch	Big Chino	AZ State Land Dept	1,226	Fire Protection
Upper Goldwater	Prescott AMA	City of Prescott	700	Recreation

Source: ADWR Water Atlas
http://www.azwater.gov/AzDWR/StatewidePlanning/WaterAtlas/CentralHighlands/documents/volume_5_VRB_final.pdf
http://www.azwater.gov/azdwr/StatewidePlanning/WaterAtlas/ActiveManagementAreas/documents/Volume_8_PRE_final.pdf

There are many smaller reservoirs available to store water. The Arizona Water Atlas provides the number of small reservoirs (capacity less than 500 acre feet) for the Prescott AMA and the Verde River Basin. However, locations are not provided. In addition, data addressing the volume of potential storage is not available. The number of reservoirs by sub-basin can be determined using a spatial layer provided by the Arizona State Land Department. However, the layer does not provide an estimation of potential storage for each reservoir. Table 17 shows the number of potential storage reservoirs for the study area by sub-basin. Figure 9 illustrates the locations of lakes and reservoirs in the study area.

Table 17. Small Storage Reservoirs by Sub-Basin

Sub-Basin	Number of Small Storage Reservoirs
Big Chino	17
Prescott AMA	13
Verde River	14

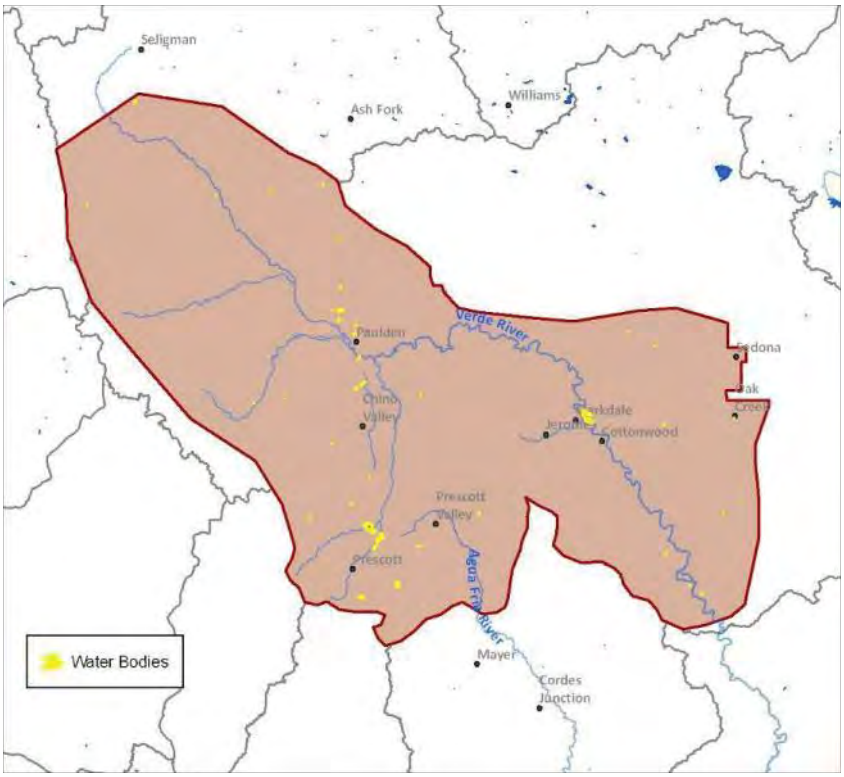

Figure 9. Spatial distribution of lakes and reservoirs in CYH Study Area

The ADWR Water Atlas provides the number of registered stock ponds for the Prescott AMA and the Verde River Basin. No additional data were found indicating maximum storage or location. Given the lack of data it's not possible to determine water supply available from stock ponds.

Available Water

ADWR SOC data were also used to determine water availability for lakes and reservoirs. Tabular queries using the names of the large reservoirs produce no results. This is probably due to the incompleteness of the data set.

A spatial query of claims within 50 meters of large reservoirs produced limited results. The only claims returned with volumes are by the Chino Valley Irrigation District spatially adjacent to Willow Creek Reservoir and Watson Lake. The data show that the maximum storage amount is claimed for these two lakes. Those rights were severed and transferred to the City of Prescott. As described on the ADWR Water Management section for the Prescott AMA: "The City chooses to maintain the lakes for recreational uses and releases approximately 1,500 afy for recharge at their recharge facility."
(http://www.azwater.gov/AzDWR/Watermanagement/AMAs/PrescottAMA/Prescott_Issues.htm#SurfaceWater2)

Determining water availability with any confidence for smaller reservoirs is not achievable for this appraisal study. The water supply is not known and as a result, any volumes that could be found in the SOC data would not provide an indication of water availability.

Summary

Water supply from the larger lakes and reservoirs is quantified; however, data are very limited for smaller reservoirs. An approximate number of smaller reservoirs for the study area are available but volume is not. Assessing water availability for large reservoirs within the study area only returned information for Willow Creek Reservoir and Watson Lake. These two lakes are the largest within the study area. The SOC data demonstrate that all potential water for those reservoirs is claimed for use and already accounted in the Central Yavapai Highlands Demand analysis by the City of Prescott.

2. Groundwater

There are many factors associated with quantifying groundwater available in the CYHWRMS study area:

1. Uncertainty (amounts are best expressed as a range)
2. Recoverable water (not all water in storage can be recovered by wells for a variety of potential reasons)
3. Water Quality
4. Natural Groundwater discharge (groundwater contribution to base flow; some groundwater is supplying base flow to streams; may be counted in the surface water quantification)
5. Water budgets (e.g. groundwater natural and artificial recharge amounts, pumping amounts)
6. State Water law (defines groundwater as a different source from surface water)

a. Basin Fill aquifers

Water supply

Groundwater is the primary source of water for domestic use in the study area. The most reliable and accessible groundwater resource is the aquifers composed of younger (Cenozoic age) sedimentary and volcanic rocks. These younger materials fill the basins beneath the Big Chino, Little Chino and Verde Valleys. The map below (Figure 10) shows the thickness of saturated sediments in the Verde River sub-basin (modified from Blasch *et al* 2006, Figure 22, p. 55). Blasch *et al* 2006 provides a written description of the regional geology and the aquifer units along with maps and cross sections (e.g. pp 37-58). The water is accessible through wells drilled into the saturated materials (aquifers).Wells drilled outside of the areas with younger rocks can

produce water for domestic uses however, yields are variable (usually low). Typically, these "hard rock" areas are not viable places to locate production wells.

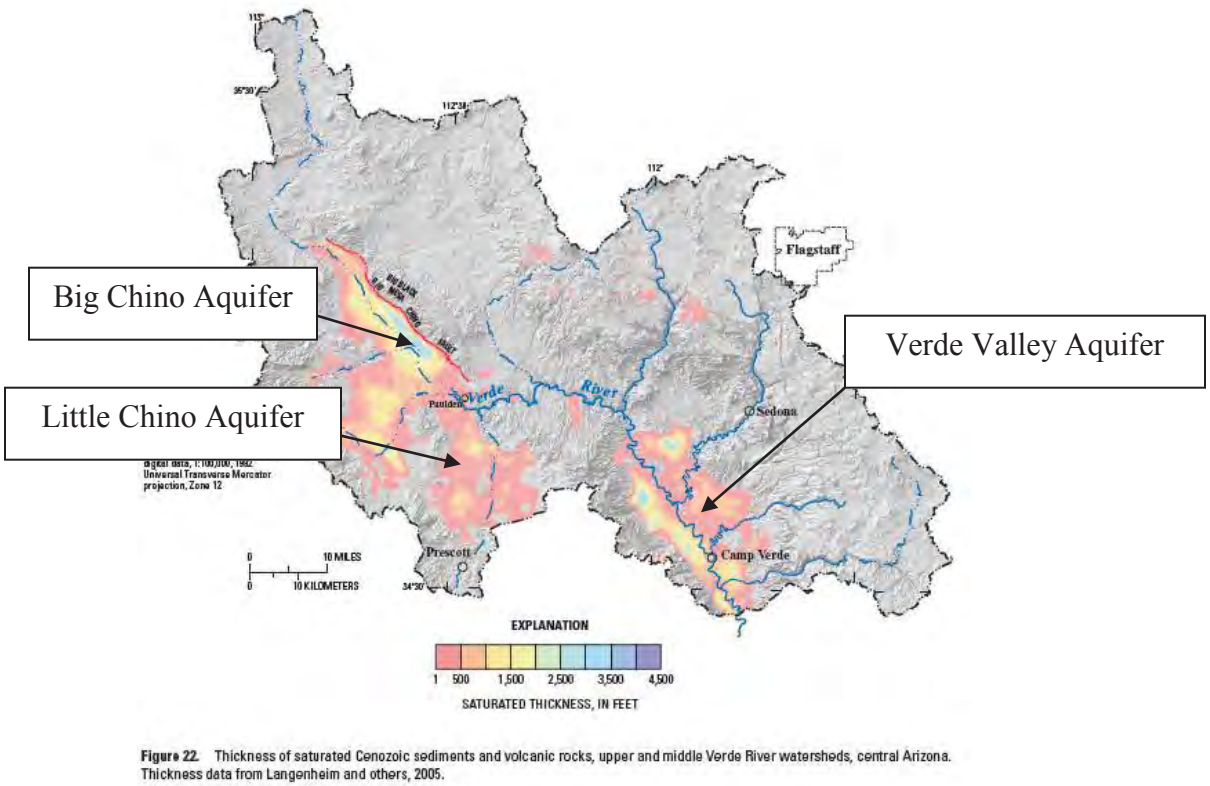

Figure 10. Thickness of saturated sediments in the Verde River Basin (modified from Blasch *et al*, 2006)

<u>Water in Storage</u>

Table 18 below shows a range of available stored groundwater in the Big Chino, Little Chino, Verde Valley, and Upper Agua Fria (within AMA) basin-fill aquifers (based on specific yield). The calculations are based on the estimated amount of saturated sediments from the Blasch and others 2006 report and estimated *specific yields* of 4% and 10% (from Corkhill, November 2007 Big Chino Discussion). Blasch *et al* 2006 did not estimate saturated volume for the portion of the Prescott AMA that is within the Upper Agua Fria Basin. Therefore, for simplicity the value used in the AMA hydrology model is reported in Table 18. The three million acre feet value in Table 18 is a "rough estimate" based on the Verde basin portion reported in Blasch et al 2006, Upper Agua Fria land area, geology and ADWR information for the AMA (ranges from 1.9 – 4.9 million acre feet depending on specific yield.)

Aquifer storage capacity is defined as the maximum amount of water that can be stored in an aquifer. Storage capacity is related to the material properties of the aquifer, such as pore space.

Water in storage is held in the open pore spaces within an aquifer. *Specific yield* is related to the amount of water that is physically available to pumps. Specific yield can be stated as a measurement, usually in units of gpm, of the amount of water a well can produce.

Table 18. Groundwater Storage Estimates for Prescott AMA (Little Chino and Upper Agua Fria), Big Chino, Verde Valley Sub-basins[1] (SEE NOTES BELOW)

Watershed Sub-Basin	**Saturated Thickness (Blasch et al, 2006; Table 13, p46), (Million Acre-Feet)**	**Water in Storage using 4% specific yield; (Million Acre-Feet)**	**Water in Storage using 10% specific yield; (Million Acre-Feet)**	**Water in storage ADWR Water Atlas (<1200' bls)**
Big Chino	155	6.2	15.5	10.0
Verde Valley	112	4.5	11.2	
Prescott AMA	49**	3.0*		

*ADWR (2005) estimated that there was 3.0 maf of groundwater in storage in the AMA. **Value was not reported in Blasch *et.al*, 2006.due to the Upper Agua Fria section of the AMA being outside of that study boundary.

Notes (Table 18):

1. Due to inherent uncertainty in aquifer properties, storage estimates are appropriately expressed as a range.
2. Not all water held in storage can be released from the aquifer. Some water will be held in the pore spaces due to surface attraction. Specific yield is more representative of water available by pumping than storage capacity (and is thus used for this calculation).
3. Other factors may limit the amount of recoverable water from storage by pumping wells (and the ability to use the water):
    - Aquifer permeability
    - Aquifer heterogeneity
    - Drilling costs
    - Infrastructure costs
    - Water Quality
    - Legal and Environmental concerns
4. Paleozoic aquifers beneath the fill are not included but are present beneath the Big Chino and Verde Valley
5. The granite rocks, ("basement") which underlie much of the study area, have been found unsuitable for large-scale groundwater production and are not considered viable aquifers for the purpose of this study.

b. Paleozoic Rock Aquifers

Water supply

While the basin-fill aquifers are the most readily accessible and most used aquifers in the study area, groundwater may be present in underlying Paleozoic rock aquifers "Paleozoic aquifers" beneath the Big Chino and the Verde Valley subbasins (e.g. Redwall Limestone Martin Formation). Figure 11 is a simplified cross section that shows the location of the Paleozoic aquifers beneath the basin fill aquifers. The location and amount of water that could be available to wells is not well understood. The Little Chino and upper Agua Fria sub-basins do not appear to have a significant "Paleozoic aquifer" beneath the basin-fill. Rather those areas are largely directly underlain by Precambrian age granitic and other rock types ("hard rock basement") which are not productive aquifers (Blasch *et al,* 2006; DeWitt *et al*, 2008).

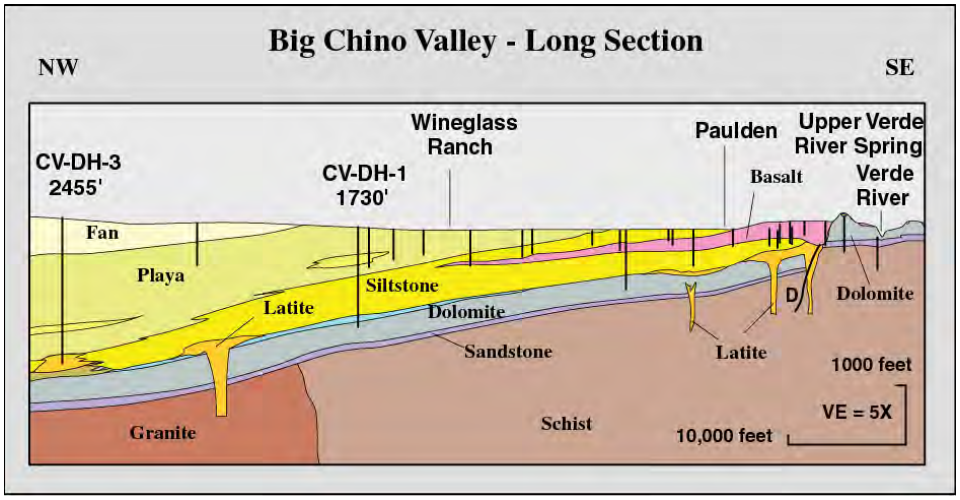

Figure 11. Geologic Cross Section along portion of Big Chino Basin. Paleozoic Aquifers are represented by purple color shades (Dolomite and Sandstone). The basin fill aquifer is represented by layers above the Paleozoic Dolomite layer. Vertical black lines represent wells. (From: US Geological Survey; also see Figure 18 in Blasch et al, 2006)

The nature of the connection between the basin-fill aquifers and the underlying Paleozoic aquifers is unclear. It appears that in at least some areas the Paleozoic aquifer is confined by overlying sedimentary units in the lower basin fill aquifers. References used for this report did not include a storage assessment of the Paleozoic aquifers in the study area (DeWitt *et al*, 2008; Blasch *et al*, 2006)

c. Net Natural Recharge

In Phase 1 – Demand Analysis of this study, the net natural recharge for each sub-basin was estimated and used as a method to identify how much water enters the groundwater system each year that is not exiting through streams as baseflow or outflow to another groundwater basin. It is referred to in the Phase 1 summary table as the Water Balance Method for determining existing available supplies (Phase 1 Demand Analysis Summary Table 4-1-10). The estimate is calculated by subtracting published values for baseflow leaving the sub-basin from natural recharge entering each basin (Blasch *et al*, 2006; ADWR Natural Recharge Memo, 2009; ADWR 1999 Declaration, 1999). Table 19 below shows renewable groundwater supply based on the Water Balance Method. (Note: existing groundwater development exceeds net natural recharge in the Prescott AMA and Verde Valley sub-basins, so no new renewable groundwater supply is available in either of those basins.)

Table 19. Net Natural Recharge Calculation (values in acre feet per year)

Sub-Basin	Inflow	Baseflow Out	Net Natural Recharge
Big Chino	30,300	17,900	12,400
Prescott AMA	8,070	4,850	3,220
Verde Valley	167,000	144,100	22,900

The values in Table 19 represent a small fraction of the amount of water stored in the sub-basins (Table 18). However, decisions regarding the use of these groundwater basins for future supplies will likely consider the water balance for each sub-basin. Groundwater withdrawals greater than recharge to the aquifer create a state of overdraft on the aquifer such as has been declared in the Prescott AMA (ADWR, 1999) and is apparent in the Verde Valley by Phase 1 of this study.

<u>Summary</u>

Based on referenced information and specific yield calculations, the Big Chino sub-basin aquifer has between 6 and 15 million acre feet (maf) of water available for pumping. The Prescott AMA aquifer has approximately 3.0 maf, and the Verde Valley has between 4.5 and 11 maf. Some of the available supply may be of poor quality or subject to other limitations imposed by aquifer properties, legal, environmental, or economic issues. Additionally, groundwater use in amounts greater than the net recharge results in a state of overdraft of the aquifer. The Prescott AMA and the Verde Valley are currently in a state of overdraft.

3. Wastewater

The US Environmental Protect Agency (EPA) defines wastewater as "the spent or used water from homes, communities, farms and businesses that contains enough harmful material to damage the water's quality. Wastewater includes both domestic sewage and industrial waste from manufacturing sources. Metals, organic pollutants, sediment, bacteria and viruses may all be found in wastewater. As a result, untreated wastewater can cause serious harm to the environment and threaten human life."
Source: http://www.epa.gov/ebtpages/watewastewater.html

Wastewater does not mean:

a. Storm Water
b. Discharges authorized under the De Minimus General Permit
c. Other allowable non-storm water discharges permitted under the Construction General Permit or the Multi-Sector General Permit, or
d. Storm water discharge from a municipal storm sewer system (MS4) containing incidental amount of non-storm water the MS4 is required to prohibit.

http://www.azsos.gov/public_services/Title_18/18-11.htm

For the purpose of this study, wastewater will include water developed from septic systems, mine drainage, or brackish/saline sources.

a. Septic Systems – Graywater/Blackwater

Water Supply

With the large number of exempt wells currently discharging wastewater into septic tanks in the study area, on-site wastewater treatment systems could be utilized to collect domestic wastewater products. The water volumes collected by these systems is a potential water resource within each sub-basin in the study area.

Wastewater from a domestic household can be divided into two parts: graywater and blackwater. Graywater means wastewater collected separately from a sewage flow that originates from a clothes washer, bathtub, shower, and sink, but does not include wastewater from a kitchen sink, dishwasher, or toilet. Blackwater is the wastewater from toilets, urinals, dishwashers, and sinks with garbage disposals.

Graywater can be used directly to meet many exterior water needs. Graywater is not suitable water for all uses, but is most suitably used for irrigation of non-edible landscape plants. Graywater could supply much, if not all the irrigation needs of a domestic dwelling landscaped with vegetation of a semiarid region. Along with outside irrigation, graywater can also be used in some situations for toilet flushing.

Available Water

The average daily volume of domestic wastewater production per person is estimated to be 69 gpcd (Source US EPA 2003 and AMWUA 1999). On the average, graywater represents seventy (70% or 48 gpcd) of the daily domestic flow of wastewater and blackwater represents the other thirty (30% or 21 gpcd) of the daily domestic flow. The estimates of the 1996 distribution of graywater and blackwater volumes for each study area sub-basin are shown in Table 20, below, are made using these percentages.
Source: http://www.mass.gov/dep/water/wastewater/glossary.htm#g4 and http://www.epa.gov/owm/septic/pubs/septic_2002_osdm_all.pdf

Table 20. Estimated Water Volume for Septic Systems and Probable Distribution of Quantities of Graywater and Blackwater by CYH Sub-Basin(afy)

Sub-Basin	Total Number of Septic Systems	Graywater @ 70% of Volume (afy)	Blackwater @ 30% of Volume (afy)
Big Chino	1,440		
70% GW/30%BW		183	78
Prescott AMA (Little Chino)	10,049		
70% GW/30%BW		1,278	548
Verde Valley	8,395		
70% GW/30%BW		1,067	457

*GW – Graywater and BW – Blackwater
Source: Verde River Watershed Study, AZ Department of Water Resources, Phoenix, AZ, April 2000

Septic systems are generally located in rural areas. However, septic systems in water provider service areas may be found at a higher density, providing an opportunity to more efficiently utilize that wastewater. Table 21 shows the wastewater volume from septic tanks potentially available by planning area. The data presented in the table are as recent as 2010. The population using septic systems was estimated several ways including population served by water providers, knowledge by local experts and calculating the difference between water accounts and sewer accounts. The average daily volume of wastewater per household is estimated to be 69 gpcd.

Table 21. Wastewater Volume Collected by Septic Systems in Water Provider Service Areas.

Planning Area	**Population using Septic System**	**Wastewater Volume (Acre-Feet/Year)**
Camp Verde	2,675	207
Dewey Humboldt	N/A	
Clarkdale	520	40
Cottonwood	10,626	821

Jerome	136	10
Prescott Valley	8,593	664
Chino Valley	614	47
Prescott	9,714	751
Sedona	1,957	151
Paulden CDP	1,884	146
Big Park CDP	3,572	276
Cornville CDP	N/A	
Lake Montezuma CDP	3,292	254
Williamson CDP	N/A	
TOTAL	**43,582**	**3,368**

Septic systems in rural areas are also an important source of wastewater. Rural areas, in this specific context, are defined as areas not in a water provider service area or sanitary district. The volume of wastewater was estimated using rural population totals and assuming wastewater production of 69 gallons/day/person. Rural population was estimated using Yavapai County Geographic Information System (GIS) parcel data. Residential parcels were queried to select those located outside of a water provider service area and outside of a sewer service area. The number of parcels was multiplied by the appropriate average number of people per household according to US Census 2000 data. This processes yielded a rural population estimate by planning area.

Table 22 shows the wastewater volume potentially available in septic tanks located in rural areas. The volumes are reported by planning area.

Table 22. Wastewater Volume Collected by Septic Systems in Rural Areas.

Planning Area	Population using Septic System	Wastewater Volume (Acre-Feet/Year)
Ashfork	470	36
Cornville	2,986	231
Cottonwood	933	72
Humboldt	227	18
Lake Montezuma	863	67
Mingus Mountain	2,170	168
Paulden	2,565	198
Prescott CCD	9,957	770
Prescott Valley	6,250	483
Prescott	4,454	344
Verde	1,056	82
Verde Village	893	69
Williamson	2,952	228
TOTAL	**35,776**	**2,766**

Summary:

The volume of water estimated to be available in urban areas (water served by a provider) from septic tank storage is 3,368 afy. An additional 2,766 afy of wastewater may be available in rural areas. This source of water would require high levels of treatment and the construction of a significant infrastructure system, both sewer and WWTFs, to make this water supply available to incorporate into any water supply budget.

b. Mine Drainage

Metals that find their way into the surface waters of the Verde River are one of most significant water quality problems in the Verde Watershed because of the potential toxicity to aquatic life. Constituent groups evaluated for Verde Watershed are: mercury, copper, zinc, and arsenic.

The primary sources for metals in the Verde Watershed are probably runoff and erosion from active and abandoned mines. Developed urban areas may also be considered as a nonpoint source for metals pollutants.
Source: NEMO Watershed Based Plan, Verde Watershed, Section 6 – Watershed Classification, University of Arizona, 2005

Table 23 shows the distribution of active and non-active mines in Yavapai County by study area sub-basin

Table 23. Economic Mining – by Sub-Basin

Type	Big Chino Sub-Basin	Prescott AMA and Verde Valley Sub-Basins
Mineral Location	5	2
Placer	1	3
Prospect	5	41
Surface/Underground	4	13
Surface	99	151
Underground	3	68
Unknown	7	45
Total Mines	124	323

Source: http://nemo.srnr.arizona.edu/nemo/characterizations/verde/V_Sect4SocDec05final.pdf

Available Water

The listing of all mines shown in the table represents a total of 447 mines. It is not known if any of the listed mines produces a significant source of mine drainage.

Summary

While there are many mines in the study area; there appears to be little or no data to quantify mine drainage water volumes available for use anywhere in the study area. Drainage from mines does not appear to be a viable option as source water for local or regional supply.

c. Brackish/Saline Water

Summary

There are little or no brackish/saline water within the study area. Brackish/saline waters, within the study area, are not considered to be available for development as either a local or regional water supply.

4. Flood Water

Water Supply

In Arizona, the waters of all sources flowing in streams, canyons, ravines or other natural channels, or in definite underground channels, whether perennial or intermittent, flood, waste or surplus water, and of lakes, ponds and springs on the surface, belong to the public and are subject to appropriation and beneficial use. Source: http://www.azleg.state.az.us/FormatDocument.asp?inDoc=/ars/45/00141.htm&Title=45&DocType=ARS

Although claims for surface water exceed available supply, there is little dedicated flood control space in the Verde River system and water from flood events is often released rather than stored in the system for later use. And, although flood events are relatively rare, capturing flood water is a potential source of new supply in the study area.

Four continuous recording gages are located along the Verde River (see Figure 1). The uppermost gage on the Verde near Paulden, *Big Chino Sub-Basin*, has a contributing drainage area of about 2,000 mi^2, which is about 40% of the total basin area. Despite its large size, this portion of the basin has contributed little runoff to the peak discharges of large floods recorded at the gages downstream because flood peaks recorded at Paulden almost always follow those at the Clarkdale gage, *Prescott AMA and Verde Valley Sub-Basin – Upper Verde Valley*, downstream by several hours. The contributing area of the Clarkdale gage is 3,200 mi^2, accounting for about 60% of the total basin area. More importantly, several fairly large tributaries draining the western Mogollon Rim join the Verde River between the Paulden and Clarkdale gages. The next gage downstream near Camp Verde, *Verde Valley Sub-Basin*, has a contributing drainage area of 4,700 mi^2, which is 85% of total basin area (the remaining percentage is largely in the Upper Agua Fria portion of the study area).

Three large tributaries draining the Mogollon Rim join the Verde River between the Clarkdale and Camp Verde gages: Oak Creek, Beaver Creek, and West Clear Creek. They account for about 55% of the drainage area between the Clarkdale and Camp Verde gages. The lowermost gage on the unregulated portion of the Verde River basin below Tangle Creek records runoff from a total of 5,500 mi^2.

The sizes of floods recorded at the Paulden, Clarkdale, and Camp Verde gages reflect the increasing size of the flood-producing watershed downstream through the upper canyon reach and Verde Valley. Since 1963, there have been 5 floods of greater than 10,000 cfs at the Paulden gage, derived from either Granite Creek or Big Chino Valley. At the Clarkdale gage, there have been 14 floods greater than 10,000 cfs over this same interval, and the largest floods in 1920 and 1993 were about twice as large as the largest peak at Paulden. The largest flood recorded at the Camp Verde gage sites is more than twice as large as the largest peak at Clarkdale, reflecting the substantial contributions of the major tributaries in Verde Valley.

The historical record is most complete for the lower Verde River, so these data are most useful for evaluating variations in flood occurrence. Since 1891, 20 floods larger than 50,000 cfs have occurred on the lower Verde River. The largest floods occurred in February, 1891, January, 1993, and February, 1993. Other large floods occurred in 1906, 1920, 1938, 1978 (2 floods), 1980, and 1995 (2 floods).

As is the case with some other rivers in Arizona, large floods occurred more frequently in the late 1800's and early 1900's, and in the late 1900's, with a general absence of large floods in the mid-1900's. On the lower Verde River, however, at least one moderately large flood greater than 50,000 cfs has occurred in each decade of the historical record.

All of the largest historical floods on the Verde River have occurred in the winter and typically have resulted from successions of frontal storms that culminate in heavy rain-on-snow in the upper basin and heavy rain in lower altitude portions of the basin. Only one moderately large flood in the gage record (September, 1970) was generated by a dissipating warm-season tropical storm. Summer thunderstorms have not generated sizable floods on the Verde River.

The incursion of multiple winter storm fronts and dissipating tropical storms into the Southwest is commonly associated with El Nino -- positive El Nino Southern Oscillations (ENSO) conditions. Since 1950, all of the floods greater than about 50,000 cfs (13 floods) recorded at the Tangle Creek gage on the lower Verde River occurred during positive ENSO conditions or during transitional periods between positive and negative ENSO conditions (3 floods). All 6 floods greater than 90,000 cfs occurred during positive ENSO conditions, and winter flooding has not occurred during La Nina (negative ENSO) conditions. The correlation between El Nino and flooding is far from perfect, however, as no notable winter floods occurred during the strong

El Nino conditions of 1972-73, 1982-83, 1986-87, and 1997-98. Although the relationship between El Nino and Verde River flooding evidently is not straightforward, the likelihood of flooding is higher during periods of positive ENSO conditions.

Source: http://azconservation.org/dl/TNCAZ_VerdeRiver_Ecological_Flows.pdf ; and http://azconservation.org/dl/TNCAZ_VerdeRiver_Ecological_Flows_Summary.pdf

Available Supply

Flood water is generated in tributaries in each of the sub-basins and is available to be developed as an additional supply in the study area.

Summary

Water supply developed from the collection and storage of flood water is dependent on high flow events and will be relatively unreliable. Additionally, this supply will likely be quite expensive and may have many issues associated with location of diversion and potential exchanges on the Verde River.

5. Storm Water

Water Supply

The term "Storm water" means storm water runoff, snow melt runoff, and surface runoff and drainage. http://www.azsos.gov/public_services/Title_18/18-09.htm . Impervious surfaces like driveways, sidewalks, and streets prevent storm water runoff from naturally soaking into the ground. Storm water can pick up debris, chemicals, dirt, and other pollutants and flow into a storm sewer system or directly to a lake, stream, river, wetland, or coastal water. Anything that enters a storm sewer system is discharged untreated into the water bodies that are used for swimming, fishing and providing drinking water. Source: http://www.epa.gov/weatherchannel/stormwater.html

Available Supply

Information relating to storm water runoff volumes is limited. Storm water may have the potential to produce large volumes of surface runoff within any given developed community and, potentially, on a larger landscape scale.

Summary

An extended study effort would be required to determine if a collection, treatment, storage, and distribution system could be developed to produce a significant volume of supply.

6. Effluent

Water Supply

Effluent, or reclaimed water, means water that has been collected in a sanitary sewer for subsequent treatment in a facility that is regulated pursuant to A.R.S. title 49, chapter 2 Water Quality Control. Such water remains effluent until it acquires the characteristics of groundwater or surface water.
Source:
http://www.azleg.state.az.us/search/oop/qfullhit.asp?CiWebHitsFile=/ars/45/00101.htm&CiRestriction=effluent

Available Water

There are good water supply data for 18 Wastewater Treatment Facilities (WWTF) in the study area. Other WWTFs exist in the study area but there is insufficient data for analysis in this study. Some WWTFs already utilize effluent through recharge or irrigation, removing that volume as a possible new water supply. Unutilized effluent volume is shown where it can be quantified. An example of unutilized effluent is disposing of effluent through evaporation.

a. **Big Chino Sub-Basin** –
There is one WWTF in the Big Chino located at the Talking Rock subdivision development. This facility collects and treats wastewater from other nearby developments and supplies treated effluent to the golf course.

Table 24. Wastewater Treatment Facilities – Big Chino Sub-Basin (2008).

Facility Name*	Ownership	City/Location Served	Population Served	Annual Volume Treat/Generated (acre-feet)	Disposal or Reuse Method
Talking Rock	Talking Rock Subdivision	Talking Rock	N/A	30	Golf Course Irrigation

As reported by a Quality Water Co., operator of the Talking Rock WWTP, all of the effluent produced from at the WWTP is utilized to irrigate a golf course.

Table 25 presents the projected volumes of effluent for the listed communities.

Table 25. Big Chino Sub-Basin -- Projected Effluent Volumes for Listed Communities – 2050

Community	2050 Projected Effluent (afy)**
Paulden CDP	677
Prescott CCD*	277
Ashfork CCD	5,219
Total	6,173

*Portion of CCD only

**Based on new population only and assuming a waste water volume of 69 gpcd.

b. **Prescott AMA Sub-Basin** –
There are seven (7) WWTFs in the Prescott AMA. Collectively, the seven WWTFs could produce 6,837 acre-feet annually. Table 26 lists the WWTF for the Prescott AMA.

Table 26. Wastewater Treatment Facilities – Prescott AMA Sub-Basin (2008).

Facility Name*	Ownership	City/Location Served	Population Served	Annual Volume Treat/Generated (acre-feet)	Disposal or Reuse Method
Chino Valley WWTF, Town of	Town of Chino Valley	Chino Valley	8,500	37	Golf Course Irrigation
Hassayampa WWTF	City of Prescott	Prescott	N/A	347	Golf Course Irrigation
La Fiesta WWTF	Prescott Country Club	Dewey	N/A	3	Evaporation Pond
Prescott Valley WWTF	Prescott Valley	Prescott Valley	33,500	2,750	Water Course, Golf Course Irrigation, & Discharged to Another Facility – Infiltration Basin
Prescott City of – Airport WWTF	City of Prescott	Prescott	11,300	784	Golf Course Irrigation & Industrial Reuse Also Discharged to

					Another Facility – Infiltration Basins
Prescott City of – Sundog WWTF	City of Prescott	Prescott	25,500	2,912	Golf Course Irrigation & Infiltration Basin Also Discharged to Another Facility – Infiltration Basins
Softwinds Mobile Home Park	Private	Dewey	NA	4	N/A
Total Effluent				6,837	

*Note: While there may be other WWTFs in the Prescott AMA, the table only presents those WWTFs where data is available.
Source:
http://www.azwater.gov/azdwr/StatewidePlanning/WaterAtlas/ActiveManagementAreas/documents/Volume_8_PRE_final.pdf

For the Hassayampa WWTP, NA should be for "not applicable" vs. "not available". For Prescott Airport and Prescott Sundog, effluent supplies are sent to the Underground Storage Facility which supports the City's water portfolio (Decision and Order 2005 –Designated Water Provider. Based on 2008 COP operator's records, treated volumes are as follows: Sundog = 2,995 AF, Airport = 1,267 AF, and Hassayampa = 226 AF. The numbers shown in the Water Atlas in their reference doc, COP Water Mgt Policy 2005-2010 were not found.

All of the WWTFs in the Prescott AMA completely utilize their effluent.

Table 27 presents the projected volumes of effluent for the listed communities.

Table 27. Prescott AMA Sub-Basin -- Projected Effluent Volumes for Listed Communities – 2050

Community	2050 Projected Effluent (afy)**
Dewey Humboldt	217
Prescott Valley	7,914
Chino Valley	3,942
Prescott	3,936
Prescott CCD*	1,569
Mingus Mountain CCD*	151
Humboldt CCD*	3
Total	17,733

*Portion of CCD only

**Based on new population only and assuming a waste water volume of 69 gpcd.

c. **Verde Valley Sub-Basin** –
There are seven (11) WWTFs in the Verde Valley Sub-Basin. Collectively, the eleven WWTFs could produce 3,289 acre-feet annually. Table 28 lists the 11 WWTFs in the Verde Valley Sub-Basin.

Table 28. Wastewater Treatment Facilities – Verde Valley Sub-Basin (2009).

Facility Name*	Ownership	City/Location Served	Population Served	Annual Volume Treat/Generated (acre-feet)	Disposal Method
Big Park ID	Yavapai County	Big Park	8,000	365	Irrigation
Camp Verde WWTF	Camp Verde SD	Camp Verde	2,500	195	Evaporation Pond
Clarkdale WWTF	Clarkdale	Clarkdale	1,920	291	Evaporation Pond & Irrigation
Cottonwood WWTF	Cottonwood	Cottonwood	8,500	1,008	Irrigation
Jerome WWTF	Jerome	Jerome	400	56	Water Course
Lolo Mai Springs	Private	N/A	420	34	Water Course
Oak Property Owners	Private	Oak Creek	29	1	Other
Sedona Venture WWTF	Private	Sedona	272	50	Water Course
Sedona WWTF	Sedona	Sedona	12,420	1,350	Evaporation Pond, Irrigation, & Wildlife Area
Seven Canyons of Sedona	Private	Sedona	37	10	Golf Course Irrigation
Verde Santa Fe	Private	Cornville	928	70	Golf Course Irrigation
Total Effluent				3,289	

*Note: While there may be other WWTFs in the Verde Valley Sub-Basin, the table is only presenting those WWTFs where data is available.

Source:
http://www.azwater.gov/AzDWR/StatewidePlanning/WaterAtlas/CentralHighlands/documents/volume_5_VRB_final.pdf

Table 29 presents updated effluent volumes and unused volumes in the Verde Valley Sub-Basin. A total of 2,244 afy of unused effluent are available.

Table 29. Volume of Unused Effluent – Verde Valley Sub-Basin

WWTF	Volume Generated (Acre-Feet/Year	Unused Volume (Acre-Feet/Year)
Camp Verde	195	195
Clarkdale	291	291
Sedona Venture – Sedona	*50*	
Sedona	*1350*	
Seven Canyons - Sedona	*10*	
City of Sedona Total	1410	1410
TOTAL		**1,896**

Data provided by plant operators or from reports.

Table 30 presents projected effluent volumes for listed communities – 2050.

Table 30. Verde Valley Sub-Basin -- Projected Effluent Volumes for Listed Communities – 2050

Community	2050 Projected Effluent (afy)**
Camp Verde	820
Clarkdale	1,427
Cottonwood	4,423
Jerome	22
Sedona	465
Big Park CDP	83
Cornville CDP	261
Lake Montezuma CDP	315
Ctn-Verde Village CDP	567
Verde CCD	642
Mingus Mtn CCD*	65
Humboldt CCD*	172
Total	9,262

*Portion of CCD only
**Based on new population only and assuming a waste water volume of 69 gpcd.

Summary

There are three sources of effluent development in the study area. The first is the conversion of existing septic to sewer systems. This alternative could produce more than 3,000 afy (See Septic Systems section above). The second effluent development alternative assumes that all existing effluent is accounted for in 2006 water budget and all new growth would be provided access to a sewer system. This assumption could produce 30,000 afy of new supply within the study area by 2057. The third alternative is effluent not currently utilized by treatment facilities. There are almost 1,896 afy of unutilized effluent within the study area in 2010. There are significant issues with the public perception of total reclamation and reuse and some legal and institutional barriers that may hinder the development of this entire supply.

B. **Water Resources Available Outside the Study Area**

Investigation of available water resources outside of the Central Yavapai Highlands Study area is limited to surface water, including flood water, and groundwater supplies. Because wastewater, storm water and effluent are localized supplies and would likely produce lower and dispersed volumes of water, they were not considered as viable supplies when developed outside the study area. However, flood waters on the Verde River which may flow out of the study are considered.

The primary source of data in this study is the ADWR Water Atlas. ADWR has prepared seven Water Atlases. ADWR has organized each Water Atlas volume by a specific Planning Area and its related Groundwater Basins. The Planning Areas that surround the Study Area are listed in Table 31.

Table 31. ADWR Water Atlas Planning Areas and Associated Land Areas

Water Atlas Planning Area	Number of Groundwater Basins	Land Area (mi^2)
Western Plateau	6	13,700
Eastern Plateau	1	26,700
Central Highlands	5	13,900
Active Management Areas	5	6,131*
Upper Colorado River	9	11,860

*Phoenix and Prescott AMAs only

Figure 12 offers a sense of distance with respect to the centroid of the entire study area. Different diversion points can be identified along the Colorado River are within the 75 mile and the 125 radii. There may be other points of access to the Colorado River as well. Between the 150 mile and 175 radii, both Lake Mead and Lake Powell become included for assessment.

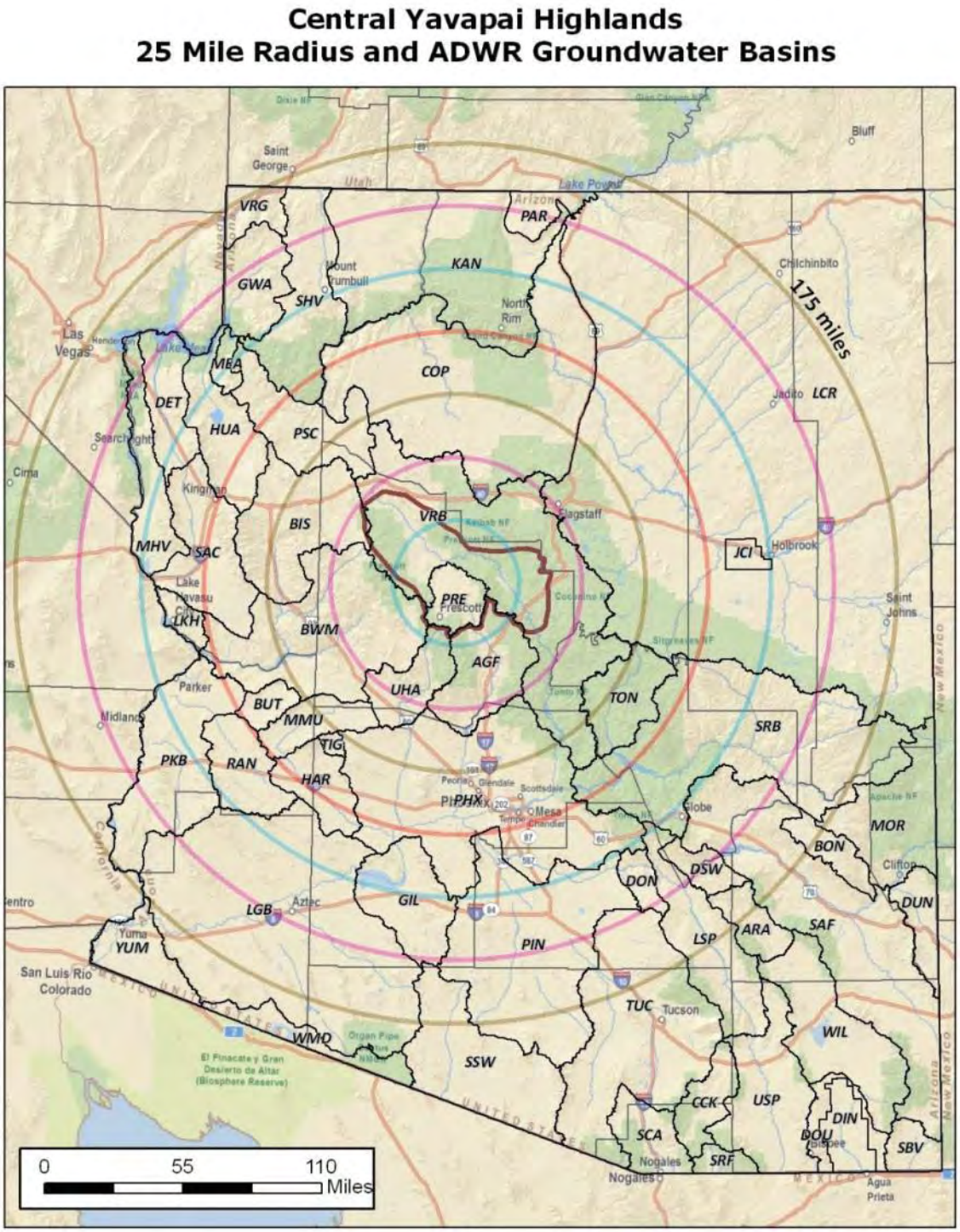

Figure 12. 25 mile Incremental Radii from the Centroid of the Entire Central Yavapai Highlands Study Area -- with Groundwater Basins.

1. Surface Water

There are six (6) Arizona Surface Water Basins surrounding the Verde River Basin (equivalent to a portion of the CYHWRMS area). The surface water basins are: Agua Fria River, Colorado River, Little Colorado River, Salt River, Middle Gila River, and Bill Williams River. Table 32 presents the surface land area for each of these basins. While the land area for each surface water basin is large in scale, research for a non-study area water supply was limited to within the land areas contained in a 125 mile radius from a designated study area centroid (see Figure 12).

Table 32. Surface Water Basins surrounding the Study Area and Associated Land Area

River Basin	Accounting Unit	Surface Area (mi^2)
Aqua Fria	Lower Gila – Painted Rock Reservoir, AZ -- 150701	2,420
Colorado	Lower Colorado – Marble Canyon, AZ -- 150100	29,900
Little Colorado	Little Colorado, AZ & NM -- 150200	26,900
Salt	The Salt River Basin, excluding the Verde River Basin, AZ -- 150601	7,120
Middle Gila	The Gila River from Coolidge Dam to the Confluence with the Salt River Basin, excluding the Santa Cruz and San Pedro River Basins and the Wilcox Closed Basin, AZ -- 150501	16,900
Bill Williams	The Bill Williams River Basin, AZ -- 150302	5,370
Verde River	Verde River Basin	6,590

The Little Colorado, Salt, Middle Gila, and Verde rivers are either involved in the Arizona general stream adjudication, an Indian water rights settlement, or both.

In the Bill Williams Basin there exist two large surface water reservoirs. The largest is Alamo Lake, with a maximum capacity of 1,409,000 acre-feet, although normal capacity is less than 500,-acre-feet. There is an allowance for water conservation storage in Alamo Lake of 230,000 acre-feet. General uses include flood control and recreation.

The Colorado River Basin has several potential points of diversion accessible to the study area and, though the Colorado River is completely allocated, though, there may be opportunities for acquiring a surface water supply.

Figure 13 offers a graphic display of the Surface Water Basins with respect to the study area.

Figure 13. The Geographic Relationships of the Surface Water Basins to the Verde River Basin.

The surface water basins can be further subdivided into accounting units and their related eight-digit cataloging units or hydrologic unit codes. Generally the Hydrological Unit Code (HUC) and the groundwater sub-basin are not compatible with one another. Usually the groundwater basin may be located under two or more HUCs. The exceptions to this statement are the Little Colorado River Plateau and the Verde River and their respective groundwater basins. The surface waters and groundwater are contained more or less within the same surface geography. There are sixteen HUCs in or around the study area (see Figure 14 and Table 33).

Central Yavapai Highlands HUCS

Figure 14. shows the 8-digit Arizona Hydrological Unit Codes in and near study area

The Hydrological Units and their land areas (mi^2) are listed in Table 33.

Table 33. Six-Digit Hydrologic Unit Codes in and around Study Area Sub-Basin – with Land Areas

Accounting Unit	Description	Hydrologic Unit Code	Description	Land Area (mi^2)
150100	Lower Colorado River – Lake Mead	15010002	Grand Canyon	2,530
"	"	15010004	Havasu Canyon	2,920
"	"	15010007	Hualapai Wash	1,540
150200	Little Colorado River	15020016	Lower Little Colorado River	2,390
"	"	15020015	Canyon Diablo	1,200
"	"	15020008	Middle Little Colorado River	2,450
150601	Salt River (excluding the Verde River)	15060105	Tonto Creek	1,030
"	"	15060106	Lower Salt River	1,340
150602	The Verde River Basin	15060201	Big Chino – Williamson Valley	2,170
"	"	15060202	Upper Verde River	2,480
"	"	15060203	Lower Verde River	1,940
150601	Salt River	15060105	Tonto Creek	1,030
		15060106	Lower Salt River	1,340
150701	Lower Gila River	15070102	Agua Fria River	2,090
"	"	15070103	Hassayampa River	1,410
150302	Bill Williams River	15030203	Santa Maria River	1,440
"	"	15030202	Burro	708
"	"	15030201	Big Sandy	2,120

Surface Water data was collected for selected USGS stream gage locations within HUCs that had surface water flow data. Table 34 presents the median annual surface water supply by HUC for each non study – near study area.

Table 34. Median Annual Surface Water Supply by Hydrologic Unit Code -- Non-Study -- Near Area

Hydrologic Unit Code	Name	USGS Stream Gage	Median Annual Water Supply (afy)
15010002	Grand Canyon	Colorado River above Diamond Creek near Peach Spring -- 09404200	9,249,100
15010004	Havasu Canyon	Havasu Creek at Supai, AZ -- 09404110	47,893
15010007	Hualapai Wash	ND	ND
15020016	Lower Little Colorado River	Little Colorado River above Mouth near Desert View, AZ -- 09402300	249,020
15020015	Canyon Diablo	ND	ND
15020008	Middle Little Colorado River	Little Colorado River near Winslow, AZ -- 9400350	89,776
15070102	Agua Fria River	Agua Fria River near Humboldt -- 9512450	1,354
15070103	Hassayampa River	Hassayampa River at Box Damsite near Wickenburg, AZ -- 09515500	4,351
15030203	Santa Maria River	Santa Maria River near Bagdad, AZ – 9424900	16,652
15030202	Burro Creek	Burro Creek at Old US 93 Bridge near Bagdad, AZ – 9424447	40,906
15030201	Big Sandy	Big Sandy River near Wikieup, AZ -- 9424450	30,698

Summary:
Surface water availability in Arizona is limited. With ongoing general stream adjudications and Indian waters rights settlements it is difficult to quantify surface water available, in excess of existing appropriations, to meet the future water supply needs in the Central Yavapai Highlands study area. As outlined in Table 32, there are 6 major river systems that could provide surface

water to the study area. The most likely sources, however, are the Colorado and Bill Williams Rivers. Although the Verde River has many SOCs, legal and environmental concerns, unappropriated flood water may be available for development outside of the study area (i.e. Horseshoe and Bartlett Dams).

2. Groundwater

There are 12 groundwater basins that touch one or more sub-basins of the study area. Table 35 lists those groundwater sub-basins.

Table 35. Groundwater Basins either Contained in or Contiguous to the Study Area including Land Area.

Planning Area	Groundwater Basin	Land Area (mi^2)
Western Plateau	Coconino Plateau	5,812
Eastern Plateau	Little Colorado River Plateau	26,700
Central Highlands	Agua Fria	1,263
Central Highlands	Salt River Basin	5,232
Central Highlands	Tonto Creek Basin	985
Central Highlands	Upper Hassayampa Basin	787
Central Highlands	Verde River Basin	5,661
Active Management Areas	Phoenix AMA Basin	5,646
Active Management Areas	Prescott AMA Basin	485
Upper Colorado River	Big Sandy Basin	1,988
Upper Colorado River	Bill Williams Basin	3,350
Upper Colorado River	Peach Springs Basin	1,409

Figure 15 shows the relationship of the contiguous groundwater basins with respect to the study area.

Figure 15. Near and Contiguous to Study Area Groundwater Basins

Shown below in Table 36 is information for selected groundwater basins in, near, and beyond the study area. Information contained in this Table includes surficial area of the groundwater basin and estimated water currently in storage (acre-feet).

Table 36. Groundwater Basin Water Resource Data – In and Near Study Area GW Basins

Groundwater Basins	Area (mi^2)	Estimated Water Currently in Storage (acre-feet)	Remarks
Verde River	5,661	28,000,000	USGS -- Blasch
Salt River	5,232	8,700,000	SRB
Agua Fria	1,263	620,000	AGFB
Tonto Creek	955	3,000,000	TCB
Upper Hassayampa	787	1,100,000	UHB
Little Colorado River Plateau	26,700	508,000,000	LCRPB
Coconino Plateau	5,812	3,000,000	CPB
Shivwits Plateau	1,821	N/A	SPB
Big Sandy	1,988	9,500,000	BSB
Bill Williams	3,350	23,000,000	BWB
Peach Springs	1,409	1,000,000	PSB
Prescott AMA	485	N/A	PrAMA

Figure 16 shows an annotated graphic of the probable aquifer storage within each groundwater basin.

Figure 16. Aquifer Storage within a Groundwater Basin (acre-feet)

Eventually, a delineated relationship between a surface watershed and ground water basins will be established during alternative formulation. Table 37 shows the relationship between and among the Planning Areas, HUCs, and Groundwater Basins.

Table 37. The Planning Area, Surface Water, and Groundwater Spatial Relationships

Water Atlas Planning Area	Eight-Digit Hydrologic Unit Codes	Name	Groundwater Basin
Western Plateau	15010002	Grand Canyon	Shivwits Plateau
Western Plateau	15010004	Havasu Canyon	Coconino Plateau
Eastern Plateau	15020016	Lower Little Colorado River	Little Colorado River Plateau
Eastern Plateau	15020015	Canyon Diablo	Little Colorado River Plateau
Eastern Plateau	15020008	Middle Little Colorado River	Little Colorado River Plateau
Central Highlands	15060201	Big Chino – Williamson Valley	Verde River
Central Highlands	15060202	Upper Verde River	Verde River
Central Highlands	15060203	Lower Verde River	Verde River
Central Highlands	15070102	Agua Fria River	Agua Fria River
Central Highlands	15070103	Upper Hassayampa River	Upper Hassayampa River
Upper Colorado	15030203	Bill Williams River	Bill Williams
Upper Colorado	15030202	Santa Maria River	Bill Williams
Upper Colorado	15030201	Big Sandy River	Big Sandy
Upper Colorado	15010007	Hualapai Wash	Peach Springs

Figure 17 shows the overlays of both HUCs and Groundwater basins.

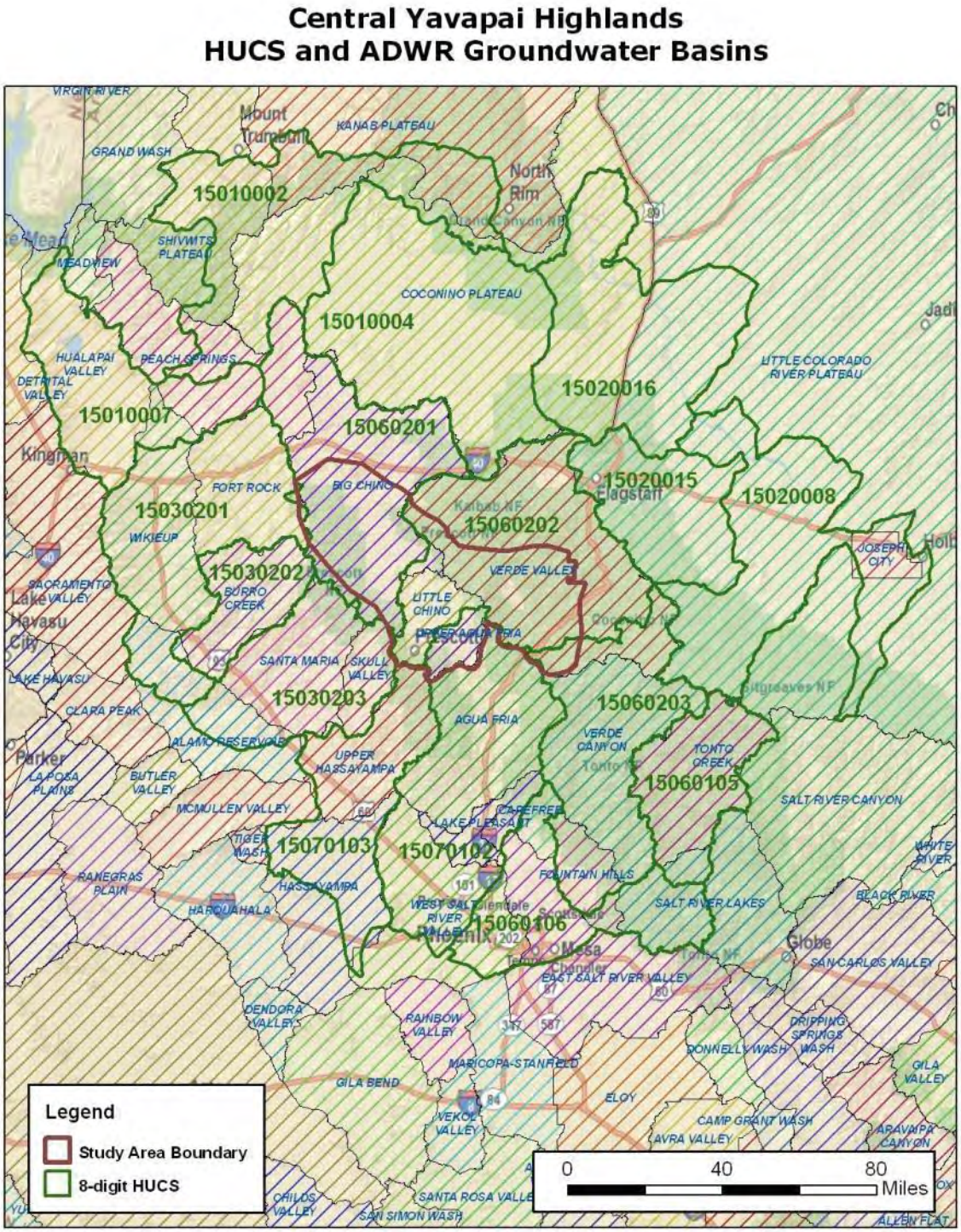

Figure 17. Hydrologic Unit Codes overlaying Groundwater Basins

Summary:
Groundwater is the main source of water supply in the Yavapai County Water Resources Management Study area and throughout much of rural Arizona. Although there are sources outside of the study area, those immediately to the east and north of the study area have been investigated in other water resources planning studies (i.e. Mogollon Rim Water Resources Management Study and North Central Water Supply Study) and in most cases have been found to be unsustainable as a renewable supply. It is possible that groundwater may be available for development in the study area from basins to the west (i.e. Bill Williams Basin) or in any basin on a groundwater mining basis.

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AGFB: Arizona Department of Water Resources, Arizona Water Atlas, Volume 5, Central Highlands Planning Area, Section 5.1, Agua Fria Basin, August 2009

TCB: Arizona Department of Water Resources, Arizona Water Atlas, Volume 5, Central Highlands Planning Area, Section 5.3, Tonto Creek Basin, August 2009

UHB: Arizona Department of Water Resources, Arizona Water Atlas, Volume 5, Central Highlands Planning Area, Section 5.4, Upper Hassayampa Basin, August 2009

LCRPB: Arizona Department of Water Resources, Arizona Water Atlas, Volume 2, Eastern Plateau Planning Area, May 2009

CPB: Arizona Department of Water Resources, Arizona Water Atlas, Volume 6, Western Plateau Planning Area, Section 6.1, Coconino Plateau Basin, October 2009

SPB: Arizona Department of Water Resources, Arizona Water Atlas, Volume 6, Western Plateau Planning Area, Section 6.5, Shivwits Plateau Basin, October 2009

BSB: Arizona Department of Water Resources, Arizona Water Atlas, Volume 4, Upper Colorado River Planning Area, Section 4.1, Big Sandy Basin, July 2009

BWB: Arizona Department of Water Resources, Arizona Water Atlas, Volume 4, Upper Colorado River Planning Area, Section 4.2, Bill Williams Basin, July 2009

PSB: Arizona Department of Water Resources, Arizona Water Atlas, Volume 4, Upper Colorado River Planning Area, Section 4.8, Peach Springs Basin, July 2009

PrAMA: Arizona Department of Water Resources, Arizona Water Atlas, Volume 8, Active Management Area Planning Area, Section 8.3, Prescott AMA, April 2010

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Central Yavapai Highlands Water Resource Management Study (CYHWRMS)

Appendix C

Phase 3: Alternatives Analysis Results and Documentation

- **Phase III Water Supply Alternatives Report (with Appendices)**
- **Alternative Summaries Document**
- **Alternatives Evaluation Criteria**
- **Environmental Issues Assessment and Alternative Description**
- **Natural Resources Index (Spreadsheet)**
- **Natural Resources per WPA (Spreadsheet)**
- **Environmental Issues Definitions and Key**
- **Environmental Assessment Mapping Methodologies**
- **Legal and Institutional Considerations**
- **Legal and Institutional Considerations Table**

Phase III - Water Supply Alternatives
06/21/2013

1.0 Introduction

The purpose of this document is to describe and analyze, at an appraisal level, water supply alternatives to satisfy unmet water demand in the Central Yavapai Highlands Water Resources Management Study (CYHWRMS) Planning Area in 2050. Figure 1.1 shows the location of the study area, and identifies the water planning areas (WPAs), groundwater sub-basins, and the Prescott Active Management Area (PRAMA).

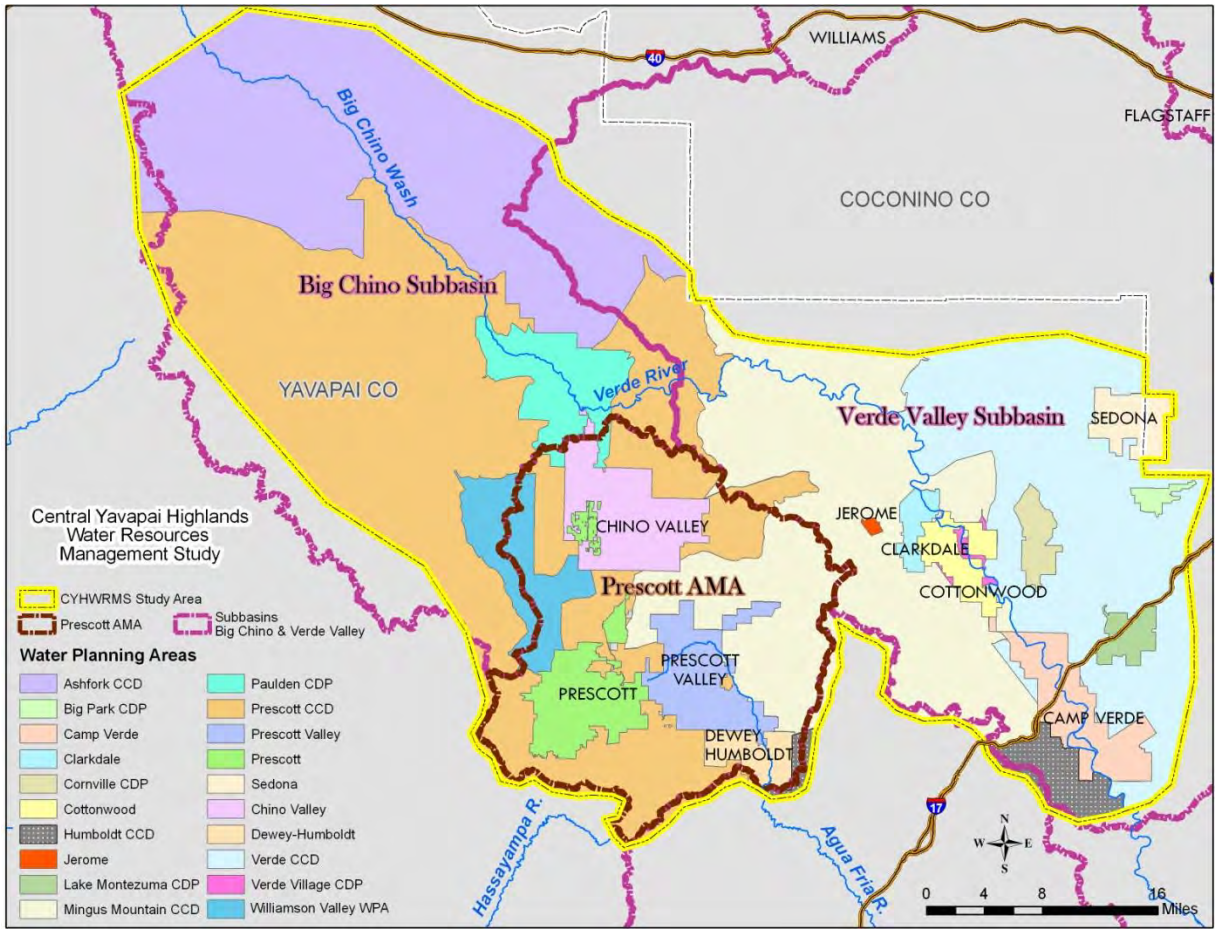

Figure 1.1: Study Area, Water Planning Areas, Sub-basins, and the Prescott Active Management Area

Table 1.1 shows the 2050 water supply excess or deficit for the WPAs; only three WPAs show a supply excess in 2050. It should be noted that the volumes in Table 1.1 are the result of assumptions used in the Phase I Demand Analysis. Specifically, conservation measures and reduction of future agriculture were incorporated into the Phase I methodology. The 2050 water supply excess or deficit was determined by calculating the difference between the 2006 total demand (which is assumed to be the 2006 supply) and the 2050 total demand. The total 2050 water supply deficit is 45,279 AF/yr (Status Quo method of calculation).

Table 1.1: Water Supply Excesses or Deficits in 2050 from Phase I – Demand Analysis

Water Planning Area	2050 Water Supply (AF/yr)	Water Planning Area	2050 Water Supply (AF/yr)
Camp Verde	1,887	Big Park CDP	-591
Dewey-Humboldt	-456	Cornville CDP	356
Clarkdale	-1,706	Lake Montezuma CDP	-264
Cottonwood	-7,092	Ctn-Verde Village CDP	-1,145
Jerome	-0[1]	Williamson CDP	-1,441
Prescott Valley	-13,869	Verde CCD	-170
Chino Valley	-6,946	Prescott CCD	-712
Prescott	-6,695	Mingus Mountain CCD	-444
Sedona	-1,584	Humboldt CCD	190
Paulden CDP	-590	Ashfork CCD	-4,007

The potential alternative water supplies inside the study area were identified in Phase II and include: groundwater, effluent, flood water[2], and storm water. Surface water[3] and groundwater sources outside the study area were also identified as potential alternative sources of supply.

Through the stakeholder process, 13 potential water supply alternatives were developed. Upon further consideration and investigation, three of the alternatives were removed from the list because, although considered, they will not be evaluated. These alternatives were either a demand side reduction which incorporated conservation measures into the 2050 GPPD (Alt. 9 Implement Conservation) or resulted in increased or restored volumes of surface water flow (Alt.

[1]Jerome's 2050 Water Supply Deficit has been updated from 0 in Phase I Demand Analysis to -23 as requested by Jane Moore, Jerome WPA Representative.

[2] From Phase II, "Flood water is generated in tributaries in each of the sub-basins and is available to be developed as an additional supply in the study area. Water supply developed from the collection and storage of unappropriated flood water is dependent on high flow events and will be relatively unreliable from year to year." This water is available because there is little dedicated flood control space in the Verde River system and water from flood events is released when system storage is at capacity. This is typically called a "spill" condition.

[3] The Phase II analysis concluded that existing claims for surface water far exceed available supply within the study area. Therefore, surface water inside the study area was not a potential alternative supply.

12 Weather Modification/Cloud Seeding and Alt. 13 Watershed Management), but they did not have a component for collecting the water supply.

This document provides an assessment of 10 potential water supply alternatives grouped by water supply types (Table 1.2) including the following: a brief summary of the water supply alternative; the WPAs for which the alternative is considered; a description of the alternative including assumptions and volumes of water that will be developed; infrastructure requirements; an alternative cost analysis; and annual and project worth costs. Table 1.3 describes the alternatives that were considered but not evaluated. Additional information regarding those alternatives is presented in section 3.0 of this document.

No single alternative fully meets the 2050 total unmet demand for the study area. However, imported surface water meets nearly all of the demand, except for some outlying areas where distribution is not practical. Therefore, any complete solution will likely involve more than one alternative

Table 1.2: Water Supply Alternatives and Description Grouped by Water Supply Type

Water Supply	Alternative	Alternative Description
Groundwater	**1**	Local Groundwater Development within the WPA (Inside and outside PRAMA)
	2	Regional Groundwater Development – Big Chino Pipelines (PRAMA and Verde Valley)
	3	Regional Groundwater Development Outside Study Area - Bill Williams Sub-basin and Big Sandy Sub-basin
Effluent	**4**	Conversion of Existing Systems - Urban
	5	Conversion of Existing Systems - Rural
	6	Additional Effluent from Increased Population
Flood Water	**7**	Capture and Store Unappropriated Verde River or tributary water
Storm Water	**8**	Rainwater Harvesting – Aquifer Storage
Conservation	**9**	Implement Conservation (e.g. low flow toilets, turf restrictions, educational programs, etc.)
Surface Water	**10**	Alamo Lake
	11	Colorado River via (a) Alamo Lake, (b) Diamond Creek, (c) Lake Mead, (d) Lake Havasu, (e) Lake Mohave, and (f) Lake Powell
Other	**12**	Weather Modification – Cloud Seeding
	13	Watershed Management

Table 1.3: Water Supply Alternatives Considered but not Evaluated

Water Supply	Alternative	Alternative Description
Conservation	**9**	Implement Conservation (e.g. low flow toilets, turf restrictions, educational programs, etc.)
Other	**12**	Weather Modification – Cloud Seeding
	13	Watershed Management

The next step after the assessment of the alternatives is to evaluate the alternatives for viability. This document serves as a just one part of the evaluation process and describes the alternatives, assumptions and provides costs. Other analyses will be considered during the evaluation of alternatives process. A significant outcome of the evaluation of alternatives is the ability to compare the annual cost per thousand gallons of water for each of the alternatives. At the appraisal study level, it should be noted that all cost estimates for the alternatives are strictly comparative in nature and represent costs only as an order of magnitude. They should not be taken to represent actual construction costs. Refinements would be required for each alternative before an actual cost estimate could be represented which is done at a feasibility level study. Table 1.4 summarizes the costs for each alternative. Alternative number 8 volume and cost information is for 64 acre sample improvements.

Table 1.4: Alternative Annual Cost per Volume

Alt #	Description of Alternative	Volume (AF/yr)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
Alternatives Using Groundwater Supplies							
1	Local GW – Inside PRAMA, Non-exempt Wells	1,648	$1,080,713	$51,400	-	$31	$0.10
1	Local GW – Inside PRAMA, Exempt Wells	19,623	$1,570,685,813	$74,687,700	-	$3,806	$11.68
1	Local GW – Outside PRAMA, Non-exempt or Urban Wells	12,178	$8,144,135	$387,300	-	$32	$0.10
1	Local GW – Outside PRAMA, Exempt or Rural Wells	7,592	$607,708,336	$28,897,100	-	$3,806	$11.68
2	Regional GW – Big Chino to PRAMA	12,468	$121,892,305	$5,796,100	$1,868,805	$615	$1.89
2	Regional GW – Big Chino to Verde Valley	12,382	$311,005,854	$14,788,600	$2,643,426	$1,408	$4.32
3	Regional GW Outside Study Area – Big Sandy Sub-basin	42,379	$987,537,108	$46,958,400	$11,595,880	$1,382	$4.24
3	Regional GW Outside Study Area – Bill Williams Sub-basin	42,379	$910,985,979	$43,318,300	$11,124,148	$1,285	$3.94
Alternatives Using Effluent Supplies							
4	Conversion of Existing Systems – Urban	3,367	$237,629,700	$11,299,500	$19,010,376	$9,002.04	$27.63
5	Conversion of Existing Systems – Rural	2,766	$200,201,200	$9,519,800	$16,016,096	$9,232.07	$28.33
6	New Effluent from New Population – High Volume	34,934	$963,742,300	$45,826,900	$77,099,400	$3,518.82	$10.80
6	New Effluent from New Population – Conservative Volume	21,614	$834,349,600	$39,674,100	$66,748,000	$4,923.76	$15.11

Alternatives Using Flood Water[4]							
Alt #	Description of Alternative	Volume (AF/yr)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
7	Capture and Store Unappropriated Verde River - Bartlett Dam A	10,000	$166,981,000	$7,940,100	$1,923,800	$986	$3.03
7	Capture and Store Unappropriated Verde River - Bartlett Dam B	25,000	$345,877,000	$16,446,800	$4,888,000	$853	$2.62
7	Capture and Store Unappropriated Verde River - Bartlett Dam C	45,000	$570,108,000	$27,109,200	$8,378,350	$789	$2.42
7	Capture and Store Unappropriated Verde River - Horseshoe Dam A	10,000	$157,956,000	$7,511,000	$1,923,000	$943	$2.90
7	Capture and Store Unappropriated Verde River - Horseshoe Dam B	25,000	$335,785,000	$15,966,900	$4,887,995	$834	$2.56
7	Capture and Store Unappropriated Verde River - Horseshoe Dam C	45,000	$559,746,000	$26,616,500	$8,378,350	$778	$2.39
7	Sullivan Dam	2,240	$48,229,000	$2,293,300	$480,640	$1,238	$3.80
7	Page Springs	2,240	$44,664,000	$2,123,800	$488,040	$1,166	$3.58
Alternatives Using Storm Water							
8	Rainwater Harvesting – Aquifer Storage Scenario 1	18	-	-	-	$4,389	$13.47
8	Rainwater Harvesting – Aquifer Storage Scenario 2	20	-	-	-	$4,805	$14.74
8	Rainwater Harvesting – Aquifer Storage Scenario 3	20	-	-	-	$3,691	$11.33
8	Rainwater Harvesting – Aquifer Storage Scenario 4	20	-	-	-	$3,161	$9.70

[4] Alternative 8 field costs and amortized and O&M annual costs are not shown because local and regional costs were not directly additive until presented on a unit area basis. Local and regional field costs are separately presented in Table 2.8.7. Refer to Table 2.8.8 for amortized and O&M annual costs. Alternative 8 volumes are for 64 acre sample improvements.

Alt #	Description of Alternative	Volume (AF/yr)	Costs				
			Field Cost ($)	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
8	Rainwater Harvesting – Aquifer Storage Scenario 5	14	-	-	-	$4,328	$13.28
8	Rainwater Harvesting – Aquifer Storage Scenario 6	9	-	-	-	$8,370	$25.69
8	Rainwater Harvesting – Aquifer Storage Scenario 7	8	-	-	-	$6,796	$20.77
8	Rainwater Harvesting – Aquifer Storage Scenario 8	26	-	-	-	$5,449	$16.72
8	Rainwater Harvesting – Aquifer Storage Scenario 9	36	-	-	-	$1,746	$5.36
8	Rainwater Harvesting – Aquifer Storage Scenario 10	26	-	-	-	$5,571	$17.10
Alternatives Using Imported Surface Water							
10	Alamo Lake	42,379	$895,515,610	$42,582,700	$11,744,870	$1,282	$3.93
11	Colorado River via Alamo Lake	42,379	$895,515,610	$42,582,700	$11,744,870	$1,282	$3.93
11	Colorado River via Diamond Creek	42,379	$1,028,225,962	$48,893,200	$12,243,356	$1,443	$4.43
11	Colorado River via Lake Mead	42,379	$1,447,553,494	$68,832,600	$14,700,056	$1,971	$6.05
11	Colorado River via Lake Havasu	42,379	$1,397,988,786	$66,475,800	$13,966,410	$1,898	$5.83
11	Colorado River via Lake Mohave	42,379	$1,273,716,646	$60,566,500	$14,709,294	$1,776	$5.45
11	Colorado River via Lake Powell	42,379	$1,161,614,426	$55,235,900	$12,722,029	$1,605	$4.92

2.0 Alternatives

The assessment of alternatives 1 through 13 includes the following elements for evaluation:

Summary
Water Planning Areas Affected
Description
Infrastructure Requirements
Field Costs and Assumptions Analysis
Annual and Project Worth Cost

The alternatives 9, 12 and 13 that did not warrant further evaluation, do not contain all of these elements.

2.1 Alternative 1 – Local Groundwater Development within the WPA (Inside and outside the PRAMA)

A. Summary of Alternative 1

This alternative proposes the continued use and development of groundwater supplies within the WPAs to meet all future water demand. The continued use of local groundwater to meet future demand is perceived to be the most convenient or easiest of the alternatives because it requires the least amount of change as it will continue on the current course of development. However, there may be impacts to the local aquifer that require evaluation and consideration. In areas where unlimited development of groundwater results in overdraft, problems associated with land subsidence, declines in stream flow, and reduction in riparian vegetation may occur. Additionally, the development of groundwater to meet municipal demand inside the Prescott Active Management Area (PRAMA) is limited by the Assured Water Supply regulations.

This alternative relies solely on development of groundwater within the sub-basin to meet the water supply deficit in 2050. For clarity of discussion, this alternative is separated into two components because of regulatory differences with respect to groundwater use within the WPAs. In this alternative, 13 of the WPAs are outside of the PRAMA, consequently, there is little regulation regarding groundwater use within those WPAs. Four of the WPAs are inside the PRAMA and have significant regulatory constraints on development and use of groundwater.

B. Alternative 1 Water Planning Areas

The WPAs considered in this alternative are those that show a 2050 water supply deficit (Table 1.1). Because only part of Williamson Valley, Mingus Mountain CCD and Prescott CCD are within the PRAMA, it has been assumed that they will pump groundwater from outside the PRAMA and are not subject to groundwater restrictions within the AMA.

C. Alternative 1 Description

WPAs inside the PRAMA

The Active Management Areas (AMAs) were created in 1980 in an effort to more effectively manage groundwater use in the highest groundwater use areas of the state through more intense regulation. The goal for the PRAMA is safe yield by 2025. In general, safe yield means that no more groundwater is withdrawn than is naturally and/or artificially replenished. The PRAMA was determined to be out of safe yield in 1999.

The 1999 declaration that the PRAMA was out of safe yield resulted in the implementation of more stringent Assured Water Supply requirements, particularly more stringent limitations on the volume of groundwater that could be utilized by new subdivisions. As a result, new municipal demand that results from the development of new subdivisions must be predominantly met by renewable water supplies. New municipal demand that does not result from the development of new subdivisions may be met with local groundwater.

Prescott WPA

Because the City of Prescott is a designated provider, the Prescott WPA is different from all other WPAs from a regulatory perspective, therefore it was evaluated differently. The method used to determine the manner in which local groundwater could be developed and utilized within the Prescott WPA was guided by the City of Prescott's Modified Designation of Assured Water Supply issued December 30, 2009 - Decision and Order No. 86-401501.0001 (Modified Designation). The Modified Designation mandates the maximum volume of groundwater that may be withdrawn and used by the City of Prescott for 100 years while still meeting the criteria for a designated provider. The City of Prescott has recently developed new wells with sufficient capacity to pump the groundwater allowance in accordance with the Modified Designation. Consequently, it was determined that there is existing well capacity to meet the Prescott WPA 2050 water supply deficit, therefore drafting cost estimates for new wells was determined to be unnecessary for the Prescott WPA

Chino Valley WPA/Dewey Humboldt WPA/Prescott Valley WPA

For these WPAs, Geographic Information System (GIS) was used to query currently platted subdivisions from the Yavapai County parcel database in order to determine the maximum groundwater allowance allowed under currently issued Certificates of Assured Water Supply. The number of subdivision lots was the number of vacant subdivision lots within the WPAs obtained from the Yavapai County parcel database (Table 2.1). For this alternative it was assumed one subdivision lot represented one household. For each subdivision lot, the groundwater volume was calculated by multiplying the WPAs Census Persons per Household (PPH) times 120 gallons per day per person.

The maximum groundwater allowance volume associated with currently undeveloped subdivisions lots was assumed to be met by new non-exempt, municipal wells (Table 2.1.1, column F). Any volume of groundwater in excess of the maximum groundwater allowance, or the 2050 water supply deficit must be met by exempt wells or by an alternative water supply (Table 2.1.1, column H). Private domestic wells are referred to as exempt wells. It was assumed

that new non-exempt wells would be operated by water providers pumping an average of 248 gallons per minute for 12 hours per day, or 200 AF/yr. It was assumed that new exempt wells would provide 0.33 AF/yr as identified in the Phase I analysis.

Table 2.1.1. Allowable and not Allowable Groundwater Volume and Number of New Non-exempt and Exempt Wells Required to Supply the Deficit

Water Planning Area	Subdivision Lots	Census PPH	Gallons Per Day per Household (GPD)	Total Subdivision Allowable GW Use (GPD)	Total Subdivision Allowable GW Use (AF/yr)	2050 Water Supply Deficit (AF/yr)	2050 Water Supply Deficit minus Total Subdivision Allowable GW Use (AF/yr)	Number of New Non-exempt Wells	Number of New Exempt Wells
A	B	C	D *(C*120)*	E *(B*D)*	F	G	H *(G-F)*	I *(F/200)*	J *(H/0.33)*
Chino Valley	1,189	2.58	309.6	368,114	412	6,946	6,534	2	19,800
Dewey-Humboldt	685	2.23	267.6	183,306	205	456	251	1	761
Prescott Valley	2,950	2.6	312	920,400	1,031	13,869	12,838	5	38,903
Total	4,824			1,471,820	1,648	21,271	19,623	8	59,464

WPAs Outside the PRAMA

Groundwater use outside the PRAMA is not subject to AMA regulations and beneficial use is the legal limit in these areas. There are four entities outside the PRAMA that have obtained Designations of Adequate Water Supply. There are no volumetric limitations on the volume of groundwater that can be utilized by these entities; however, to maintain an adequate designation, groundwater pumping cannot cause groundwater depths to go below 1,200 feet below land surface. General Statement: It does not appear that groundwater pumping under this alternative would cause groundwater declines of this magnitude, therefore there were no regulatory limitations put upon these WPAs with respect to non-exempt well pumpage.

For these WPAs, an analysis was done to determine what percentage of municipal demand is provided either by a water company or by private domestic wells. It was assumed that groundwater in rural areas is generally accessed by private domestic wells that are referred to as exempt wells. Conversely, it was assumed that urban areas are generally served by water companies of varying sizes by non-exempt wells. The proportion of non-exempt wells and exempt wells reflects an approximation of rural and urban populations in each planning area. It is assumed that the present pattern for rural or urban areas will be similar in future growth. The 2006 Water Use Tables from the Phase I Demand Analysis were analyzed to determine what percentage of municipal water was provided by a water company (urban) and what percentage was provided by private domestic wells (rural) (see Table 2.1.2).

The first step in determining the number of new exempt and non-exempt wells needed to meet demand was calculation of the 2050 urban and rural water supply deficits. This was derived by applying the rural and urban percentages to the 2050 water supply deficit. The number of new non-exempt wells was then calculated by dividing the urban supply deficit by 200 as it was assumed that new non-exempt wells would be operated by water providers pumping an average of 248 gallons per minute for 12 hours per day or 200 AF/yr. The number of new exempt wells was calculated by dividing the rural supply deficit by 0.33 as 0.33 AF/yr (family household usage for private domestic wells identified in the Phase I analysis). The numbers of new non-exempt and exempt wells needed to meet the 2050 water supply deficit are shown in Table 2.1.2.

Table 2.1.2. 2050 Water Supply Deficit and Number of New Non-exempt and Exempt Wells to Withdraw

Water Planning Area	2050 Water Supply Deficit (AF/yr)	Urban %	Rural %	2050 Urban Water Supply Deficit (AF/yr)	2050 Rural Water Supply Deficit (AF/yr)	Number of New Non-exempt Urban Wells	Number of New Exempt Rural Wells
Clarkdale	1,706	100	0	1,706	0	9	0
Cottonwood	7,092	100	0	7,092	0	35	0
Jerome	23	100	0	23	0	0	0
Sedona	1,584	100	0	1,584	0	8	0
Paulden CDP	590	36	64	212	378	1	1,145
Big Park CDP	591	100	0	591	0	3	0
Lake Montezuma CDP	264	56	44	148	116	1	352
Ctn-Verde Village CDP	1,145	0	100	0	1,145	0	3,471
Williamson CDP	1,441	57	43	821	620	4	1,879
Verde CCD	170	0	100	0	170	0	514
Prescott CCD	712	0	100	0	712	0	2,158
Mingus Mtn CCD	444	0	100	0	444	0	1,344
Ashfork CCD	4,007	0	100	0	4,007	0	12,144
Total	19,770			12,178	7,592	61	23,006

D. Infrastructure Requirements

In this alternative, the only infrastructure evaluated is wells. Information regarding well depth, casing diameter and pump capacity was obtained for wells located in the study area from the Arizona Department of Water Resources Well Registry. Initially, this information was intended to be utilized to estimate well construction costs. However, due to the range in well construction costs, it was determined that an average construction cost per well would be more appropriate than determination of a well construction cost based on assumptions regarding depth, casing and pump capacity.

E. Alternative 1 Field Cost Analysis

Exempt Wells

The cost to construct a single exempt well as presented in this document is general in nature and is on a unit cost basis including drilling and casing the well, installing the pump and a volume of on-ground storage. Actual construction costs for wells can vary significantly and are dependent on the well size, depth, and location.

This cost analysis utilizes a construction cost of $17,500 per exempt well. This cost estimate was provided by Nathan White from Northern Arizona Pump Incorporated. Table 2.1.3 summarizes the total cost for all exempt wells within the WPAs included in this alternative. These costs utilize the construction cost plus additional contingencies as appropriate.

Non-exempt Wells

The cost to construct a single non-exempt well as presented in this document is general in nature and is on a unit cost basis including drilling and casing the well, installing the pump and a volume of on-ground storage. Actual construction costs for wells can vary significantly and are dependent on the well size, depth, and location.

This cost analysis utilizes three construction costs based on location of the wells. Non-exempt wells in the Big Chino Sub-basin have a construction cost of $46,500, wells in the PRAMA have a construction cost of $89,500 and wells in the Verde Valley Sub-basin have a construction cost of $92,200. These cost estimates were provided by Nathan White from Northern Arizona Pump Incorporated. Table 2.1.4 summarizes the total cost for all non-exempt wells within the WPAs included in this alternative; WPAs within the Big Chino Sub-basin are highlighted in the table and PRAMA WPAs are italicized.

Table 2.1.3. Total Construction Cost for Exempt Wells

Water Planning Area	**Number of New Exempt Rural Wells**	**Exempt Well Cost ($)**
Dewey-Humboldt	761	13,317,500
Clarkdale	0	0
Cottonwood	0	0
Jerome	0	0
Prescott Valley	38,903	680,802,500
Chino Valley	19,800	346,500,000
Prescott	0	
Sedona	0	0
Paulden CDP	1,145	20,037,500
Big Park CDP	0	0
Lake Montezuma CDP	352	6,160,000
Ctn-Verde Village CDP	3,471	60,742,500
Williamson CDP	1,879	32,882,500
Verde CCD	514	8,995,000
Prescott CCD	2,158	37,765,000
Mingus Mtn CCD	1,344	23,520,000
Ashfork CCD	12,144	212,520,000
Total	82,471	1,443,242,500

Table 2.1.4. Total Construction Cost for Non-exempt Wells

Water Planning Area	**Number of New Non-exempt Wells**	**New Non-exempt Well Cost ($)**
Dewey-Humboldt	1	89,500
Clarkdale	9	829,800
Cottonwood	35	3,227,000
Jerome	0	0
Prescott Valley	5	447,500
Chino Valley	2	179,000
Prescott	0	
Sedona	8	737600
Paulden CDP	1	46,500
Big Park CDP	3	276,600
Lake Montezuma CDP	1	92,200
Ctn-Verde Village CDP	0	0
Williamson CDP	4	186,000
Verde CCD	0	0
Prescott CCD	0	0
Mingus Mtn CCD	0	0
Ashfork CCD	0	0
Total	69	6,111,700

F. Annual and Project Worth Costs

There are a number of different costs that are utilized in the process of cost analysis. The field cost includes the construction costs plus any contingencies that must be factored in. The amortized annual construction cost is the annual payment necessary to amortize the field cost over 50 years at the planning interest rate of 4.125%. The annual cost per AF is the amortized annual construction costs plus the annual operation and maintenance (O&M) costs divided by the water supply yield. There is no cost inflation for O&M over the 50 year evaluation period. The annual costs for the Alternative 1 variations are shown in Table 2.1.5.

The present worth project cost is derived by adding together the field costs plus the present value of 50 years of O&M costs at 4.125% divided by the water supply yield. The present worth projects costs for the Alternative 1 variations are shown in Table 2.1.6.

Table 2.1.5 Annual Project Costs

Alternative Versions	Amortized Annual Const Cost ($)	Annual Cost ($/AF)	Annual Cost ($/ Kgal)
Prescott AMA Non-exempt Wells	$51,400	$31.19	$0.10
Prescott AMA Exempt Wells	$74,687,700	$3,806.13	$11.68
Outside AMA (Big Chino & Verde Valley Sub-basins) Non-exempt or Urban Wells	$387,300	$31.80	$0.10
Outside AMA (Big Chino & Verde Valley Sub-basins) Exempt or Rural Wells	$28,897,100	$3,806.26	$11.68

Table 2.1.6. Present Worth Project Costs

Alternative Versions	Field Cost ($)	Present Worth Cost ($/AF)	Present Worth Cost ($/Kgal)
Prescott AMA Non-exempt Wells	$1,080,713	$655.77	$2.01
Prescott AMA Exempt Wells	$1,570,685,813	$80,043.10	$245.64
Outside AMA (Big Chino & Verde Valley Sub-basins) Non-exempt or Urban Wells	$8,144,135	$668.76	$2.05
Outside AMA (Big Chino & Verde Valley Sub-basins) Exempt or Rural Wells	$607,708,336	$80,045.88	$245.65

2.2 Alternative 2 – Regional Groundwater Development - Big Chino Pipelines (PRAMA & Verde Valley)

A. Summary of Alternative 2

This alternative proposes two versions that rely on development of groundwater supplies from the Big Chino Sub-basin for transportation via pipeline to either specific WPAs within the PRAMA or to specific WPAs within the Verde Valley. This alternative is considered to be regional groundwater development because it requires development of groundwater supply from the Big Chino Water Ranch, within the study area.

It should be noted that Black & Veatch completed a pipeline conceptual design report for the Big Chino Water Ranch including preliminary design work and design and construction cost estimates. The Black and Veatch report has a total project cost estimated at $174,761,600 in 2007 dollars. However, to insure consistency between the alternatives in this document, the Bureau of Reclamation has re-evaluated this alternative at the appraisal level, including costs, and with the assumptions identified within this alternative.

B. Alternative 2 Water Planning Areas

The WPAs considered for this alternative within the PRAMA and the volume of 2050 water supply deficit that will be met are shown in Table 2.2.1. In this alternative, the water supply deficits for Prescott and Prescott Valley WPAs were limited by provisions within the City of Prescott's Modified Designation of Assured Water Supply. The water supply deficit for the Town of Chino Valley to be met by this alternative was determined by the Town of Chino Valley.

Table 2.2.1. Alternative 2 – PRAMA Version WPAs and Volume of 2050 Water Supply Deficit

Water Planning Area	2050 Water Supply (AF/yr)
Prescott Valley	-3,703
Chino Valley	-4,400
Prescott	-4,365
Total	**-12,468**

The WPAs considered in the Verde Valley version of this alternative are: Clarkdale, Cottonwood, Sedona, Big Park CDP, Lake Montezuma CDP and Ctn-Verde Village CDP. This alternative meets the total 2050 water supply deficit of 12,382 AF for these WPAs (Table 1.1). Rural WPAs that are primarily served from private, domestic wells were not included within this alternative.

C. Alternative 2 Description

This alternative is based, in part, on the provisions of A.R.S. §45-555 which authorizes the transportation of groundwater withdrawn in the Big Chino Sub-basin to an initial AMA. Arizona Revised Statutes §45-555(E) permits the City of Prescott to withdraw and transport a total of 8,068 AF of groundwater. The City of Prescott and the Town of Prescott Valley have entered into an agreement to split that volume of water 54%:46% resulting in the volumes listed in Table 2.2.1 for those WPAs. Additionally §45-555(A) authorizes the transportation of groundwater associated with historically irrigated acreage. Transportation of groundwater from the Big Chino for the Chino Valley WPA will likely occur pursuant to this statute.

The transmission line for the PRAMA alternative begins at a conceptualized well field at the Big Chino Water Ranch located approximately 30 miles northwest of Paulden, Arizona. It should be recognized that groundwater transported to the Chino Valley WPA may be withdrawn from a different location. For additional information regarding the transmission facilities (including pumping plant locations, pressure reducing stations, pipeline size and pipeline flows) for this alternative, see Appendix A. The transmission line continues through Paulden south on Highway 89 to the first distribution center located in the Chino Valley WPA. The transmission line continues to Prescott Valley and through the Highway 69 and Highway 89 junction to Prescott.

The transmission line for the Verde Valley alternative also begins at a conceptualized well field at the Big Chino Water Ranch. As stated above, it should be recognized that groundwater transported to the Verde Valley may be withdrawn from a different location. The transmission line continues south through Paulden to the Highway 69 and Highway 89 junction. The transmission line then continues to deliver water west towards each of the water distribution centers from the Highway 69 and Highway 89 junction to Sedona and from the Interstate 17 and Highway 260 junctions to Clarkdale[5].

The location, elevation and profile of pipeline alignments were developed using GIS software and elevation data obtained from the 2004 USGS National Elevation Dataset. Elevations are referenced to the National American Vertical Datum 1988.

D. Infrastructure Requirements and Alternative 2 Field Cost Assumptions and Analysis

The infrastructure requirements and the associated cost component assumptions[6] are presented below. Unit costs were based on the North Central Arizona Water Supply Study (NCAWSS) report and adjusted using the Bureau of Reclamation construction cost indexes. The cost

[5] Alternate transmission routes for the Verde Valley version of the alternative were examined that included a pipeline alignment along the Verde River beginning at Sullivan Dam east to Clarkdale. These were not included because of limitations due to topography.

[6] Design data assumptions are based on the North Central Arizona Water Supply Study Report, October 2006 and the Peabody Coal Black Mesa Mine C-aquifer Water Supply Appraisal Study, April 2003.

estimates presented for this alternative do not include non-contract items such as right-of-ways, geological evaluations, public involvement, design costs, contracting, construction management, mitigation, legal, power costs, etc. Additional evaluations not included in these cost estimates are groundwater modeling, well field site selection, and geologic analysis for the well field site. Water storage tanks and pressure reducing stations required by water providers within their distribution system were not included in this cost analysis.

Groundwater Wells

Determination of construction costs for groundwater wells is based, in part, on a January 2010 cost estimate for drilling a 600 foot deep well in Manuelito, New Mexico and from published construction rates[7]. In the Big Chino sub-basin near Paulden, existing well data indicates that wells range from seven to 2,800 gallons per minute. It was assumed that the proposed wells will yield 400 gallons per minute. This alternative assumes that 20 wells pumping at 400 gallons per minute will produce approximately 12, 912 AF/yr. The wells are assumed to be 20 inches in diameter and 800 feet deep with a zone of influence of approximately 600 feet. Well construction estimates for this alternative are $301,643 per well installation.

Well Field Gathering System

The well field gathering system quantities were based on wells spaced on-half mile apart. For purposes of these cost estimates, 12 inch PVC pipe was assumed to convey water from the groundwater wells to the transmission pipeline.

Pipelines

Pipe lengths and head classes were determined through GIS analysis of the pipeline alignments. Hydraulic profiles for the pipeline are included in Appendix B. The cost estimate includes the cost for corrosion monitoring and cathodic protection of steel pipelines, where applicable. Construction costs for corrosion monitoring and cathodic protection were assumed to be one percent of the construction cost. Additionally, the cost estimate includes the cost for drainage crossings that includes geologic and site evaluations, design and any additional components or materials for construction. Pipeline drainage crossings were assumed to be two percent of the construction cost.

Appurtenant structures and mechanical equipment associated with the pipeline are covered under "unlisted items" in the cost estimates. These items include air valves, blowoffs, drains, flowmeters, altitude valves, and sectionalizing valves, etc.

Hydraulics

The Hazen-Williams equation was used to compute the loss due to friction in the pipe laterals. The pipeline design velocity is five feet per second or less and the maximum pumping lift would be approximately 450 feet. Pipe friction losses were limited to about 25 percent of the total dynamic head for the pumps.

[7] Rates from RS Means Heavy Construction Cost Data, 2010 edition.

It was assumed that all lateral pipe is mortar lined steel pipe with full inside diameters. A Hazen Williams Coefficient of 140 was used in the head loss calculations. Pipeline capacities were sized based on the 2050 water supply deficit only and a peaking factor was not applied. By limiting the pump lift to about 450 feet of head and adding 30 percent for an upsurge allowance, the pressure class for the pipe was generally limited to 575 feet (250 pounds per square inch). Pressure Reducing valve stations are required when pressures at a maximum exceed 500 feet.

Pressure Reducing Stations

In line pressure reducing stations were assumed to be required to limit the pipe head class to a maximum of 500 feet. The cost is based on a single pressure reducing station.

Excavation and Backfill

Excavation and backfill quantities for pipe earthwork were based on a typical trapezoidal trench section with 1:1 slopes and an average depth of cover of four feet. Excavation was assumed to be 60 percent rock and 40 percent common. This assumption allows for comparison to the NCAWSS Report. It should be noted the excavation cost for rock assumes that the material can be excavated with an excavator or trencher. Excavation that requires blasting or hoe-ramming is not included in this cost estimate because a geology evaluation and testing would be required. Embedment to three inches over the top of the pipeline was assumed to be imported material from nearby borrow areas.

Pumping Plants

The field costs for pumping plants were taken from the NCAWSS Report and adjusted for higher flows. Forebay tanks would be required upstream from each pumping plant to supply water during startup of the pumps. For this appraisal level estimate, all forebay tanks were estimated to be 10 feet in diameter and 20 feet tall. Air chambers will be required downstream and were assumed to be 20-foot-diameter spheres.

The cost estimate includes the cost for a Supervisory Control and Data Acquisition (SCADA) system for the control of the pumping plants. The construction costs for the SCADA system were assumed to be three percent of the construction cost.

Water Treatment

The unit cost of the water treatment for arsenic includes treatment and installation. For the purposes of this study it was assumed to be $1.50 gallons per day (gal/day).

Operation and Maintenance

Annual O&M costs for the pipelines were estimated to be 0.5 percent of the initial pipe costs. For pumping plants, annual O&M costs were estimated at eight percent of the pumping plant costs. Annual (O&M) costs for water treatment were estimated to be eight percent of the water treatment costs.

E. Annual and Project Worth Costs

There are a number of different costs that are utilized in the process of cost analysis. The field cost includes the construction costs plus any contingencies that must be factored in. The amortized annual construction cost is the annual payment necessary to amortize the field cost over 50 years at the planning interest rate of 4.125%. The annual cost per AF is the amortized annual construction costs plus the annual operation and maintenance (O&M) costs divided by the water supply yield. There is no cost inflation for O&M over the 50 year evaluation period. The annual costs for the Alternative 2 variations are shown in Table 2.2.2.

Table 2.2.2. Annual Project Costs

Alternative Versions	Amortized Annual Const Cost ($)	Annual O&M Cost ($)	Annual Cost ($/AF)	Annual Cost ($/ Kgal)
Pipeline from Big Chino to PRAMA	$5,796,100	$1,868,805	$615	$1.89
Pipeline from Big Chino to Verde Valley	$14,788,600	$2,643,426	$1,408	$4.32

The present worth project cost is derived by adding together the field costs plus the present value of 50 years of O&M costs at 4.125% divided by the water supply yield. The present worth projects costs for the Alternative 2 variations are shown in Table 2.2.3..

Table 2.2.3. Present Worth Project Costs

Alternative Versions	Field Cost ($)	Present Worth O&M Cost ($)	Present Worth Cost ($/AF)	Present Worth Cost ($/ Kgal)
Pipeline from Big Chino to PRAMA	$121,892,305	$39,301,071	$12,929	$40.00
Pipeline from Big Chino to Verde Valley	$311,005,854	$55,591,402	$29,607	$91.00

2.3 Alternative 3 – Regional Groundwater Development Outside Study Area - Bill Williams Sub-basin and Big Sandy Sub-basin

A. Summary of Alternative 3

This alternative proposes two options that rely on development of groundwater supplies from either the Bill Williams Sub-basin or the Big Sandy Sub-basin for transportation via pipeline to the WPAs. This alternative is considered regional groundwater development because it is development of groundwater from one localized area outside of the study area. In the Big Sandy version of the alternative, the groundwater is developed near Wikieup, Arizona and in the Bill Williams version the groundwater is developed at Burro Creek.

B. Alternative 3 Water Planning Areas

The WPAs considered in this alternative are those that show a 2050 water supply deficit (Table 1.1) with the exception of rural WPAs that are primarily served from private, domestic wells. The following WPAs were not included within this alternative: Jerome, Verde CCD, Prescott CCD, Mingus Mountain CCD, Humboldt CCD and Ashfork CCD.

C. Alternative 3 Description

In the Big Sandy version of the alternative, the transmission line begins at a conceptualized well field that is assumed to be placed in the river bed alluvium. The transmission line continues southeast along Highway 93 and north along Highway 89 to the first water distribution center located in Prescott, Arizona. The transmission line then continues on to each of the water distribution centers from Prescott to Sedona through the Highway 89 and Highway 69 Junction to Paulden and from the Interstate 17 and Highway 260 junction to Clarkdale.

The Bill Williams transmission line also begins at a conceptual well field and continues heading southeast along Highway 93 towards Congress. The transmission line to the study area from Congress is the same as in the Big Sandy alternative.

For additional information regarding the transmission facilities (including pumping plant locations, pressure reducing stations, pipeline size and pipeline flows) for this alternative, see Appendix A.

The location, elevation and profile of pipeline alignments was developed using GIS software and elevation data obtained from the 2004 USGS National Elevation Dataset. Elevations are referenced to the National American Vertical Datum 1988.

D. Infrastructure Requirements and Alternative 3 Field Cost Assumptions and Analysis

This alternative is very similar to Alternative 2 with respect to infrastructure requirements and field costs assumptions. The infrastructure requirements and the associated cost component

assumptions[8] are presented below. Again, unit costs were based on the NCAWSS report and adjusted using the Bureau of Reclamation construction cost indexes. The cost estimates presented for this alternative do not include non-contract items such as right-or-ways, geological evaluations, public involvement, design costs, contracting, construction management, mitigation, legal, power costs, etc. Additional evaluations not included in these cost estimates are groundwater modeling, well field site selection, and geologic analysis for the well field site. Water storage tanks and pressure reducing stations required by water providers within their distribution system were not included in this cost analysis.

Groundwater Wells

Determination of construction costs for groundwater wells is based, in part, on a January 2010 cost estimate for drilling a 600 foot deep well in Manuelito, New Mexico and from published construction rates[9].

In the Bill Williams basin where Highway 93 crosses Burro Creek, existing well data indicates that wells range from five to 5,000 gallons per minute. It was assumed that the proposed wells will yield 280 gallons per minute. This version of the alternative assumes that 94 wells pumping an average of 280 gallons per minute will produce approximately 42,482 AF/yr. The wells are assumed to be 20 inches in diameter and 650 feet deep with a zone of influence of approximately 550 feet.

In the Big Sandy groundwater basin near Wikieup, existing well data indicates that wells range from 100 to 2,000 gallons per minute. It was assumed that the proposed wells will yield at least 300 gallons per minutes. This version of the alternative assumes that 88 wells pumping at 300 gallons per minute will produce approximately 42,612 AF/yr. The wells are assumed to be 20 inches in diameter and 700 feet deep with a zone of influence of approximately 600 feet.

Well construction estimates for the Bill Williams version of this alternative is $279,893 per well installation and for the Big Sandy version it is $288,143.

Well Field Gathering System

The well field gathering system quantities were based on wells spaced on-half mile apart. For purposes of these cost estimates, 12 inch PVC pipe was assumed to convey water from the groundwater wells to the transmission pipeline.

Pipelines

Pipe lengths and head classes were determined through GIS analysis of the pipeline alignments. Hydraulic profiles for the pipeline are included in Appendix B. The cost estimate includes the cost for corrosion monitoring and cathodic protection of steel pipelines, where applicable. Construction costs for corrosion monitoring and cathodic protection were assumed to be one percent of the construction cost. Additionally, the cost estimate includes the cost for drainage crossings that includes geologic and site evaluations, design and any additional components or

[8] Design data assumptions are based on the North Central Arizona Water Supply Study Report, October 2006 and the Peabody Coal Black Mesa Mine C-aquifer Water Supply Appraisal Study, April 2003.

[9] Rates from RS Means Heavy Construction Cost Data, 2010 edition.

materials for construction. Pipeline drainage crossings were assumed to be two percent of the construction cost.

Appurtenant structures and mechanical equipment associated with the pipeline are covered under "unlisted items" in the cost estimates. These items include air valves, blowoffs, drains, flowmeters, altitude valves, and sectionalizing valves, etc.

Hydraulics

The Hazen-Williams equation was used to compute the loss due to friction in the pipe laterals. The pipeline design velocity is five feet per second or less and the maximum pumping lift would be approximately 450 feet. Pipe friction losses were limited to about 25 percent of the total dynamic head for the pumps.

It was assumed that all lateral pipe is mortar lined steel pipe with full inside diameters. A Hazen Williams Coefficient of 140 was used in the head loss calculations. Pipeline capacities were sized based on the 2050 water supply deficit only and a peaking factor was not applied. By limiting the pump lift to about 450 feet of head and adding 30 percent for an upsurge allowance, the pressure class for the pipe was generally limited to 575 feet (250 pounds per square inch). Pressure Reducing valve stations are required when pressures at a maximum exceed 500 feet.

Pressure Reducing Stations

In line pressure reducing stations were assumed to be required to limit the pipe head class to a maximum of 500 feet. The cost is based on a single pressure reducing station.

Excavation and Backfill

Excavation and backfill quantities for pipe earthwork were based on a typical trapezoidal trench section with 1:1 slopes and an average depth of cover of four feet. Excavation was assumed to be 60 percent rock and 40 percent common. This assumption allows for comparison to the NCAWSS Report. It should be noted the excavation cost for rock assumes that the material can be excavated with an excavator or trencher. Excavation that requires blasting or hoe-ramming is not included in this cost estimate because a geology evaluation and testing would be required. Embedment to three inches over the top of the pipeline was assumed to be imported material from nearby borrow areas.

Pumping Plants

The field costs for pumping plants were taken from the NCAWSS Report and adjusted for higher flows. Forebay tanks would be required upstream from each pumping plant to supply water during startup of the pumps. For this appraisal level estimate, all forebay tanks were estimated to be 10 feet in diameter and 20 feet tall. Air chambers will be required downstream and were assumed to be 20-foot-diameter spheres.

The cost estimate includes the cost for a Supervisory Control and Data Acquisition (SCADA) system for the control of the pumping plants. The construction costs for the SCADA system were assumed to be three percent of the construction cost.

Water Treatment
The unit cost of the water treatment for arsenic includes treatment and installation. For the purposes of this study it was assumed to be $1.50 gallons per day (gal/day).

Operation and Maintenance
Annual O&M costs for the pipelines were estimated to be 0.5 percent of the initial pipe costs. For pumping plants, annual O&M costs were estimated at eight percent of the pumping plant costs. Annual (O&M) costs for water treatment were estimated to be eight percent of the water treatment costs.

E. Annual and Project Worth Costs

There are a number of different costs that are utilized in the process of cost analysis. The field cost includes the construction costs plus any contingencies that must be factored in. The amortized annual construction cost is the annual payment necessary to amortize the field cost over 50 years at the planning interest rate of 4.125%. The annual cost per AF is the amortized annual construction costs plus the annual O&M costs divided by the water supply yield. There is no cost inflation for O&M over the 50 year evaluation period. The annual costs for the Alternative 3 variations are shown in Table 2.3.1.

Table 2.3.1. Annual Project Costs

Alternative Versions	Amortized Annual Const Cost ($)	Annual O&M Cost ($)	Annual Cost ($/AF)	Annual Cost ($/ Kgal)
Bill Williams Pipeline Alignment	$43,318,300	$11,124,148	$1,285	$3.94
Big Sandy Pipeline Alignment	$46,958,400	$11,595,880	$1,382	$4.24

The present worth project cost is derived by adding together the field costs plus the present value of 50 years of O&M costs at 4.125% divided by the water supply yield. The present worth projects costs for the Alternative 3 variations are shown in Table 2.3.2.

Table 2.3.2. Present Worth Project Costs

Alternative Versions	Field Cost ($)	Present Worth O&M Cost ($)	Present Worth Cost ($/AF)	Present Worth Cost ($/ Kgal)
Bill Williams Pipeline Alignment	$910,985,979	$233,941,457	$27,016	$83.00
Big Sandy Pipeline Alignment	$987,985,108	$243,861,999	$29,057	$89.00

2.4 Alternative 4 - Conversion of Existing Septic Systems - Urban

A. Summary of Alternative 4

Treated effluent is considered to be a renewable water resource that increases as population increases. This renewable water supply has the potential to augment water resources if it replaces use of another water supply. Reuse options include: turf irrigation, groundwater recharge, or industrial use. Costs for reuse options are not developed in this Study. Identification of types and locations of reuse could be part of a feasibility investigation and the associated costs would be developed at that time. This alternative focuses on conversion of urban septic systems to public systems, identifies the potential volume of water that would be available, and develops costs to convey and treat the wastewater.

Septic systems are a source of unutilized or underutilized wastewater. Septic systems may provide a benefit via groundwater recharge, however, recharge volumes are difficult to quantify. Another benefit of converting septic systems to sewer connections is that septic systems may have a negative impact on groundwater quality. The EPA concluded that septic systems are a potential source of water contamination in the United States [1]. Factors that may negatively impact groundwater quality include the density of septic systems, depth to groundwater, and the age of the septic systems. Converting septic systems to sewer systems would minimize the potential for groundwater contamination and provide a new water source to augment water supplies.

This alternative proposes conversion of urban residential septic systems to sewer connections. For the purposes of this study, "urban" refers to a WPA that is serviced by a water provider, sewer provider, or is within the boundary of a Certificates of Convenience and Necessity (CC&N). A CC&N defines an area where an entity holds exclusive rights to supply water or wastewater services within a specified geographic area.

This analysis estimated the number of residential properties in urban areas that use on-site septic systems. Under this alternative, residential septic systems would be converted to connections with sewer conveyance infrastructure. This would involve extending sewer conveyance infrastructure into areas where residences are currently on septic systems.

B. Alternative 4 Water Planning Areas

For Alternative 4, eleven WPAs are considered urban. They are Camp Verde, Chino Valley, Clarkdale, Cottonwood, Jerome, Prescott, Prescott Valley, Sedona, Big Park CDP, Lake Montezuma CDP and Paulden CDP.

C. Alternative 4 Description

Under this alternative, residential septic systems would be converted to sewer service to increase the availability of effluent for reuse in urban areas. Urban areas typically consist of properties with smaller lot sizes and a higher density of households than rural areas. Septic conversions in higher density developments may be more cost effective than conversions in rural areas because

less infrastructure may be required. Resources may already be in place in urban areas, such as right-of-ways, that would facilitate the construction of sewer infrastructure.

In this analysis, infrastructure requirements for each alternative are based on the status of the WWTF's. When average daily flow into a WWTF reaches 80 percent of its rated capacity, it was determined that a WWTF would require expansion. Based on this criterion, the WWTF's are categorized into three groups within each WPA.

Group A – Existing WWTF can accommodate additional wastewater capacity. Expansion of sewer conveyance infrastructure is required.

Group B – Existing WWTF requires expansion to accommodate additional wastewater capacity Expansion of sewer conveyance infrastructure is required.

Group C – Construction of new WWTF and sewer conveyance infrastructure is required.

Each WPA is assessed based on the group that its associated WWTF falls under. WPAs that have WWTF's with the capacity to process increased wastewater flows are within Group A, WPAs that have WWTF's that require expansion to process increased wastewater flows are within Group B, and WPAs that require construction of new WWTF's to process wastewater are within Group C.

Table 2.4.2 segregates the WPAs by WWTF group and shows 2010 wastewater volumes. Wastewater volumes for each WPA were estimated for 2010 using an average wastewater production of 69 gallons per person per day. Average wastewater production could be reduced in the future as implementation of conservation measures further reduces household water use. The number of septic systems located within each urban WPA was estimated using population served by water providers, knowledge of local experts and by calculating the difference between water accounts and sewer accounts.

Table 2.4.2. Grouping of WPAs for Urban Septic Conversion by WWTF Status

Group	Water Planning Area	2010 Septic Wastewater Volume
Group A	Camp Verde	207 AFY (184,798 gal/day)
	Chino Valley	47 AFY (41,959 gal/day)
Group B	Big Park	276 AFY (246,397 gal/day)
	Clarkdale	40 AFY (35,710 gal/day)
	Cottonwood	821 AFY (732,943 gal/day)
	Prescott	751 AFY (670,450 gal/day)
	Prescott Valley	664 AFY (592,782 gal/day)
	Sedona	151 AFY (134,804 gal/day)
Group C	Jerome	10 AFY (8,927 gal/day)
	Lake Montezuma	254 AFY (226,757 gal/day)
	Paulden	146 AFY (130,341 gal/day)

AFY - Acre-feet per year

Although the Jerome WPA is included in Group C (WPA without WWTF) Jerome does have a WWTF. The majority of Jerome's septic systems are located at elevations that are below the existing sewer transmission lines and these septic systems cannot easily be tied into the existing gravity fed sewer system. The Jerome Town Council indicated that a separate WWTF would need to be constructed to serve areas that are located below the elevation of the current WWTF infrastructure.

D. Alternative 4 Infrastructure Requirements

The type and amount of infrastructure required for this alternative depends on the WPA grouping which is based on the status of the associated WWTF.

WWTF's in Group A may require additional infrastructure to expand sewer conveyance systems. Sewer lines, manholes and lift stations would comprise the main components of the expansion. Septic system conversions would require a wastewater pipeline and connection between the residence and the sewer conveyance system.

WWTF's in Group B would include the infrastructure requirements of Group A and in addition, infrastructure to increase the wastewater treatment capacity. Additional infrastructure may include screens, clarifiers, pumps and basins. WWTF expansions would be designed to operate at 80% capacity.

WWTF's in Group C would include the infrastructure requirements of Group A and in addition, construction of a new WWTF. New WWTF's would be designed to operate at 80% capacity and to produce Class A+ effluent.

E. Alternative 4 Field Cost Analysis

General cost estimates are provided for the WPAs based on the WWTF grouping. Cost estimates to construct new sewer conveyance infrastructure, to convert residential septic systems to sewer connections, and to construct additional capacity or new WWTF's are provided in this analysis. Development of detailed cost estimates would require specific information for each WWTF within the WPAs. This level of detail would be completed during a feasibility study and is beyond the scope of an appraisal study.

Group A

Table 2.4.3 shows wastewater volumes and WWTF capacities for WPAs in Group A. If the septic systems in this group were converted to sewer systems, the existing WWTF's would still operate at 80% capacity.

Table 2.4.3. 2010 Wastewater Volumes – Urban Septic Conversion Group A

Water Planning Area	New Wastewater Volume	Current Effluent Generated	Current Plant Capacity
Camp Verde	207 AFY (184,798 gal/day)	195 AFY (174,085 gal/day)	728 AFY (649,917 gal/day)
Chino Valley	47 AFY (41,959 gal/day)	242 AFY (216,044 gal/day)	560 AFY (499,936 gal/day)

AFY - Acre-feet per year

Construction costs for Group A include expansion of the sewer conveyance infrastructure, connection to the sewer system and abandonment of septic systems. Costs to build sewer conveyance infrastructure are shown in Table 2.4.4. Table 2.4.5 shows the unit cost estimate to connect a septic system to a sewer system.

The cost of adding sewer conveyance infrastructure was determined using estimated costs per linear mile of pipeline. To estimate the cost per linear foot to expand sewer conveyance infrastructure, contractor bids for expansion of the City of Prescott sewer system were used. Three project types or sewer system types were identified and bids were averaged for each type: residential ($346 per linear foot), force main residential ($575 per linear foot) and rural ($120 per linear foot). Construction costs may be higher in residential areas due to sidewalks, curbs, gutters, and traffic control features. Costs were indexed to 2011. Urban area sewer infrastructure expansion lengths were determined by taking the square root of the corresponding water service area. Assumptions used to develop costs for urban sewer conveyance expansions include: 1) 80 percent of the line would be residential and, 2) 20 percent would be a force main. Rural sewer infrastructure expansion lengths were assumed to be half of the longest distance across the corresponding WPA.

Costs to connect a septic system to a sewer conveyance pipeline were estimated using an assumed distance of 400 feet from the home to the sewer line, a yard line depth of 18 inches, a 4-inch PVC pipe, and septic system abandonment including emptying the septic tank and filling it with compacted dirt or sand. Costs were indexed to 2011. Permits are required to convert a septic system to a sewer system. Fees associated with septic conversion can be expensive and variable and details regarding specific costs for conversion fees are not provided in this analysis.

Table 2.4.4. Sewer Conveyance Infrastructure Cost Estimate for Urban Area – Group A

Type of System	Linear Foot Estimate	Linear Mile Estimate
Residential Area	$346	$1,826,880
Forced Main in Residential Area	$575	$3,036,000
Rural Area	$120	$633,600

Table 2.4.5. Septic System Conversion Cost Estimate – Group A

Pipe costs including trenching	$10.08/linear foot	$4,032
Backfill and compaction	$35.28/cubic yard	$522
Connection to sewer line	$750	$750
Septic System Abandonment	$2,000	$2,000
	TOTAL	$7,304

Group B

Table 2.4.6 shows wastewater volumes for each WPA in Group B. The WWTF's in these WPA's would require construction of additional capacity to process new wastewater from septic conversions and remain at or below the 80% capacity threshold.

Table 2.4.6. 2010 Wastewater Volumes – Urban Septic Conversion Group B

Water Planning Area	New Wastewater Volume	Current Effluent Generated	Current Plant Capacity
Big Park	276 AFY (246,397 gal/day)	365 AFY (325,851 gal/day)	560 AFY (499,936 gal/day)
Clarkdale	40 AFY (35,710 gal/day)	291 AFY (259,788 gal/day)	280 AFY (249,968 gal/day)
Cottonwood	821 AFY (732,943 gal/day)	1,008 AFY (899,886 gal/day)	1,680 AFY (1,499,809 gal/day)
Prescott*	751 AFY (670,450 gal/day)	4,144 AFY (3,700,000 gal/day)	4,704 AFY (4,200,000 gal/day)
Prescott Valley	664 AFY (592,782 gal/day)	2,750 AFY (2,455,045 gal/day)	4,200 AFY (3,749,523 gal/day)
Sedona	151 AFY (134,804 gal/day)	1,410 AFY (1,258,769 gal/day)	1,792 AFY (1,599,797 gal/day)

AFY - Acre-feet per year

*- Current effluent generated and capacity are for Sundog and Airport plants only and obtained from Sundog WWTP and Airport WRF Capacity and Technology Master Plan, October 2010

Table 2.4.7 shows the additional treatment capacity needed for WWTF's in each WPA to process additional wastewater from converted septic systems. The additional capacity is determined using the new effluent volume generated plus a 20 percent increase to account for the extra capacity required for expansion of the WWTF.

Estimated costs for Group B WPA's include construction of sewer conveyance infrastructure, as described for Group A plus the cost to expand the WWTF's to operate at 80% capacity. WWTF expansion costs were estimated using actual costs to expand six WWTF's in Arizona. Based on this, the average cost for a WWTF expansion is $9.42 per gallon per day. Costs were indexed to 2011.

Table 2.4.7. Wastewater Treatment Facility Expansion Volumes – Group B

Planning Area	Additional Plant Capacity	Total New Capacity	
Big Park	209 AFY (186,583 gal/day)	769 AFY (686,519 gal/day)	Cost of expanding existing facility capacity $9.42/gallon/day
Clarkdale	117 AFY (104,450 gal/day)	397 AFY (354,419 gal/day)	
Cottonwood	515 AFY (459,762 gal/day)	2,195 AFY (1,959,570 gal/day)	
Prescott	1,170 AFY (1,044,508 gal/day)	5,874 AFY (5,243,969 gal/day)	
Prescott Valley	103 AFY (91,952 gal/day)	4,303 AFY (3,841,471 gal/day)	
Sedona	81 AFY (72,312 gal/day)	1,873 AFY (1,672,107 gal/day)	

AFY - Acre-feet per year

Group C

Table 2.4.8 shows the wastewater volumes that would be generated in WPA's in Group C if new WWTF's were constructed and residential septic systems were converted to sewer connections.

Table 2.4.8. 2010 Wastewater Volumes – Urban Septic Conversion Group C

Planning Area	New Wastewater Volume	Current Effluent Generated	Current Plant Capacity
Jerome	10 AFY (8,927 gal/day)	N/A	N/A
Lake Montezuma	254 AFY (226,757 gal/day)	N/A	N/A
Paulden	146 AFY (130,340 gal/day)	N/A	N/A

AFY - Acre-feet per year

Table 2.4.9 shows the capacity requirements for new WWTF's for WPA's in Group C. The capacity requirements are based on the new effluent volumes that would be generated plus a 20 percent increase to account for the extra capacity required for a new WWTF to operate at 80 percent capacity. Construction costs include sewer conveyance infrastructure for conversion of septic to sewer as described for Group A and construction of new WWTF's. Costs to construct a new WWTF were estimated using actual costs to construct three new WWTF's located in the City of Peoria, Town of Cave Creek and City of Kingman. These facilities produce Class A+ effluent. The average cost to construct a new WWTF that operates at 80% capacity and produces Class A+ effluent is $13.38 per gallon per day. Costs were indexed to 2011.

Table 2.4.9. New Wastewater Treatment Facility Capacities for WPA's in Group C

Planning Area	Plant Capacity	Cost of building new facility
Jerome	12 AFY (10,713 gal/day)	$13.38/gallon/day
Lake Montezuma	305 AFY (272,286 gal/day)	
Paulden	175 AFY (156,230 gal/day)	

AFY - Acre-feet per year

F. Alternative 4 Annual and Project Worth Costs

There are a number of different costs that are utilized in the process of cost analysis. The field cost includes the construction costs plus any contingencies that must be factored in. The amortized annual construction cost is the annual payment necessary to amortize the field cost over 50 years at the planning interest rate of 4.125%. The annual cost per AF is the amortized annual construction costs plus the annual operation and maintenance (O&M) over the 50 year evaluation period. The annual costs for the Alternative 4 groups are shown in Table 2.4.10.

The present worth project cost is derived by adding together the field costs plus the present value of 50 years of O&M costs at 4.125% divided by the water supply yield. The present worth projects costs for each group in Alternative 4 are shown in Table 2.4.11.

Table 2.4.10. Annual Costs - Conversion of Existing Septic Systems (Urban)

Group	Amortized Annual Const Cost ($)	Annual O&M Cost ($)	Annual Cost ($/AF)	Annual Cost ($/Kgal)
A	$1,176,800	$1,979,900	$12,427.91	$38.14
B	$8,474,800	$14,258,100	$8,410.24	$25.81
C	$1,647,900	$2,772,400	$10,781.22	$33.09
Total	$11,116,300	$18,702,100	$9,002.04	$27.63

Table 2.4.11 Present Worth Costs - Conversion of Existing Septic Systems (Urban)

Group	Field Cost ($)	Present Worth O&M Cost ($)	Present Worth Cost ($/AF)	Present Worth Cost ($/Kgal)
A	$24,748,600	$41,637,200	$261,361.24	$802.09
B	$178,226,100	$299,848,400	$176,868.11	$542.99
C	$34,655,000	$58,303,700	$226,728.60	$695.80
Total	$237,629,700	$399,789,300	$189,313.62	$580.98

Reuse of Treated Effluent

One of the most efficient tools in the conservation toolbox is reuse or recharge of treated effluent. The appropriate use of treated effluent is an important strategy in every community's water portfolio. It is important for Cities and towns to use the right water quality for the right use – potable water for potable uses and reclaimed water for non-potable uses. With the advent of new technologies for purifying treated effluent, such as multi-stage membrane bioreactors, the industry is demonstrating that wastewater can be treated to a high degree of quality that may be purer than potable water. When this is the case, it's logical to consider using treated effluent for potable use rather than non-potable use. The reality is that non-potable demands exist and that matching the water quality to use is a best management practice. Depending upon a community's water demand portfolio, there can often be a considerable amount of effluent that

may be recharged or reused in a beneficial way. Considering a community's water use profile and its non-potable uses, the demand on groundwater supplies may be reduced if treated effluent is converted to potable water and used as such.

Legal, institutional, and psychological barriers currently prevent direct use of treated effluent for potable use. The psychological barrier and political (institutional) intransigence are the two biggest barriers. Opponents of "direct potable reuse" often tag such use as "toilet to tap," and convince regulators and policymakers that potable reuse is risky to public health and expensive to implement. Current treatment and monitoring practices can essentially eliminate admixture of under-treated water with potable supplies, but the stigma remains. As the public becomes better informed about the quality of treated effluent and the risks and benefits of potable reuse, the stigma will eventually be overcome, and decisions to implement direct or indirect potable reuse projects will gain support. As treatment technologies improve and costs decline, the economics of potable reuse of treated effluent will become more practical. In this analysis, direct use of treated effluent is assumed to be turf irrigation and indirect use is assumed to be basin recharge. The Arizona Department of Environmental Quality (ADEQ) minimum reclaimed water quality standard for turf irrigation is Class B. Class B reclaimed water has undergone secondary treatment and disinfection. The quality of effluent required for basin recharge is dependent on site specific variables including geology, aquifer depth, and groundwater quality. The ADEQ issues an Aquifer Protection Permit for a recharge facility which contains site specific compliance standards for recharge of treated effluent.

Planning Areas Considered for Existing Unused Effluent

To quantify the volume of treated effluent that may be available for reuse, fourteen WPAs were assessed: Camp Verde, Chino Valley, Clarkdale, Cottonwood, Dewey-Humboldt, Jerome, Prescott, Prescott Valley, Sedona, Big Park CPD, Cornville CDP, lake Montezuma CDP, Paulden CDP and Williamson CDP.

Existing Unused Effluent

In this analysis, unused effluent is defined as effluent that is passively disposed of. Effluent that is evaporated or discharged into a wash is not considered used. Effluent that is provided to an area or body of water via a formal agreement is interpreted to be utilized. For example, Big Park Domestic Wastewater Improvement District has an agreement with the Forest Service to discharge a particular volume of effluent down a tributary of Jack's Canyon Wash. Effluent that is discharged to a surface water designated as an effluent dependent water is considered utilized. For example, The Town of Jerome discharges effluent into Bitter Creek which is designated as an effluent dependent water. Table 2.4.12 lists WWTF's with unused effluent volumes.

Table 2.4.12. WWTF's with Unused Effluent Volumes

Facility	Planning Area	Volume Generated (Acre-Feet/Year)	Unused Volume
Camp Verde WWTP	Camp Verde	195	195 AFY (174,085 gal/day)
Clarkdale WWTP	Clarkdale	291	291 AFY (259,788 gal/day)
City of Sedona (3 facilities)	Sedona	1,410	1,410 AFY (1,258,769 gal/day)

AFY - Acre-feet per year

Infrastructure Requirements for Reuse

The type and amount of infrastructure required depends on the volume and end use of the effluent. Direct and indirect reuse would require a pressurized system with valves to deliver effluent for turf irrigation or basin recharge. Indirect use would also include costs to construct recharge basins. Indirect use would likely require WWTF upgrades to improve effluent quality for recharge. Infrastructure requirements to upgrade a facility are site specific. Upgrades can include new digesters, clarifiers, ultra-violet disinfection system, and larger drying beds. Details regarding requirements to upgrade a WWTF are not identified in this analysis and would be determined at the feasibility level.

Reuse Analysis

Cost

General unit costs are provided to upgrade facilities and install required infrastructure for direct and indirect reuse. Unit costs were derived from actual WWTF's that were upgraded in the United States.

Reuse Summary

Direct Reuse of Effluent

Construction costs include the installation of a pressurized 8-inch water line with valves to irrigate turf, on-site metering, and connections are shown on Table 2.4.13. These costs are based on actual costs to deliver treated effluent to golf courses in Casa Grande. Costs were indexed to 2011 dollars.

Table 2.4.13. Effluent Delivery for Turf Irrigation Cost Estimate

Linear Foot Estimate	Linear Mile Estimate
$131.88	$696,326

Indirect Reuse of Effluent

Construction cost estimates for a basin recharge facility were based on actual costs to construct 4 recharge facilities in Casa Grande and are shown in Table 2.4.14. Costs were indexed to 2011. Construction costs include pipeline, pump station, and spreading basins. Information available for the Casa Grande recharge facilities indicates that a total of 76.8 acres would be required to recharge 10 million gallons per day. Based on this information, approximately 130,000 gallons per day can be recharged in a 1 acre basin at an average infiltration rate of 1.2 feet per day. In this analysis, it is assumed that half of the basins would be wetted at any time and that 1.5 times the basin acreage would be needed for berms, roads and buffers for the facility.

Table 2.4.14. Cost Estimate to Construct Basin Recharge Facility

24-inch Pipeline	$272/linear foot
1.5 to 2.0 MGD Pump Station	$1.6 million
Spreading Basin berms roads buffers	$186,600/acre

Upgrade Treatment Facility

Cost estimates to upgrade an existing WWTF were developed based on actual costs to upgrade four existing WWTF's that produce Class A+ effluent. The upgrades consisted solely of improving the quality of the effluent produced at the facility. Three of the upgraded WWTF's were located on the East Coast and one was located on the West Coast. Table 2.4.15 shows the total cost and unit cost for the WWTF upgrades. Costs were indexed to 2011. Review of the unit costs indicate cost savings based on an economy of scale. Smaller facilities are much more expensive to upgrade on a unit cost basis.

Table 2.4.15. Total and Unit Costs to Upgrade Effluent Water Quality at Four WWTF's

	Project Cost	Plant Capacity	Unit Cost
San Diego, CA	$92.7 million	25 mgd	$3.71/gallon
Aberdeen, MD	$8 million	4 mgd	$2.00/gallon
Sturbridge, MA	$17 million	.75 mgd	$22.66/gallon
Bowie, MD	$10.5 million	.50 mgd	$21.00/gallon

These unit costs provide general information for effluent reuse and may be used for planning reclaimed water turf irrigation systems and effluent recharge facilities. When locations for turf irrigation and recharge facilities are identified, refined cost estimates can be prepared. This could be a part of a feasibility investigation.

2.5 Alternative 5 - Conversion of Existing Septic Systems - Rural

A. Summary of Alternative 5

Treated effluent is considered to be a renewable water resource that increases as population increases. This renewable water supply has the potential to augment water resources when used to irrigate turf, recharge groundwater, or when used for industrial processes. Costs for reuse options are not developed in this Study. Identification of types and locations of reuse could be part of a feasibility investigation and the associated costs would be developed at that time. This alternative focuses on conversion of rural septic systems to public systems, identifies the potential volume of water that would be available, and develops costs to convey and treat the wastewater.

Septic systems are a source of unutilized or underutilized wastewater. Septic systems may provide a benefit via groundwater recharge, however, recharge volumes are difficult to quantify. Another benefit of converting septic systems to sewer connections is that septic systems may have a negative impact on groundwater quality. The EPA concluded that septic systems are a potential source of water contamination in the United States [1]. Factors that may negatively impact groundwater quality include the density of septic systems, depth to groundwater, and the age of the septic systems. Converting septic systems to sewer systems would minimize the potential for groundwater contamination and provide a new water source to augment water supplies.

This alternative proposes conversion of rural residential septic systems to sewer connections. For the purposes of this study, "rural" refers to areas that are not served by a WPA that is serviced by a water provider, sewer provider, or is within the boundary of a Certificates of Convenience and Necessity (CC&N). A CC&N defines an area where an entity holds exclusive rights to supply water or wastewater services within a specified geographic area.

This analysis estimated the number of residential properties in rural areas that use on-site septic systems. Under this alternative, residential septic systems would be converted to connections with sewer conveyance infrastructure. This would involve extending sewer conveyance infrastructure into areas where residences are currently on septic systems.

B. Alternative 5 Water Planning Areas

All WPAs were considered for this alternative because every WPA contains areas that are not served by a water service area, a wastewater service area, or are designated as a CC&N. Only those planning areas where identifiable wastewater volumes could be documented are assessed.

C. Alternative 5 Description

This alternative involves conversion of residential septic systems to sewer service to increase the availability of effluent for reuse, in rural areas. This assessment considers rural areas to be outside of a water provider service area, a sewer service area or a CC&N. Rural areas tend to have larger lots and lower household density than urban areas. The WPAs are assessed individually.

Rural wastewater volumes were calculated using the number of rural parcels (2007 Yavapai County Geographic Information System), population (US Census 2000), and an average wastewater production of 69 gallons per person per day (Table 2.5.1). Average wastewater production could be reduced in the future as implementation of conservation measures further reduces household water use. Only residential parcels are considered for conversion of septic systems to a sewer system. This process yielded a rural population estimate by planning area.

Table 2.5.1. Conversion of Septic Systems in Rural Areas, Wastewater Volumes Greater than 10 AFY by WPA.

	Rural Population	Volume of Septic Wastewater (acre-feet per year)
Ashfork	470	36
Cornville	2,986	231
Cottonwood	933	72
Humboldt	227	18
Lake Montezuma	863	67
Mingus Mountain	2,170	168
Paulden	2,565	198
Prescott CCD	9,957	770
Prescott Valley	6,250	483
Prescott	4,454	344
Verde	1,056	82
Cottonwood-Verde Village	893	69
Williamson	2,952	228

D. Alternative 5 Infrastructure Requirements

All rural WPAs would require construction of sewer conveyance infrastructure and new WWTF's. The capacity of each WWTF would be specific to each WPA and designed to operate at 80% capacity and produce Class A+ effluent.

E. Alternative 5 Field Cost Analysis

Cost estimates for this appraisal study are general and limited to unit costs. The sewer systems differ in extent and material type. Table 2.5.2 shows the estimated unit cost of constructing a

sewer conveyance infrastructure. Table 2.5.3 shows estimated unit costs to connect a septic system to a sewer system. Table 2.5.4 shows the capacity requirements for new WWTF's by WPA. The capacity requirements are determined using the new effluent volume generated plus a 20 percent increase to account for the extra capacity required for the new WWTF's to operate at 80 percent capacity.

The cost of adding sewer conveyance infrastructure was determined using estimated costs per linear mile of pipeline. To estimate the cost per linear foot to expand sewer conveyance infrastructure, contractor bids for expansion of the City of Prescott sewer system were used. Three project types or sewer system types were identified and bids were averaged for each type: residential ($346 per linear foot), force main residential ($575 per linear foot) and rural ($120 per linear foot). Costs were indexed to 2011. Rural area sewer infrastructure expansion lengths were assumed to be the square root of the area of the corresponding WPA.

Costs to connect a septic system to a sewer conveyance pipeline were estimated using an assumed distance of 400 feet from the home to the sewer line, a yard line depth of 18 inches, 4-inch PVC pipe, and septic system abandonment including emptying the septic tank and filling it with compacted dirt or sand. Costs were indexed to 2011. Permits are required to convert a septic system to a sewer system. Fees associated with septic conversion can be expensive and variable and details regarding specific costs for fees are not provided in this analysis.

Table 2.5.2 Sewer Conveyance Infrastructure Cost Estimate for Rural Area

Type of System	Linear Foot Estimate	Linear Mile Estimate
Forced Main in Residential Area	$575	$607,200
Rural Area	$120	$506,880

Table 2.5.3 Septic Conversion Cost Estimate per Residence for Rural Area

Pipe costs including trenching	$10.08/linear foot	$4,032
Backfill and compaction	$35.28/cubic yard	$522
Connection to sewer line	$750	$750
Septic System Abandonment	$2,000	$2,000
	TOTAL	$7,304

Table 2.5.4 New Wastewater Treatment Facility Capacities for Septic Conversion in Rural Areas

Water Planning Area	Plant Capacity	
Ashfork	43 AFY (38,388 gal/day)	Cost of building new facility $13.38/gallon/day
Cornville	277 AFY (247,289 gal/day)	
Cottonwood	86 AFY (76,776 gal/day)	
Humboldt	22 AFY (19,640 gal/day)	
Lake Montezuma	80 AFY (71,419 gal/day)	
Mingus Mountain	202 AFY (180,334 gal/day)	
Paulden	238 AFY (212,473 gal/day)	
Prescott CCD	924 AFY (824,894 gal/day)	
Prescott Valley	580 AFY (517,791 gal/day)	
Prescott	413 AFY (368,703 gal/day)	
Verde	98 AFY (87,489 gal/day)	
Cottonwood-Verde Village	83 AFY (74,098 gal/day)	
Williamson	274 AFY (244,611 gal/day)	

AFY - Acre-feet per year

F. Alternative 5 Annual and Project Worth Costs

There are a number of different costs that are utilized in the process of cost analysis. The field cost includes the construction costs plus any contingencies that must be factored in. The amortized annual construction cost is the annual payment necessary to amortize the field cost over 50 years at the planning interest rate of 4.125%. The annual cost per AF is the amortized annual construction costs plus the annual operation and maintenance (O&M) over the 50 year evaluation period. The annual costs for the Alternative 5 groups are shown in Table 2.5.5.

The present worth project cost is derived by adding together the field costs plus the present value of 50 years of O&M costs at 4.125% divided by the water supply yield. The present worth projects costs for each group in Alternative 5 are shown in Table 2.5.6.

Table 2.5.5. Annual Costs - Conversion of Existing Septic Systems (Rural)

Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost ($/AF)	Annual Cost ($/Kgal)
$9,519,800	$16,016,096	$9,232.07	$28.33

Table 2.5.6. Present Worth Costs - Conversion of Existing Septic Systems-Rural

Field Cost ($)	Present Worth O&M Cost ($)	Present Worth Cost ($/AF)	Present Worth ($/Kgal)
$200,201,200	$336,819,400	$194,150.61	$595.83

Reuse of Treated Effluent

Refer to the discussion provided in Alternative 4.

2.6 Alternative 6 - New Effluent from New Population

A. Summary of Alternative 6

Treated effluent is considered to be a renewable water resource that increases as population increases. This renewable water supply has the potential to augment water resources if it replaces use of another water supply. Reuse options include: turf irrigation, groundwater recharge, or industrial use. Costs for reuse options are not developed in this Study. Identification of types and locations of reuse and/or recharge could be part of a feasibility investigation and the associated costs would be developed at that time. This alternative focuses on new wastewater volumes as a result of new population in 2050, identifies the potential volume of water that would be available, and develops costs to convey and treat the wastewater.

This alternative proposes that future effluent volumes will increase based on population increases in each of the WPAs from 2006 to 2050. This alternative assumes that new conveyance infrastructure will be required to connect new locations to sewer connections and that some

existing WWTF's will be expanded and new WWTF's will be constructed to accommodate the new wastewater volumes.

B. Alternative 6 Water Planning Areas

Under Alternative 6, all WPA's were considered.

C. Alternative 6 Descriptions

This alternative estimates the volume of treated effluent that would be produced from new population in each of the twenty WPAs from 2006 to 2050. The new population was determined during the Phase I - Demand Analysis conducted for this Study. The new population was multiplied by an average wastewater production of 69 gallons per day per person to estimate the new wastewater volume available in 2050. Average wastewater production could be reduced in the future as implementation of conservation measures further reduces household water use. Table 2.6.1 shows the new population and new wastewater volumes by WPA.

Table 2.6.1. 2050 New Wastewater Volume by Water Planning Area

Planning Area	New Population (2006 to 2050)	New Wastewater Volume
Camp Verde	10,780	833 AFY (743,820 gal/day)
Dewey Humboldt	2,809	217 AFY (193,821 gal/day)
Clarkdale	18,461	1,427 AFY (1,273,809 gal/day)
Cottonwood	57,230	4,423 AFY (3,948,870 gal/day)
Jerome	290	22 AFY (20,010 gal/day)
Prescott Valley	104,390	8,068 AFY (7,202,910 gal/day)
Chino Valley	51,000	3,942 AFY (3,519,000 gal/day)
Prescott	50,928	3,936 AFY (3,514,032 gal/day)
Sedona	5,220	403 AFY (360,180 gal/day)
Paulden CDP	8,757	677 AFY (604,233 gal/day)
Big Park CDP	1,079	83 AFY (74,451 gal/day)
Cornville CDP	3,373	261 AFY (232,737 gal/day)

Planning Area	New Population (2006 to 2050)	New Wastewater Volume
Lake Montezuma CDP	4,071	315 AFY (280,899 gal/day)
Ctn-Verde Village CDP	8,333	644 AFY (574,977 gal/day)
Williamson CDP	6,617	511 AFY (456,573 gal/day)
Verde CCD	2,733	211 AFY (188,577 gal/day)
Prescott CCD	18,300	1,414 AFY (1,262,700 gal/day)
Mingus Mtn CCD	2,825	218 AFY (194,925 gal/day)
Humboldt CCD	382	30 AFY (26,358 gal/day)
Ashfork CCD	35,779	2,765 AFY (2,468,751 gal/day)

Table 2.6.2 shows the volume of effluent generated from new wastewater as a high estimate and a conservative estimate. The high estimate assumes that all new wastewater is captured in a sewer system for treatment, reuse and/or recharge. The conservative estimate takes into account the percentage of population in the region served by WWTF's. In 2002, the NACOG Section 208 Plan estimated that 45% of the population in Yavapai County was served by WWTF's. The conservative estimate uses the percent of the population that is served by a WWTF which may vary for each WPA based on projected land use and wastewater management plans.

Table 2.6.2. 2050 New Effluent High and Conservative Volumes

Planning Area	High Estimate (gallons/day)	% of Population served by WWTF (2050)	Conservative Estimate (gal/day)
Camp Verde	743,820	45%	334,719
Dewey Humboldt	193,821	45%	87,219
Clarkdale	1,273,809	45%	573,214
Cottonwood	3,948,870	60%	2,369,322
Jerome	20,010	45%	9,005
Prescott Valley	7,202,910	100%	7,202,910
Chino Valley	3,519,000	45%	1,583,550

Planning Area	High Estimate (gallons/day)	% of Population served by WWTF (2050)	Conservative Estimate (gal/day)
Prescott	3,514,032	45%	1,581,314
Sedona	360,180	45%	162,081
Paulden CDP	604,233	45%	271,905
Big Park CDP	74,451	45%	33,503
Cornville CDP	232,737	45%	104,732
Lake Montezuma CDP	280,899	45%	126,405
Ctn-Verde Village CDP	574,977	45%	258,740
Williamson CDP	456,573	45%	205,458
Verde CCD	188,577	45%	84,860
Prescott CCD	1,262,700	45%	568,215
Mingus Mtn CCD	194,925	45%	87,716
Humboldt CCD	26,358	45%	11,861
Ashfork CCD	2,468,751	45%	1,110,938

In this analysis, infrastructure requirements for each alternative are based on the status of the WWTF's. When average daily flow into a WWTF reaches 80 percent of its rated capacity, it was determined that a WWTF would require expansion. Based on this criterion, the WWTF's are categorized into three groups within each WPA.

Group A – Existing WWTF can accommodate additional wastewater capacity. Expansion of sewer conveyance infrastructure is required.

Group B – Existing WWTF requires expansion to accommodate additional wastewater capacity Expansion of sewer conveyance infrastructure is required.

Group C – Construction of new WWTF and sewer conveyance infrastructure is required.

Each WPA is assessed based on the group that its associated WWTF falls under. WPAs that have WWTF's with the capacity to process increased wastewater flows are within Group A, WPAs that have WWTF's that require expansion to process increased wastewater flows are within Group B, and WPAs that require construction of new WWTF's to process wastewater are within Group C.

WPAs were segregated into the WWTF groupings based on the high and conservative wastewater volume estimates and the associated WWTF treatment capacity (Table 2.6.3).

Table 2.6.3. Grouping of WPAs based on High and Conservative Wastewater Volumes

	High Estimate	**Conservative Estimate**
Group A	Big Park	Big Park
		Camp Verde
Group B	Camp Verde	Chino Valley
	Chino Valley	Clarkdale
	Clarkdale	Cottonwood
	Cottonwood	Prescott
	Prescott	Prescott Valley
	Prescott Valley	Sedona
	Sedona	
Group C	Ashfork CCD	Ashfork CCD
	Cornville CDP	Cornville CDP
	Dewey Humboldt	Dewey Humboldt
	Humboldt CCD	Humboldt CCD
	Jerome	Jerome
	Lake Montezuma	Lake Montezuma
	Mingus Mountain CDP	Mingus Mountain CDP
	Paulden	Paulden
	Prescott CCD	Prescott CCD
	Verde CCD	Verde CCD
	Ctn-Verde Village CDP	Verde Village CDP
	Williamson CDP	Williamson CDP

D. Alternative 6 Infrastructure Requirements

Group A infrastructure requirements include expansion of sewage collection systems.

Group B consists of the requirements from Group A and expansion of existing WWTF's to operate at 80% capacity. Group C includes the requirements from Group A and construction of a new WWTF designed to operate at 80% capacity and to produce Class A+ effluent.

E. Alternative 6 Field Cost Assumptions and Analysis

Cost estimates to construct new sewer conveyance infrastructure, to convert residential septic systems to sewer connections, and to construct additional capacity or new WWTF's are provided in this analysis. Development of detailed cost estimates would require specific information for each WWTF within the WPAs. This level of detail would be completed during a feasibility study and is beyond the scope of an appraisal study.

Total 2050 wastewater volumes calculated for Alternative 6 add effluent that is currently generated to new effluent estimated to be generated in 2050. This alternative does not include effluent volumes generated from conversion of septic to sewer.

Group A

Table 2.6.3 shows the new wastewater volumes associated with WPAs in Group A. The existing WWTF's in these WPAs can treat additional wastewater and operate at 80% capacity. Only the Big Park WWTF has enough capacity to handle both the high and conservative new wastewater volume estimates. The Camp Verde WWTF only has the capacity to treat the conservative wastewater volume estimate.

Table 2.6.3. 2050 Wastewater Volumes – Group A

Planning Area	Total 2050 Wastewater Volume		Current Plant Capacity
	High	Conservative	
Big Park	448 AFY (400,302 gal/day)	402 AFY (359,354 gal/day)	560 AFY (499,936 gal/day)
Camp Verde	N/A	570 AFY (508,804 gal/day)	728 AFY (649,917 gal/day)

AFY - Acre-feet per year

Table 2.6.4 shows the estimated cost to construct sewer conveyance infrastructure for WWTF's in Group A. Costs were indexed to 2011.

Table 2.6.4. 2050 Wastewater Volumes Sewer Conveyance Infrastructure Cost Estimate – Group A

Type of System	Linear Foot Estimate	Linear Mile Estimate
Residential Area	$346	$1,826,880
Forced Main in Residential Area	$575	$3,036,000
Rural Area	$120	$633,600

Group B

Table 2.6.5 shows the 2050 wastewater volume capacity requirements and deficiencies for WWTF's for each WPA. Deficiencies were determined using 2010 WWTF treatment capacities. Construction costs include conveyance infrastructure as detailed for Group A and the cost to expand WWTF treatment capacities to operate at 80% capacity. The WWTF capacity required to process new effluent volumes in 2050 is determined using current effluent volumes plus new effluent volumes and a 20 percent increase to ensure that expanded WWTF's operate at 80 percent capacity.

Table 2.6.5. 2050 Wastewater Treatment Facility Capacities – High and Conservative Volumes Group B

Planning Area	High Estimate		Conservative Estimate	
	2050 Capacity Required	Capacity Deficit	2050 Capacity Required	Capacity Deficit
Camp Verde	1,234 AFY (1,101,486 gal/day)	506 AFY (451,569 gal/day)	N/A	N/A
Chino Valley	5,021 AFY (4,482,053 gal/day)	4,461 AFY (3,982,117 gal/day)	2,419 AFY (2,159,513 gal/day)	1,859 AFY (1,659,577 gal/day)
Clarkdale	2,062 AFY (1,840,316 gal/day)	1,782 AFY (1,590,349 gal/day)	1,120 AFY (999,602 gal/day)	840 AFY (749,635 gal/day)

Cottonwood	6,517 AFY (5,818,507 gal/day)	4,837 AFY (4,318,700 gal/day)	3,598 AFY (3,923,050 gal/day)	1918 AFY (2,423,242 gal/day)
Prescott	9,696 AFY (8,656,838 gal/day)	4,992 AFY (4,457,378 gal/day)	7,098 afy (6,337,577 gal/day)	2,394 AFY (2,138,116 gal/day)
Prescott Valley	12,982 AFY (11,589,546 gal/day)	8,782 AFY (7,840,028 gal/day)	12,982 AFY (11,589,546 gal/day)	8,782 AFY (7,840,028 gal/day)
Sedona	2,176 AFY (1,942,739 gal/day)	384 AFY (342,944 gal/day)	1,910 AFY (1,705,020 gal/day)	118 AFY (105,226 gal/day)

AFY - Acre-feet per year

Group C

Table 2.6.6 shows the capacity requirements of new WWTF's, by WPA, to process high and conservative wastewater volumes. Construction costs for this group include those detailed for Group A and the cost to construct a new WWTF to operate at 80% capacity and produce Class A+ effluent. The WWTF capacity required to process new effluent volumes in 2050 is determined using current effluent volumes plus new effluent volumes and a 20 percent increase to ensure that new WWTF's operate at 80 percent capacity.

Table 2.6.6. 2050 Wastewater Treatment Facility Capacities - High and Conservative Volumes – Group C

Planning Area	**Plant Capacity**	
	High Estimate	Conservative Estimate
Ashfork	3,318 AFY (2,962,501 gal/day)	1,493 AFY (1,333,126 gal/day)
Cornville	313 AFY (279,284 gal/day)	141 AFY (125,678 gal/day)
Cottonwood-Verde Village	773 AFY (689,972 gal/day)	348 AFY (310,488 gal/day)
Dewey-Humboldt	260 AFY (232,585 gal/day)	117 AFY (104,663 gal/day)
Humboldt CCD	36 AFY (31,630 gal/day)	16 AFY (14,233 gal/day)
Jerome	26 AFY (24,012 gal/day)	12 AFY (10,806 gal/day)
Lake Montezuma	378 AFY	170 AFY

Planning Area	Plant Capacity	
	High Estimate	Conservative Estimate
	(337,079 gal/day)	(151,686 gal/day)
Mingus Mountain	262 AFY (233,910 gal/day)	118 AFY (105,259 gal/day)
Paulden	812 AFY (725,080 gal/day)	365 AFY (326,286 gal/day)
Prescott CCD	1,697 AFY (1,515,240 gal/day)	764 AFY (681,858 gal/day)
Verde CCD	253 AFY (226,292 gal/day)	114 AFY (101,832 gal/day)
Williamson CDP	613 AFY (547,888 gal/day)	276 AFY (246,550 gal/day)

AFY - Acre-feet per year

F. Alternative 6 Annual and Project Worth Costs

There are a number of different costs that are utilized in the process of cost analysis. The field cost includes the construction costs plus any contingencies that must be factored in. The amortized annual construction cost is the annual payment necessary to amortize the field cost over 50 years at the planning interest rate of 4.125%. The annual cost per AF is the amortized annual construction costs plus the annual operation and maintenance (O&M) over the 50 year evaluation period. The annual costs for Alternative 6 are shown in Tables 2.6.7 and 2.6.9.

The present worth project cost is derived by adding together the field costs plus the present value of 50 years of O&M costs at 4.125% divided by the water supply yield. The present worth project costs for each group in Alternative 6 are shown in Tables 2.6.8 and 2.6.10.

Table 2.6.7. Annual Costs - New Effluent from New Population in 2050 (High Future Wastewater Volume Estimate)

Group	Amortized Annual Const Cost ($)	Annual O&M Cost ($)	Annual Cost ($/AF)	Annual Cost ($/Kgal)
A	$968,400	$1,629,200	$5,798.30	$17.79
B	$33,325,000	$56,066,200	$3,472.31	$10.66
C	$11,533,500	$19,404,000	$3,538.95	$10.86
Total	$45,826,900	$77,099,400	$3,518.82	$10.80

Table 2.6.8 Present Worth Costs - New Effluent from New Population in 2050 (High Future Wastewater Volume Estimate)

Group	Field Cost ($)	Present Worth O&M Cost ($)	Present Worth Cost ($/AF)	Present Worth Cost ($/Kgal)
A	$20,365,500	$34,263,000	$121,938.63	$374.22
B	$700,827,200	$1,179,074,800	$73,022.92	$224.10
C	$242,549,600	$408,066,500	$74,424.17	$228.40
Total	$963,742,300	$1,621,404,400	$74,000.88	$227.10

Table 2.6.9 Annual Costs - New Effluent from New Population in 2050 (Conservative Future Wastewater Volume Estimate)

Group	Amortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost ($/AF)	Annual Cost ($/Kgal)
A	$2,083,000	$3,504,400	$5,748.38	$17.64
B	$28,597,300	$48,112,300	$4,591.19	$14.09
C	$8,993,800	$15,131,300	$6,132.46	$18.82
Total	$39,674,100	$66,748,000	$4,923.76	$15.11

Table 2.6.10 Present Worth Costs - New Effluent from New Population in 2050 (Conservative Future Wastewater Volume Estimate)

Group	Field Cost ($)	Present Worth O&M Cost ($)	Present Worth Cost ($/AF)	Present Worth Cost ($/Kgal)
A	$43,805,300	$73,698,200	$120,888.41	$370.99
B	$601,403,300	$1,011,803,600	$96,552.96	$296.31
C	$189,140,000	$318,211,700	$128,966.11	$395.78
Total	$834,349,600	$1,403,713,500	$103,546.92	$317.77

Reuse of Treated Effluent

Refer to the discussion provided in Alternative 4.

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2.7 Alternative 7 – Capture and Store Unappropriated Verde River Water – Bartlett Dam, Horseshoe Dam, Sullivan Dam or Page Springs

A. Summary of Alternative 7

This alternative proposes as a source of supply the capture of unappropriated surface water from the Verde River watershed during a spill condition. This volume of floodwater is an intermittent source that is only available when all senior downstream water rights are being satisfied and storage capacity is being exceeded at Salt River Project's (SRP) reservoirs. There are a number of versions of this alternative (see Table 2.7.1) but all include either increasing or creating additional reservoir storage. The increased reservoir storage would result in the ability to store water within the system that would normally be lost during a spill condition. Water supply credits would accrue in the new space and designated for the WPA participants and then debited when the water is used upstream. These alternatives would require appropriate surface water rights and water exchange agreements would likely need to be executed.

In both Alternatives 7.1 and 7.2, the proposed reservoir volume increases are based on the reservoir yield potential concept. The average annual water yield for different variables was determined by conducting a reservoir routing analysis. The proposed reservoir size increases (A through C) shown in Table 2.7.1 reflect the best range of water production reliability versus the historical water yields in the watershed.

Table 2.7.1 Alternative Versions and Volumes

Alternative Version	Description of Alternative Version	Volume of New Supply (AF/yr)
7.1A - Increase Bartlett Dam 3.5 Feet & Conceptualized Upstream Catchment	Captures and stores water behind Bartlett Dam that would normally have spilled. Stored water becomes a source of supply through water exchange. Requires upstream catchment conveyance and treatment facilities.	10,000
7.1 B - Increase Bartlett Dam 8.5 Feet & Conceptualized Upstream Catchment	Captures and stores water behind Bartlett Dam that would normally have spilled. Stored water becomes a source of supply through water exchange. Requires upstream catchment conveyance and treatment facilities.	25,000
7.1C - Increase Bartlett Dam 18.5 Feet & Conceptualized Upstream Catchment	Captures and stores water behind Bartlett Dam that would normally have spilled. Stored water becomes a source of supply through water exchange. Requires upstream catchment conveyance and treatment facilities.	45,000
7.2 A - Increase Horseshoe Dam 3.6 Feet & Conceptualized Upstream Catchment	Captures and stores water behind Horseshoe Dam that would normally have spilled. Stored water becomes a source of supply through water exchange. Requires upstream catchment conveyance and treatment facilities.	10,000
7.2B - Increase Horseshoe Dam 9.5 Feet & Conceptualized Upstream Catchment	Captures and stores water behind Horseshoe Dam that would normally have spilled. Stored water becomes a source of supply through water exchange. Requires upstream catchment conveyance and treatment facilities.	25,000
7.2C - Increase Horseshoe Dam 15.1 Feet & Conceptualized Upstream Catchment	Captures and stores water behind Horseshoe Dam that would normally have spilled. Stored water becomes a source of supply through water exchange. Requires upstream catchment conveyance and treatment facilities.	45,000
7.3 - On-stream Storage at Sullivan Lake	Captures water at Sullivan Dam. Requires modification of the existing dam, extensive excavation, packaged water treatment plant, pump station and waterline.	2,240
7.4 - Off-stream Storage at Page Springs	Captures water near Page Springs on the Oak Creek drainage area. Requires construction of inlet structure, reservoir, packaged water treatment plant, pump station and waterline.	2,240

B. Alternative 7 Water Planning Areas

The WPAs considered in versions 7.1 and 7.2 of this alternative are those that show a 2050 water supply deficit (Table 1.1). The WPAs considered in version 7.3 of this alternative are Dewey-Humboldt and Prescott. The WPAs considered in version 7.4 are Clarkdale and Cottonwood.

C. Alternative 7 Description

All versions of this alternative are based on availability of unappropriated surface water during a specific condition where all senior priority water rights and being met and additional surface water is still available. This condition is commonly referred to as a "spill" condition and it occurs infrequently. Consequently, this alternative will only be available on a sporadic basis.

Versions 7.1 and 7.2 of this alternative require modifications to existing SRP dams in addition to construction of upstream catchments and transmission facilities. Infrastructure requirements for these versions include: increasing dam height, dam spillway modification, dam inlet/outlet modification, access improvements and relocation/reconstruction of ancillary facilities associated with dams, construction of reservoir for off-stream storage, water treatment plant, pump station and waterline. In this evaluation, the catchment locations and transmission facilities are conceptualized and estimated based on the various increased dam heights and water volumes captured. Conceptualized transmission lines are based on eight miles of pipeline; additional transmission lines to WPAs are not estimated. There was no effort in this evaluation to determine the geologic integrity of increasing the height of the dams.

Version 7.3 of this alternative is intake and catchment of water at Sullivan Lake, located about 1.5 miles south of Paulden (Figure 2.7.1). The catchment facility size and location was based on the surrounding topography, existing infrastructure, and proposed water treatment plant. This version assumed a two million gallon per day packaged water treatment plant that yielded the 2,240 AF/yr. At this volume, 2.8 million cubic yards of sediment must be excavated.

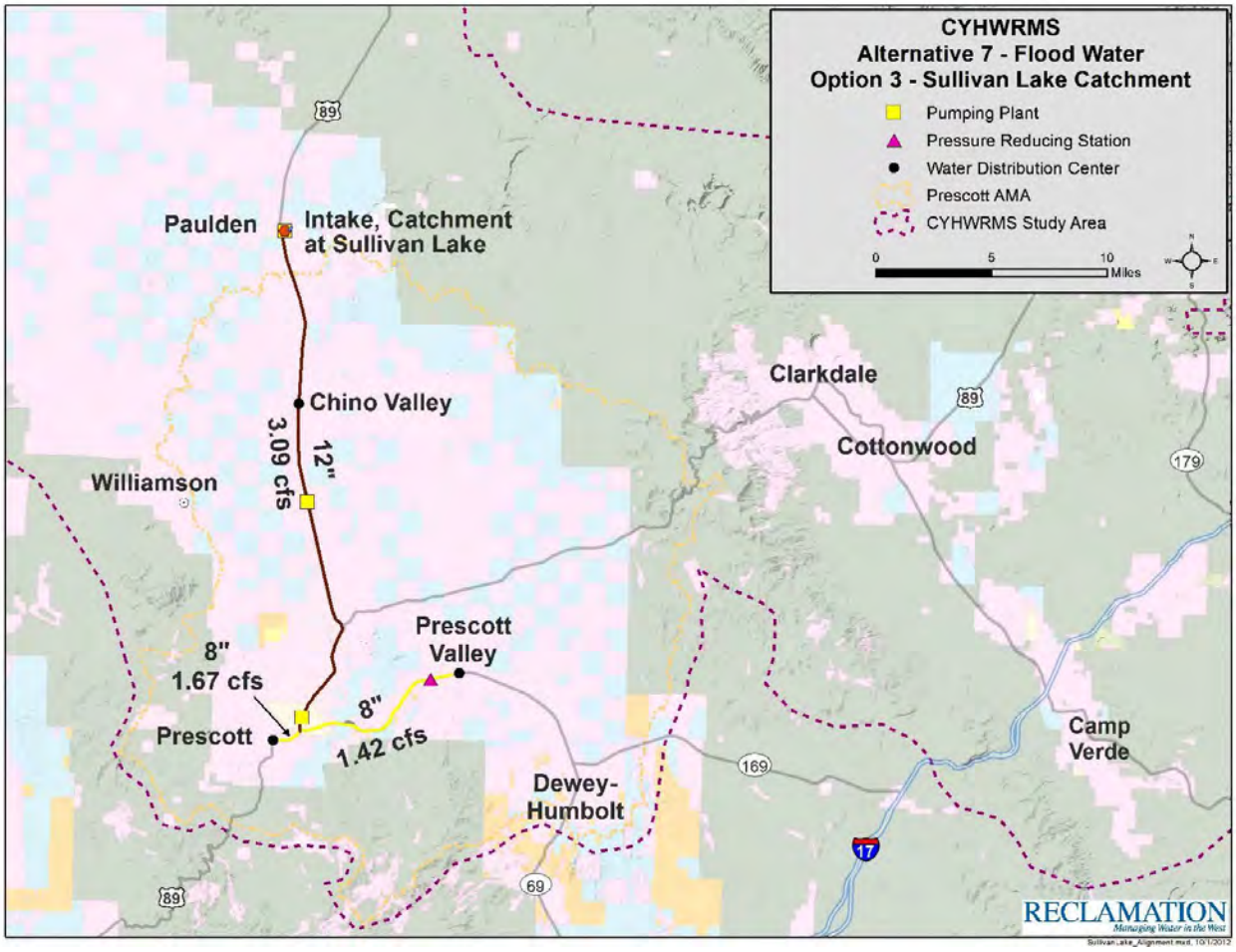


Figure 2.7.1 Depiction of Alternative Version 7.3

Additionally, this version included a 12 inch pipeline running parallel to Arizona Highway 89, south to Chino Valley, Prescott and Prescott Valley. Two pump stations and one pressure reducing station will be required for this alignment.

Version 7.4 of this alternative is catchment of water near Page Springs on the Oak Creek drainage area (Figure 2.7.2). The catchment facility size and location was based on the surrounding topography, existing infrastructure, and proposed water treatment plant. This version assumed a two million gallon per day packaged water treatment plant that yielded the 2,240 AF/yr. Additionally, this version included a 12 inch pipeline running east to a point midway between Clarkdale and Cottonwood. Three pump stations will be required for this alignment.

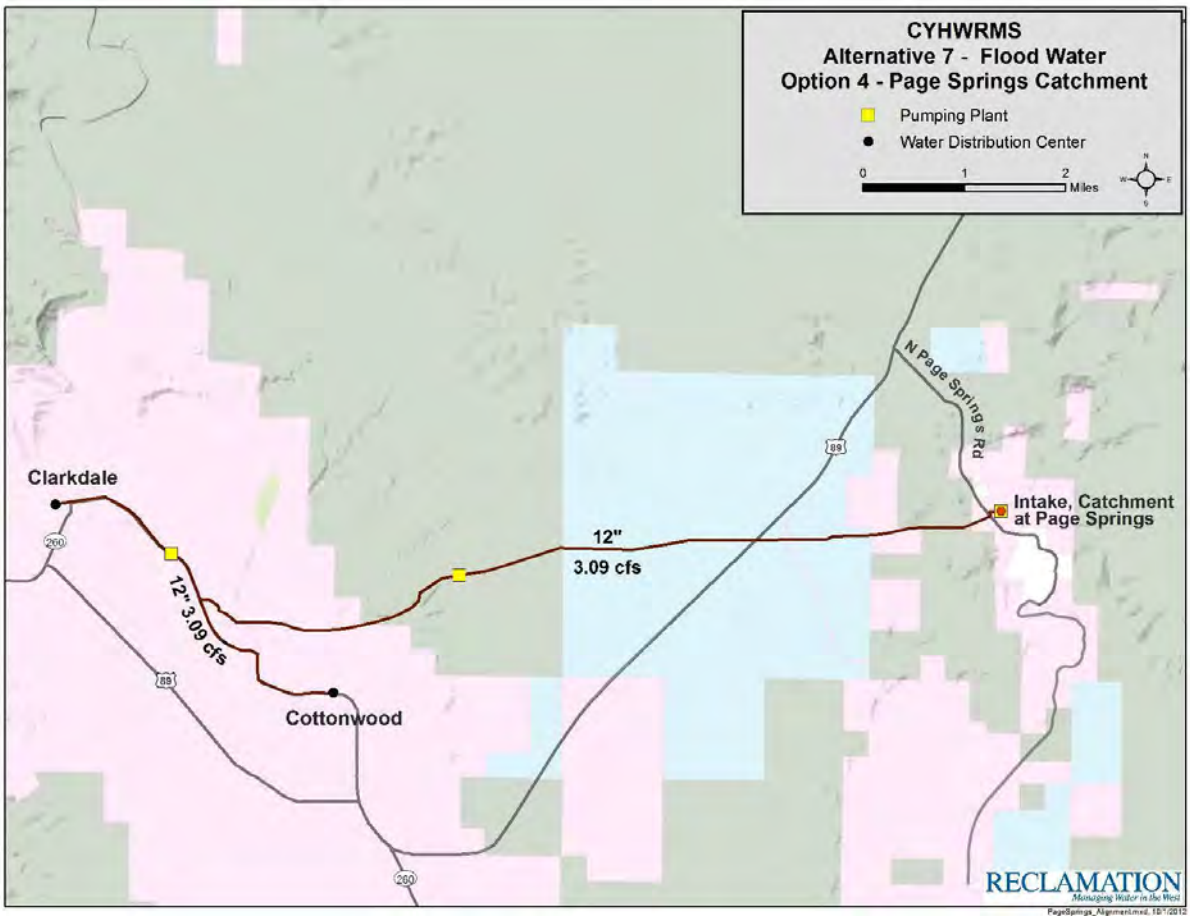


Figure 2.7.2 Depiction of Alternative Version 7.4

Dam Spill Probability

An analysis of the probability of Bartlett or Horseshoe Dam spilling during the same time frame that there were high flows on the upper Verde River were conducted using SRP and USGS data. The analysis found that for gage 09503700 near Paulden, there were 15 events where unappropriated surface water could have been diverted during 8 out of 20 yrs. For gage 09504000 near Clarkdale, there were 21 events where unappropriated surface water could have been diverted during 8 out of 20 yrs. The analysis time frame was from 1990 to 2010. Flows that were greater than 75 cfs or more above the median flow were considered high and appeared feasible for extracting water. The long term median flow for 09503700 is 24 cfs and the median flow for 09504000 is 79 cfs. Table 2.7.2 shows the Verde spill timeframes and whether it coincided with high flows on the Verde gages 09503700 and 09504000.

Table 2.7.2 Verde Spill Time Frames and Gage Flows

Verde Spill Timeframes			USGS Gages-Verde Hi Flows	
Start	End	Days	09503700	09504000
3/29/1991	3/31/1991	3	yes	yes
4/2/1991	4/3/1991	2	yes	yes
4/7/1991	4/9/1991	3	**no**	yes
2/13/1992	2/18/1992	6	yes	yes
3/5/1992	3/15/1992	11	**no**	yes
3/25/1992	3/29/1992	5	**no**	yes
8/23/1992	8/25/1992	3	yes	yes
1/3/1993	1/21/1993	19	yes	yes
2/5/1993	2/17/1993	13	yes	yes
2/20/1993	3/1/1993	10	yes	yes
3/4/1993	3/7/1993	4	yes	yes
3/12/1993	3/17/1993	6	**no**	yes
3/31/1993	4/1/1993	2	**no**	yes
2/14/1995	2/21/1995	8	yes	yes
3/5/1995	3/22/1995	18	yes	yes
3/30/1998	4/6/1998	8	yes	yes
4/10/1998	4/15/1998	6	**no**	yes
12/30/2004	3/31/2005	92	yes	yes
1/27/2008	3/23/2008	57	yes	yes
1/21/2010	1/23/2010	3	yes	yes
2/3/2010	5/27/2010	114	yes	yes

D. Infrastructure Requirements and Alternative 7 Field Cost Assumptions and Analysis

Pipelines

Pipe lengths and head classes were determined through GIS analysis of the pipeline alignments. The cost estimate includes the cost for corrosion monitoring and cathodic protection of steel pipelines, where applicable. Construction costs for corrosion monitoring and cathodic protection were assumed to be one percent of the construction cost.

Appurtenant structures and mechanical equipment associated with the pipeline are covered under "unlisted items" in the cost estimates. These items include air valves, blowoffs, drains, flowmeters, altitude valves, and sectionalizing valves, etc.

Hydraulics

The pipeline conveyance costs include the assumption that the treated water will need to overcome 350 feet of static head loss and 100 feet of dynamic head loss (maximum pumping lift about 450 feet).

It was assumed that all lateral pipe is mortar lined steel pipe with full inside diameters. Pipeline capacities were sized based on Table 2.7.1 **Alternative Versions and Volumes** and a peaking factor was not applied. Pressure Reducing valve stations are required when pressures at a maximum exceed 500 feet.

Pressure Reducing Stations

In line pressure reducing stations were assumed to be required to limit the pipe head class to a maximum of 500 feet. The cost is based on a single pressure reducing station.

Excavation and Backfill

Excavation and backfill quantities for pipe earthwork were based on a typical trapezoidal trench section with 1:1 slopes and an average depth of cover of four feet. This value was chosen because the majority of the pipe alignment is along existing roadways and gradual grades were anticipated. Excavation was assumed to be 70 percent rock and 30 percent common.

Pumping Plants

The field costs for pumping plants were taken from the North Central Arizona Water Supply Study (NCAWSS) Report and adjusted for higher flows. Forebay tanks would be required upstream from each pumping plant to supply water during startup of the pumps. For this appraisal level estimate, all forebay tanks were estimated to be 10 feet in diameter and 20 feet tall. Air chambers will be required downstream and were assumed to be 20-foot-diameter spheres.

The cost estimate includes the cost for a Supervisory Control and Data Acquisition (SCADA) system for the control of the pumping plants. The construction costs for the SCADA system were assumed to be three percent of the construction cost.

Water Treatment

The unit cost of the water treatment plant includes the treatment and installation. For the purposes of this study it was assumed at $2 gallons per day (gal/day).

Operation and Maintenance

Annual O&M costs for the pipelines were estimated to be 0.5 percent of the initial pipe costs. For pumping plants, annual O&M costs were estimated at eight percent of the pumping plant costs. Annual O&M costs for water treatment were estimated to be eight percent of the water treatment costs.

E. Annual and Project Worth Costs

There are a number of different costs that are utilized in the process of cost analysis. The field cost includes the construction costs plus any contingencies that must be factored in. The amortized annual construction cost is the annual payment necessary to amortize the field cost over 50 years at the planning interest rate of 4.125%. The annual cost per AF is the amortized annual construction costs plus the annual O&M costs divided by the water supply yield. There is no cost inflation for O&M over the 50 year evaluation period. The annual costs for the Alternative 7 variations are shown in Table 2.7.2.

Table 2.7.2. Annual Project Costs

Alternative Versions	Amortized Annual Const Cost ($)	Annual O&M Cost ($)	Annual Cost ($/AF)	Annual Cost ($/ Kgal)
7.1A	$7,940,100	$1,926,800	$986.39	$3.03
7.1B	$16,446,800	$4,888,000	$853.39	$2.62
7.1C	$27,109,200	$8,378,350	$788.61	$2.42
7.2A	$7,511,000	$1,923,000	$943.40	$2.90
7.2B	$15,966,900	$4,887,995	$834.20	$2.56
7.2C	$26,615,500	$8,378,350	$777.66	$2.39
7.3	$2,293,300	$480,640	$1,238.00	$3.80
7.4	$2,123,800	$488,040	$1,166.00	$3.58

The present worth project cost is derived by adding together the field costs plus the present value of 50 years of O&M costs at 4.125% divided by the water supply yield. The present worth projects costs for the Alternative 7 variations are shown in Table 2.7.3.

Table 2.7.3. Present Worth Project Costs

Alternative Versions	Field Cost ($)	Present Worth O&M Cost ($)	Present Worth Cost ($/AF)	Present Worth Cost ($/ Kgal)
7.1A	$166,981,000	$40,457,600	$20,744	$63.66
7.1B	$345,877,000	$102,794,800	$17,947	$55.08
7.1C	$570,108,000	$176,197,200	$16,585	$50.90
7.2A	$157,956,000	$40,440,800	$19,840	$60.89
7.2B	$335,785,000	$102,794,800	$17,543	$53.84
7.2C	$559,746,000	$176,197,200	$16,354	$50.19
7.3	$48,229,000	$10,107,900	$26,043	$79.92
7.4	$44,664,000	$10,263,500	$24,521	$75.25

2.8 Alternative 8 – Rainwater Harvesting – Aquifer Storage

A. Summary of Alternative 8

This alternative evaluates a variety of rainwater harvesting methods to capture rainwater that would normally be lost to evaporation and transpiration. The methods evaluated in this alternative are considered large-scale, or macro-rainwater harvesting methods, that capture storm water and re-direct a portion of the rainwater to recharge facilities. It assumes that the water gathered via rainwater harvesting efforts is different from surface water, although that legal distinction does not currently exist. For each alternative, the rainwater that is harvested is gathered at numerous smaller locations (lots) and then transmitted to another location for recharge and recovery.

There were two general categories of rainwater harvesting considered in this alternative. The first is harvesting from developed areas such as existing residential and commercial properties. Harvested water originates from impermeable surfaces such as rooftops, driveways, parking lots, sidewalks and roads. Additionally, there is an opportunity for micro-scale rainwater harvesting from developed areas. When individual micro-scale units reach their full capacity, runoff can overflow into the macro-scale system thus becoming one system. The second is harvesting from undeveloped areas that have land surfaces modified via compaction and re-grading to increase runoff from storm events.

For the purposes of this study, that amount of rainwater that could be harvested and defined as a new water source is estimated by multiplying the horizontal surface area by the annual runoff captured. This assumes the new water source is distinguished from appropriable surface water.

B. Alternative 8 Water Planning Areas

The WPAs evaluated in this alternative are Prescott Valley, Chino Valley, Prescott and Prescott CCD. However, this alternative is applicable to all WPAs.

C. Alternative 8 Description

In this alternative, there were 10 water harvesting scenarios developed for specific lots that differ by lot location, lot size, the amount of development on the lot (pervious versus impervious versus pervious made impervious land surfaces), existing infrastructure and proposed on-site infrastructure improvements (Table 2.8.1). Additionally, each scenario includes the construction of off-site transmission pipelines and recharge and delivery improvements including recharge basins, recovery wells, and water treatment facilities.

Rainwater harvesting scenarios for aquifer storage were evaluated within the Little Chino and Upper Agua Fria groundwater sub basins. Each of the ten scenarios proposed has the potential to be applied in all planning areas associated within the CYHWRMS area.

The intent of rainwater harvesting is to recognize and take advantage of a source of water that is currently available without affecting potential claims for surface water appropriations. Rainwater harvesting in this region is based on the notion of harvesting water that would have been lost to evaporation or transpiration and using it for aquifer storage. Distinguishing surface water from rainwater harvesting (new water source) will still need to be defined.

For each scenario, the horizontal land surface, nature of the land surface, and rainfall records were used to estimate the annual volume of rainwater that could be harvested based on a collective 12 lot sample wherein the lots were physically linked through lateral and collector infrastructure improvements. Table 2.8.5 identifies the volume of rainwater that can be harvested annually for each scenario both for the 12 lot sample size and for a larger 64 acre sample area. The volume from the 12 lot sample was extrapolated to the 64 acre sample area. The 12 lot volumes were used to determine costs for the lateral and collector improvements. The 64 acres sample volumes were used to determine costs for the transmission, recharge and recovery improvements.

The location map for each of the alternative scenarios can be seen in Appendix A. A 64 acre sample map of alternative two can be seen in Appendix A that includes conceptualized locations for transmission and water development improvements. A basic schematic of the rainwater harvesting system is show on Figure 2.8.1.

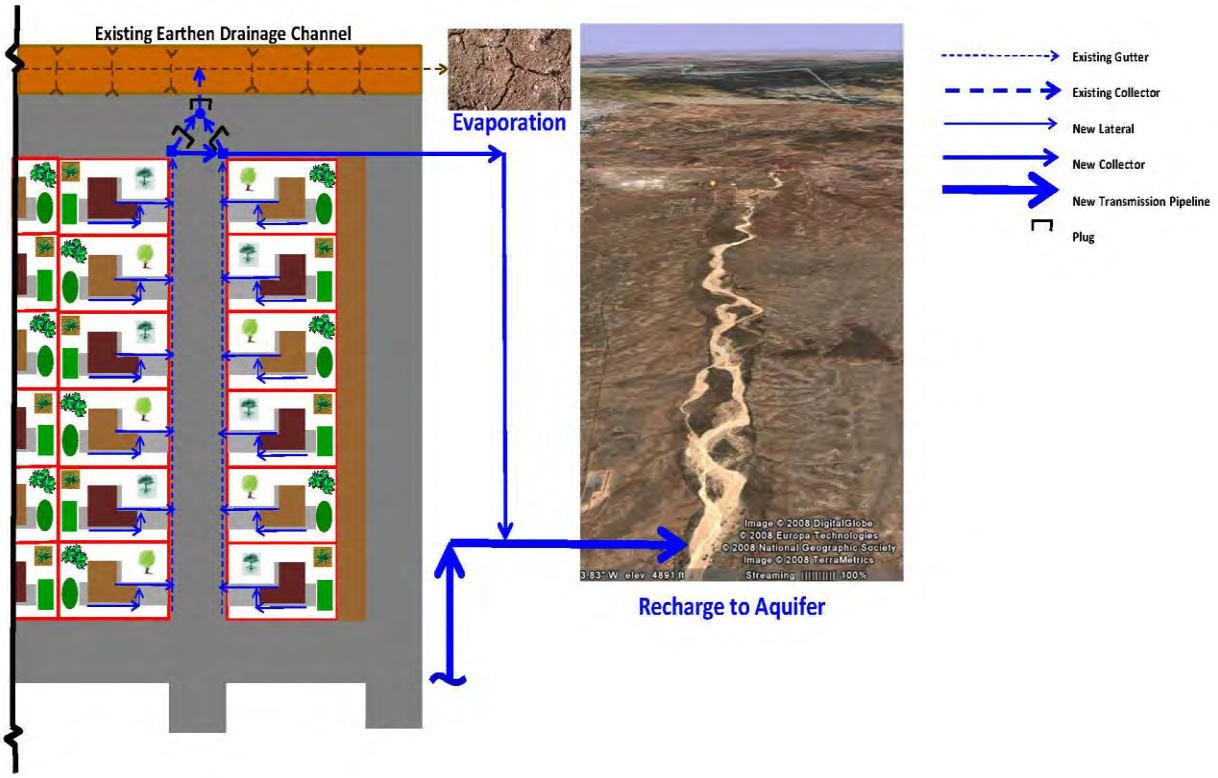


Figure 2.8.1 Schematic reference for Rainwater Harvesting Collection

Table 2.8.1. Alternative Scenario Descriptions

Scenario Number	Scenario Description
1	Located in Chino Valley; residential lots 0.15 acres in size. Existing infrastructure includes paved streets and concrete curbs and gutters. Proposed infrastructure includes lateral and collector pipe improvements, 6 inch and 15 inch corrugated pipe, respectively. Transmission line comprised of 30 inch and 42 inch corrugated pipe.
2	Located in Prescott Valley; residential lots 0.20 acres in size. Existing infrastructure includes paved streets and earthen v-ditches. Proposed infrastructure includes concrete curb and gutters, and lateral and collector pipe improvements, 6 inch and 15 inch corrugated pipe, respectively. Transmission line comprised of 36 inch and 54 inch corrugated pipe.
3	Located in Prescott Valley; residential lots 0.25 acres in size. Existing infrastructure includes paved streets and concrete curbs and gutters. Proposed infrastructure includes lateral and collector pipe improvements, 6 inch and 18 inch corrugated pipe, respectively. Transmission line comprised of 36 inch and 54 inch corrugated pipe.
4	Located in Prescott; residential lots 0.50 acres in size. Existing infrastructure includes paved streets and concrete curbs and gutters. Proposed infrastructure includes lateral and collector pipe improvements, 6 inch and 24 inch corrugated pipe, respectively. Transmission line comprised of 36 inch and 54 inch corrugated pipe.
5	Located in Yavapai County, east of Williamson Valley Road; residential lots 0.80 acres in size. Existing infrastructure includes paved streets and earthen v-ditches. Proposed infrastructure includes concrete curb and gutters, and lateral and collector pipe improvements, 6 inch and 24 inch corrugated pipe, respectively. Transmission line comprised of 36 inch and 48 inch corrugated pipe.
6	Located in Yavapai County, north of Prescott Valley; residential lots 2.0 acres in size. Existing infrastructure includes non-paved streets. Proposed infrastructure includes paved streets, concrete curb and gutters and lateral and collector pipe improvements, 6 inch and 30 inch corrugated pipe, respectively. Transmission line comprised of 30 inch and 42 inch corrugated pipe.
7	Located in Yavapai County, north of Prescott Valley; residential lots 2.0 acres in size. Existing infrastructure includes non-paved streets. Proposed infrastructure includes lined v-ditch parallel to street and lateral and collector pipe improvements, 6 inch and 30 inch corrugated pipe, respectively. Transmission line comprised of 30 inch and 42 inch corrugated pipe.
8	Located in Yavapai County, north of Prescott Valley; residential lots 2.0 acres in size. Existing infrastructure includes non-paved streets. Proposed infrastructure includes lined v-ditch parallel to street, surface compaction and lateral and collector pipe improvements, 6 inch and 42 inch corrugated pipe, respectively. Transmission line comprised of 48 inch and 60 inch corrugated pipe.
9	Located in Prescott Valley; commercial lots 1.5 acres in size. Existing infrastructure includes paved streets and concrete curbs and gutters. Proposed infrastructure includes lateral and collector pipe improvements, 6 inch and 42 inch corrugated pipe, respectively. Transmission line comprised of 48 inch and 60 inch corrugated pipe.
10	No location; conceptual only; open space lots of 2.0 acres Proposed infrastructure includes lined v-ditch parallel to street, surface compaction and collector pipe improvements of 42 inch corrugated pipe. Transmission line comprised of 48 inch and 60 inch corrugated pipe.

Macro Rainwater Harvesting Methodology

As defined in the alternative description, the amount of rainwater that could be harvested and defined as a new water source is estimated by the following:

Annual rainwater harvested = (horizontal surface area) X (annual runoff captured)

The horizontal surface area or land use data for each of the alternative scenarios was determined. Each of the alternative scenarios was divided into three area categories: Impervious, pervious and pervious made impervious. These horizontal surface areas will be used to estimate the amount of annual rainwater harvested based on 12 lots sample.

Table 2.8.2. Land Use Data for 12 Lots Sample

Alternative Scenarios	Land Use Data Based on 12 lots Sample Area (Acres)			
	Impervious	*Pervious Made Impervious*	*Pervious*	*Total Area*
1	1.05	0.00	0.93	1.98
2	1.10	0.00	1.48	2.58
3	1.46	0.00	1.88	3.33
4	2.12	0.00	4.33	6.44
5	1.84	0.00	8.28	10.12
6	2.15	0.00	22.84	25.00
7	1.21	0.00	23.78	25.00
8	1.21	22.84	0.94	25.00
9	15.83	0.00	3.66	19.49
10	0.00	24.05	0.00	24.05

To estimate the annual runoff captured, 2005 hourly rainfall records for Chino Valley and Prescott were used to determine the percent captured for each of the alternative area categories. The percent captured was calculated by adding the annual sum of runoff from grouped hourly precipitation storm events and dividing by the annual rainfall amount (∑ Runoff/Annual Rainfall). Runoff was determined using the SCS TR-55 runoff equation with curve numbers associated with the alternative scenario surfaces. Annual Rainfall data was collected from PRISM Data Explorer from PRISM Climate Group, Oregon State University.

The annual runoff captured was then calculated by multiplying the annual rainfall amount by the percent captured for each of the alternative scenarios. See Table 2.8.3. Annual Runoff Captured below:

Table 2.8.3. Annual Rainfall Captured for 12 Lots Sample

Alternative Scenarios	Annual Rainfall (Inches)	Percent Captured (%)			Annual Runoff Captured (Inches)		
		Impervious Area	*Pervious Made Impervious Area*	*Pervious Area*	*Impervious Area*	*Pervious Made Impervious Area*	*Pervious Area*
1	12.62	50.0	0.0	1.0	6.31	0.00	0.13
2	14.34	50.0	0.0	9.0	7.17	0.00	1.29
3	13.97	50.0	0.0	9.0	6.99	0.00	1.26
4	19.65	50.0	0.0	4.0	9.83	0.00	0.79
5	15.81	50.0	0.0	9.0	7.91	0.00	1.42
6	13.74	50.0	0.0	9.0	6.87	0.00	1.24
7	13.74	50.0	0.0	9.0	6.87	0.00	1.24
8	13.74	50.0	35.0	9.0	6.87	4.81	1.24
9	16.13	50.0	0.0	9.0	8.07	0.00	1.45
10	13.74	-	35.0	0.0	0.00	4.81	0.00

The annual rainwater harvested for each of the alternative scenarios was computed from Table 2.8.2 Land Use Data and Table 2.8.3 Annual Runoff Captured for each of the three area categories.

Table 2.8.4. Annual Rainwater Harvested for 12 Lots Sample

Alternative Scenarios	Annual Rainwater Harvested (Acre-Feet)			
	Impervious Area	*Pervious Made Impervious Area*	*Pervious Area*	*Total*
1	0.55	0.00	0.01	0.56
2	0.66	0.00	0.16	0.82
3	0.85	0.00	0.20	1.04
4	1.73	0.00	0.28	2.02
5	1.21	0.00	0.98	2.19
6	1.23	0.00	2.35	3.59
7	0.69	0.00	2.45	3.14
8	0.69	9.15	0.10	9.94
9	10.64	0.00	0.44	11.08
10	0.00	9.64	0.00	9.64

To estimate the water supply for the 64 acre sample improvements, the total area from Table 2.8.2 was divided by the total annual rainwater harvested from Table 2.8.4 for each of the alternative scenarios. That ratio was multiplied by 64 acres to determine the 64 acre sample recharge water supply. These values where used to determine the present worth and annual project costs for the transmission improvements.

Table 2.8.5. Annual Water Harvested per Unit Area

Alternative Scenarios	Total Area of 12 Lots (Acres)	Total Annual Rainwater Harvested 12 Lots Sample (AFY)	64 Acre Sample Improvements (AFY)	Ratio AFY/Acre
1	1.98	0.56	17.9	0.28
2	2.58	0.82	20.5	0.32
3	3.33	1.04	19.8	0.31
4	6.44	2.02	19.8	0.31
5	10.12	2.19	14.1	0.22
6	25.00	3.59	9.0	0.14
7	25.00	3.14	8.3	0.13
8	25.00	9.94	25.6	0.40
9	19.49	11.08	36.5	0.57
10	24.05	9.64	25.6	0.40

D. Infrastructure Requirements and Alternative 8 Field Cost Assumptions and Analysis

The infrastructure requirements and the associate cost component assumptions[10] are presented below. Rainwater harvesting improvements were estimated based on lot size and scenario and provided by Doug McMillan (retiree from Civiltec Engineering.) The unlisted items covered in this cost estimate include: regulating structures, additional junctions (manholes), curb inlets, clearing and grubbing and road reconstruction to include paving and base course material for storm drain pipe in developed areas.

Items that are not included but not limited to are the purchase of land, mitigation, and site specific geologic evaluations.

For future consideration, increased runoff associated with land surface treatments should be intercepted and transported to downstream recharge facilities without increasing potential for damage to existing flood control facilities. Runoff from developed areas that are harvested and directed to aquifer storage may be subject to physical and regulatory water quality issues.

[10] Unit cost assumptions were based on the North Central Arizona Water Supply Study Report, October 2006 and RS Means Heavy Construction Cost Data, 2010 Edition, and adjusted using Bureau of Reclamation construction cost indexes.

Lateral & Collector Improvements

Lateral improvement estimates include storm drain pipe installation, home/lot connections to lateral storm drain pipe and soil conditioning (compaction). Compaction was estimated on 9 inches of compaction to pervious areas for developed and undeveloped lots. Home/lot connections were estimated on a lump sum price.

Pipe sizing for lateral and collector pipes are based on the rational method one year recurrence interval for each alternative scenario location. For lateral and collector improvements pipe was sized based on land use data for 12-lot samples. NOAA Atlas 14 Precipitation Frequency Data Server was used to determine values for the one year recurrence interval.

The collector improvements incorporated proposed improvements to existing infrastructure including: road improvements (asphalt paving, concrete curb and gutter), collector storm drain pipes and lined v-ditches. Similarly to pipe sizing, the lined v-ditch for collector improvements was sized based on the rational method one year recurrence interval.

Transmission Improvements

Transmission improvements include storm drain pipe installation from runoff collection areas to conceptual recharge facilities. Pipe sizing for transmission pipes used the SCS TR-55 graphical peak discharge method. Transmission improvement pipes were sized on land use data for 64 acre samples.

Improvements Common to All Pipelines (Lateral, Collector and Transmission)

Lateral, collector and transmission pipes were estimated as corrugated HDPE storm drainage pipe Type-S (corrugated outside-smooth inside).

The estimates also include the cost for pipeline utility crossings and relocations in developed areas that include: site evaluations, design, and any additional components or materials for construction. The pipe crossing/relocations were assumed to be 2 percent of the lateral and collector construction costs.

Excavation and backfill quantities for pipe earthwork were based on a typical trapezoidal trench section with 1:1 slopes and an average depth of cover of three feet. Excavation was assumed to be common earth. Lateral improvement pipe excavation is assumed to be minimal and not estimated based on a shallow excavation assumption. Collector pipe earthwork was based on Yavapai Association of Governments standard detail 2-02 trench bedding for underground conduit

Water Development Improvements

Water development improvements include recharge basin excavation, well installation, and water treatment (arsenic). Land use data and quantities for water development improvements were also estimated for 64 acre samples.

The recharge basin excavation was estimated on conceptualized storage volume calculations. The storage volume is estimated as: $V = \frac{CAP_{24}}{12}$

where, V = storage volume estimate, AC-FT
C = Rational Runoff coefficient
A = Contributing drainage area, Acres
P_{24} = One year 24 hour rainfall amount, inches

Each recharge basin will be considered "off-line" in that it only captures non-appropriated water or the amount of rainwater that could be harvested and defined as a new water source. Weighed runoff coefficients were derived from lot coverage for each of the alternative scenarios and the following values where used: impervious C=0.90, pervious C=0.35 and pervious modified C=0.80. The one year-24 hour rainfall amount is based on the NOAA Atlas 14 Precipitation Frequency Data Server, point precipitation frequency estimates with 90% confidence intervals for each alternative scenario. Free board for each recharge basins was added as 10% of the storage volume. Recharge basin excavation estimates for each of the alternative scenarios is provided below in Table 2.8.6.

Determination of construction costs for recovery wells is based, in part, on a January 2010 cost estimate for drilling a 600 foot deep well in Manuelito, New Mexico and from published construction rates[11]. The well construction estimate is $60,100 per well installation. This well installation estimate is based on the following assumptions: proposed wells will yield up to 25 gallons per minute. Groundwater levels are approximately 300 feet below land surface. Wells are assumed to be 10 inches in diameter and 500 feet deep with a zone of influence of 200 feet.

The unit cost of the water treatment for arsenic includes treatment and installation. For the purposes of this study it was assumed at $1.50 gallons per day (gal/day).

[11] Rates from RS Means Heavy Construction Cost Data, 2010 edition.

Table 2.8.6. Recharge Basin Excavation

Alternative Scenarios	Area (Acres)	Weighted Runoff Coefficient	Rainfall Amount (P_{24}) (inches)	Storage Volume (AC-FT)	Storage Volume Plus Free Board (AC-FT)	Storage Volume (yds^3)
1	64	0.64	1.36	4.65	5.12	8,258
2	64	0.58	1.59	4.96	5.46	8,802
3	64	0.59	1.54	4.85	5.33	8,605
4	64	0.53	1.87	5.29	5.82	9,388
5	64	0.45	1.63	3.91	4.30	6,944
6	64	0.40	1.51	3.20	3.52	5,678
7	64	0.38	1.51	3.03	3.33	5,380
8	64	0.79	1.51	6.34	6.98	11,258
9	64	0.80	1.66	7.05	7.76	12,516
10	64	0.80	1.51	6.44	7.09	11,434

Operation and Maintenance

The estimated annual O&M cost for each alternative scenario is $15,500. This estimate was based on estimates for biannual scheduled and unscheduled maintenance including fixed rental costs for equipment (including mobilization and demobilization) and daily labor rates. Scheduled maintenance includes sediment and trash removal from the transmission line and mowing, pruning and ripping of the recharge basins to increase infiltration. Unscheduled maintenance includes cleaning of inlets and debris from collector improvements and repairs after flooding to recharge basins. Annual O&M costs for water treatment were estimated to be eight percent of the water treatment costs.

E. Annual and Project Worth Costs

There are a number of different costs that are utilized in the process of cost analysis. The field cost includes the construction costs plus any contingencies that must be factored in. The present worth project cost is derived by adding together the field costs plus the present value of 50 years of O&M costs at 4.125% divided by the water supply yield. The present worth projects costs for the Alternative 8 scenarios are shown in Table 2.8.7.

Table 2.8.7. Present Worth Project Costs

Alternative Scenario	Lateral & Collector Improvements		Transmission & Water Development Improvements			Total Present Worth Cost per Acre Foot	Total Present Worth Cost per 1,000 gal
	Field Cost	Present Worth Cost per Acre Foot	Field Cost	Present Worth O&M Cost	Present Worth Cost per Acre Foot		
1	$30,126	$53,797	$344,429	$366,268	$39,704	$93,500	$286.94
2	$47,862	$58,368	$489,265	$372,120	$42,019	$100,387	$308.08
3	$36,246	$34,852	$486,365	$370,545	$43,278	$78,130	$239.77
4	$46,165	$22,854	$492,274	$370,545	$43,577	$66,431	$203.87
5	$78,090	$35,657	$425,809	$357,710	$55,569	$91,226	$279.96
6	$350,965	$97,762	$356,837	$346,228	$78,118	$175,880	$539.76
7	$183,193	$58,342	$353,175	$344,653	$84,076	$142,417	$437.06
8	$750,278	$75,481	$615,779	$383,603	$39,038	$114,519	$351.45
9	$85,272	$7,696	$647,291	$408,145	$1,376	$9,072	$27.84
10	$752,891	$78,101	$617,107	$383,603	$39,090	$117,191	$359.65

The amortized annual construction cost is the annual payment necessary to amortize the field cost over 50 years at the planning interest rate of 4.125%. The annual cost per AF is the amortized annual construction costs plus the annual O&M costs divided by the water supply yield. There is no cost inflation for O&M over the 50 year evaluation period. The annual costs for the Alternative 8 scenario variations are shown in Table 2.8.8.

Table 2.8.8. Annual Project Costs

Alternative Scenarios	Lateral & Collector Improvements		Transmission & Water Development Improvements			Total Annual Cost per Acre Foot	Total Annual Cost per 1,000 gal
	Amortized Annual Cost	Annual Cost per Acre Foot	Amortized Annual Cost	Annual O&M Cost	Annual Cost per Acre Foot		
1	$1,400	$2,500	$16,400	$17,416	$1,889	$4,389	$13.47
2	$2,300	$2,805	$23,300	$17,695	$2,000	$4,805	$14.74
3	$1,700	$1,635	$23,100	$17,620	$2,057	$3,691	$11.33
4	$2,200	$1,089	$23,400	$17,620	$2,072	$3,161	$9.70
5	$3,700	$1,689	$20,200	$17,009	$2,639	$4,328	$13.28
6	$16,700	$4,652	$17,000	$16,463	$3,718	$8,370	$25.69
7	$8,700	$2,771	$16,800	$16,389	$3,999	$6,769	$20.77
8	$35,700	$3,592	$29,300	$18,241	$1,857	$5,449	$16.72
9	$4,100	$370	$30,800	$19,408	$1,376	$1,746	$5.36
10	$35,800	$3,714	$29,300	$18,241	$1,857	$5,571	$17.10

2.9 Alternatives 10 and 11- Surface Water in Alamo Lake, and Colorado River water via Alamo Lake, Diamond Creek, Lake Mead, Lake Havasu, Lake Mohave or Lake Powell

A. Alternatives 10 and 11 Water Planning Areas

The WPAs considered in this alternative are those that show a 2050 water supply deficit (Table 1.1) with the exception of rural WPAs that are primarily served from private domestic wells. The following WPAs were not included within this alternative: Verde CCD, Prescott CCD, Mingus Mountain CCD, Humboldt CCD and Ashfork CCD.

B. Summary and Description of Alternatives 10 and 11

This alternative proposes use of surface water obtained from outside of the study area in the volume of 42,379 AF/yr. Alternative 10 proposes delivery of water from Alamo Lake via pipeline. The variations of Alternative 11 propose delivery of water from the Colorado River via pipelines from several different locations (Table 2.9.1) Maps of the proposed alternatives, including pipeline alignments, locations of pumping plants and pressure reducing stations and pipeline size and flows are in Appendix A.

The Lake Powell Pipeline Alignment (11F) delivers water to the planning areas as an extension of the North Central Arizona Water Supply Study (NCAWSS), Alternative #3, completed in 2006.This alternative will determine the CYHWRMS portion of field costs as the difference from the upsized portion field costs from Lake Powell to Flagstaff, AZ to the indexed field costs of the original estimate ($650,000,000 in 2006). Additionally, this estimate will include the transmission facilities and treatment from Flagstaff to the study area. The transmission line from Flagstaff continues south on I-17 to first the distribution center of Lake Montezuma, AZ. The transmission line then continues to deliver water towards each of the water distribution centers from Lake Montezuma to Paulden, AZ, through the I-17/highway 179 junction to Sedona, AZ and from I-17/highway 260 junction to Clarkdale, AZ.

Table 2.9.1 Alternative Versions

Alternative Version	Description of Alternative Version
10	Delivers water to WPAs from Alamo Lake Transmission line runs from Alamo Lake Dam to Prescott, Sedona, Paulden and Clarkdale
11A - Alamo	Delivers water to WPAs from Alamo Lake, however the water is Colorado River water obtained via an exchange agreement Infrastructure and alignment same as Alternative Version 10
11B - Havasu	Delivers mainstem Colorado River water to WPAs from Parker Dam Transmission line runs from Parker Dam through Salome and Congress to Prescott and uses same alignment from

	Prescott as Alternative Version 10
11C - Mohave	Delivers mainstem Colorado River water to WPAs from Davis Dam Transmission line runs from Davis Dam through Kingman and Ashfork to Paulden, then Sedona and Clarkdale and Prescott
11D - Mead	Delivers mainstem Colorado River water to WPAs from Hoover Dam Transmission line runs from Hoover Dam to Kingman; transmission from Kingman same as in Alternative Version 11C
11E – Diamond Creek	Delivers mainstem Colorado River water to WPAs from infiltration gallery in Diamond Creek Transmission line runs from Diamond Creek to Peach Springs then to Ashfork; transmission line from Ashfork same as in Alternative Version 11C
11F - Powell	Delivers mainstem Colorado River water to WPAs as an extension of the Lake Powell pipeline to Flagstaff Transmission line begins in Flagstaff and runs to Lake Montezuma then Paulden and Clarkdale

C. Infrastructure Requirements and Alternative 10 and 11 Field Cost Assumptions and Analysis

Each of the Alternative 10 and 11 versions include the construction of lake intakes, mortar lined steel pipes, pressure reducing stations, pumping plants, power lines and water treatment. Forebay and air chamber tanks are included separately for each pumping plant. An infiltration gallery was only included in the Diamond Creek Alternative. Storage tanks and pressure reducing stations needed by water suppliers were not included.

The infrastructure requirements and associated cost component assumptions are presented below. Design data and unit costs[12] were based on the NCAWSS report and adjusted using the Bureau of Reclamation construction cost indexes.

Infiltration Gallery
The cost of the infiltration gallery was obtained from the Grand Canyon National Park Water Supply Appraisal study from 2002 estimates and factored up for the increase in flow.

Lake Intakes
It was assumed a series of sloping borings with submersible pumps would be used. The inclined bores were assumed to be 30 inches in diameter and 330 feet long, with 18 inch diameter casing and 12 inch diameter carrier pipe. Each 12 inch pipe could deliver approximately eight cubic

[12] Design data assumptions are based on the North Central Arizona Water Supply Study Report, October 2006 and the Peabody Coal Black Mesa Mine C-aquifer Water Supply Appraisal Study, April 2003.

feet per second. The submersible pumps in each bore were priced at 3600 gallons per minute with a 300 foot lift.

Pipelines

Pipe lengths and head classes were determined through GIS analysis of the pipeline alignments. Hydraulic profiles for the pipeline are included in Appendix B. The cost estimate includes the cost for corrosion monitoring and cathodic protection of steel pipelines, where applicable. Construction costs for corrosion monitoring and cathodic protection were assumed to be one percent of the construction cost. Additionally, the cost estimate includes the cost for drainage crossings that includes geologic and site evaluations, design and any additional components or materials for construction. Pipeline drainage crossings were assumed to be two percent of the construction cost.

Appurtenant structures and mechanical equipment associated with the pipeline are covered under "unlisted items" in the cost estimates. These items include air valves, blowoffs, drains, flowmeters, altitude valves, and sectionalizing valves, etc.

Hydraulics

The Hazen-Williams equation was used to compute the loss due to friction in the pipe laterals. The pipeline design velocity is five feet per second or less and the maximum pumping lift would be approximately 450 feet. Pipe friction losses were limited to about 25 percent of the total dynamic head for the pumps.

It was assumed that all lateral pipe is mortar lined steel pipe with full inside diameters. A Hazen Williams Coefficient of 140 was used in the head loss calculations. Pipeline capacities were sized based on the 2050 water supply deficit only and a peaking factor was not applied. By limiting the pump lift to about 450 feet of head and adding 30 percent for an upsurge allowance, the pressure class for the pipe was generally limited to 575 feet (250 pounds per square inch). Pressure Reducing valve stations are required when pressures at a maximum exceed 500 feet.

Pressure Reducing Stations

In line pressure reducing stations were assumed to be required to limit the pipe head class to a maximum of 500 feet. The cost is based on a single pressure reducing station.

Excavation and Backfill

Excavation and backfill quantities for pipe earthwork were based on a typical trapezoidal trench section with 1:1 slopes and an average depth of cover of four feet. Excavation was assumed to be 60 percent rock and 40 percent common. This assumption allows for comparison to the NCAWSS Report. It should be noted the excavation cost for rock assumes that the material can be excavated with an excavator or trencher. Excavation that requires blasting or hoe-ramming is not included in this cost estimate because a geology evaluation and testing would be required. Embedment to three inches over the top of the pipeline was assumed to be imported material from nearby borrow areas.

Pumping Plants
The field costs for pumping plants were taken from the NCAWSS Report and adjusted for higher flows. Forebay tanks would be required upstream from each pumping plant to supply water during startup of the pumps. For this appraisal level estimate, all forebay tanks were estimated to be 10 feet in diameter and 20 feet tall. Air chambers will be required downstream and were assumed to be 20 foot diameter spheres.

The cost estimate includes the cost for a SCADA system for the control of the pumping plants. The construction costs for the SCADA system were assumed to be three percent of the construction cost.

Water Treatment
The unit cost of the water treatment for arsenic includes treatment and installation. For the purposes of this study it was assumed at $2 gallons per day (gal/day).

Operation and Maintenance
Annual O&M costs for the pipelines were estimated to be 0.5 percent of the initial pipe costs. For pumping plants, annual O&M costs were estimated at eight percent of the pumping plant costs. Annual O&M costs for water treatment were estimated to be eight percent of the water treatment costs.

D. Annual and Project Worth Costs
There are a number of different costs that are utilized in the process of cost analysis. The field cost includes the construction costs plus any contingencies that must be factored in. The amortized annual construction cost is the annual payment necessary to amortize the field cost over 50 years at the planning interest rate of 4.125%. The annual cost per AF is the amortized annual construction costs plus the annual O&M costs divided by the water supply yield. There is no cost inflation for O&M over the 50 year evaluation period. The annual costs for the Alternative 10 and 11 variations are shown in Table 2.9.2.

Table 2.9.2. Annual Project Costs

Alternative Versions	Amortized Annual Const Cost ($)	Annual O&M Cost ($)	Annual Cost ($/AF)	Annual Cost ($/ Kgal)
10	$42,582,700	$11,744,870	$1,282	$3.93
11A	$42,582,700	$11,744,870	$1,282	$3.93
11B	$66,475,800	$13,966,410	$1,898	$5.83
11C	$60,566,500	$14,709,294	$1,776	$5.45
11D	$68,832,600	$14,700,056	$1,971	$6.05
11E	$48,893,200	$12,243,356	$1,443	$4.43
11F	$55,235,900	$12,772,029	$1,605	$4.92

The present worth project cost is derived by adding together the field costs plus the present value of 50 years of O&M costs at 4.125% divided by the water supply yield. The present worth projects costs for the Alternative 8 variations are shown in Table 2.8.4.

Table 2.9.3. Present Worth Project Costs

Alternative Versions	Field Cost ($)	Present Worth O&M Cost ($)	Present Worth Cost ($/AF)	Present Worth Cost ($/ Kgal)
10	$895,515,610	$246,995,270	$26,959	$83
11A	$1,397,988,786	$293,714,381	$39,918	$123
11B	$1,273,716,646	$309,337,282	$37,355	$115
11C	$1,447,553,494	$309,142,993	$41,452	$127
11D	$1,028,225,962	$257,478,460	$30,338	$93
11E	$1,161,614,426	$268,596,490	$33,748	$104
11F	$895,515,610	$246,995,270	$26,959	$83

3.0 Alternatives Considered but Not Evaluated

3.1 Alternative 9 – Conservation

This alternative proposes to improve water efficiency which is a simple, effective way to conserve water. Conservation measures such as high efficiency toilets, waterless urinals, hot water recirculation, rainwater harvesting, greywater reuse, xeriscaping, public ordinances for new development and public education are examples of the programs that can be implemented.

This alternative was ultimately not developed further because conservation reduction volumes were included in the Phase I Demand Analysis which allowed WPA's to incorporate their own conservation efforts into their future GPPD. There have been many conservation studies done in the study area and because this is a locally led process, it was left to the individual WPAs to decide. There was no consistent set of criteria to ensure an equal application of conservation for all WPAs, which made it difficult then to go forward with the alternative. Each WPA provided their projected 2050 GPPD for the Demand Analysis and conservation reduction volumes vary for each WPA.

If the Conservation Alternative were developed, it may duplicate conservation reductions already accounted for in the Demand Analysis and could be misinterpreted as double counting the volume of water saved as a result of water use reductions from conservation. However, there could be some potential additional conservation measures that could be pursued and a more in-depth analysis would be done if this alternative moved forward to feasibility.

3.2 Alternative 12 – Weather Modification (Cloud Seeding)

Planning Areas Considered

All planning areas will be considered since this alternative will be done to benefit the study area as a whole. This water supply will not be collected to be delivered to the individual water planning areas but will increase surface water runoff and recharge from precipitation.

Alternative Description

This alternative proposes to look at weather modification, commonly known as cloud seeding for producing additional water. The process enhances a cloud's ability to produce precipitation. There are two primary methods employed to stimulate precipitation. Hygroscopic seeding, affects convective clouds during the warm seasons and enhances rainfall and glaciogenic seeding affects orographic clouds, which are formed over mountains during the cold seasons to augment snow. Either technology can be applied from the surface (ground-based) or from an aircraft. (Website- http://weathermodification.com/cloud-seeding.php)

For this alternative, only cloud seeding during the monsoon season will be considered because most of the rainfall in Arizona occurs during this season and are produced mainly by convective clouds which are conducive to hygroscopic seeding.

Also, there are not many opportunities for glaciogenic seeding in the study area because of specific criteria for the formation or orographic clouds. Because of the criteria, it could be difficult to find places and instances that are favorable for weather modification. However, it was "proposed that the 7,000 foot contour be used to identify potential target areas in Arizona. Part of the rationale for inclusion of this lower elevation area is based upon some earlier field studies conducted by Reclamation indicating potentially favorable seeding conditions in this area (Super et al, 1989)." (*The Potential Use of Winter Cloud Seeding Programs to Augment the Flow of the Colorado River*, Upper Colorado River Commission, March 2006)

The Mogollon Rim and the White Mountains which are both over the 7,000 foot contour and have been identified as offering the greatest potential for in-state weather modification efforts for snow augmentation. "…the Rim forms a barrier that forces flowing air upward to cool, a situation favorable to orographic cloud development." (*Weather Modification: A Water Resource Strategy to be Researched, Tested Before Tried,* Joe Gelt, Arroyo Springs 1992, Volume 6, No. 1) Dr. Rand Decker, Professor at Northern Arizona University, is currently modeling cloud seeding in the White Mountains area which has shown a 10% increase in snow.

Dr. Rand Decker did identify that for the CYHWRMS study area, cloud seeding during the monsoon season for rainfall was more plausible than winter-time cloud seeding for snow since the Mogollon Rim and White Mountains are outside the study area.

Enhancing Rainfall

"The **Arizona Monsoon** is a well-defined meteorological event that occurs during the summer throughout the southwest portion of North America. Monsoon thunderstorms are convective in nature." (Website 2012- http://geoplan.asu.eedu.monsoon.html) Cumulus (convective) clouds are responsible for producing the bulk of rainwater during the summer months. "These towering cloud formations form from strong updrafts of warm, moist air into an atmosphere that is unstable. Intense daytime heating of the near-surface layer of air, or a wedge of cold air moving across the state (as a cold front), usually triggers the formation of convective clouds." (Website 2012- http://www.license.state.tx.us/weather/summary.htm)

"Efforts to increase rainfall during the warm seasons are typically aimed at convective clouds. While it is theoretically possible to seed such clouds using ground-based equipment, targeting from aircraft is much more efficient and accurate. It is usually possible to affect the cloud through releases of a seeding agent in sub-cloud updrafts, or by dropping the seeding agents directly into the upper regions of the clouds."
(Website 2012- http://weathermodification.com/cloud-seeding.php)

"Not all cumulus clouds become rain producers. In fact, only a small percentage of them ever develop the capability to yield an appreciable amount of rainfall. Those convective clouds that do produce rainwater are often inefficient: For all the moisture they incorporate from below, only

a tiny fraction of that moisture (as cloud droplets) is ever used to grow large raindrops, which ultimately fall to the ground as rainfall. If done in a timely way and properly, cloud seeding can assist the natural process in clouds by giving them enough "seeds" to make a meaningful number of large raindrops." (Website 2012- http://www.license.state.tx.us/weather/summary.htm)

"The radar data collected after a day of seeding adds to a growing body of evidence that the process works. The data shows seeding can double the amount of moisture in a cloud and the Texas programs boast a 12 percent increase in annual rainfall because of seeding." (*Cloud Seeders Help Make it Rain Over Drought-Stricken Texas*, ABC NightLine, Juju Change, Oct. 6, 2012) Dr. Rand Decker stated that the average yield increase is between 4%-12%.

Infrastructure Requirements

"Current recognized cloud treatment techniques consist of the delivery to a selected cloud volume of (1) silver iodide complexes (Finnegan, et al., 1984) by aircraft or turbulent transport via ground release, and/or (2) dry ice pellets (solid carbon dioxide) by direct injection from aircraft. The selection of a treatment method will depend on terrain features and meteorological conditions in the area of interest. Some situations may require the availability of both ground and airborne nuclei generating systems." (*Feasibility Study on Wintertime Cloud Seeding to Augment Arizona Water Supplies*, Bureau of Reclamation, January 1987)

"While it is theoretically possible to seed such clouds using ground-based equipment, targeting from aircraft is much more efficient and accurate."
(Website- http://weathermodification.com/cloud-seeding.php)

This alternative is for enhancing rainfall yield only and does not include any infrastructure for recovery.

Alternative Analysis

Volume

Volume totals were calculated from the monthly average precipitation increase of 4% and 12% for July, August and September and multiplied by the area to determine increased water yield. This alternative does not include any losses due to evaporation, transpiration, depth-area reduction or surface retention which could be up to a 75% reduction loss (Table 3.2.1). Volume is strictly that amount of precipitation that is possible to enhance. It is not what is available to distribute as a water supply.

Table 3.2.1. Volumes from 4% & 12% Increased Rainfall Yield

Water Planning Area	July	August	September	4% July	12% July	4% August	12% August	4% September	12% September	4% Total (July/Aug/Sept)	12% Total (July/Aug/Sept)	Land Area	4% Total Enhanced Rainfall Volume	12% Total Enhanced Rainfall Volume
	monthly avg. inches	monthly avg. inches	monthly avg. inches	monthly avg. inches yield increase	monthly avg. inches yield increase	monthly avg. inches yield increase	monthly avg. inches yield increase	monthly avg. inches yield increase	monthly avg. inches yield increase	3 month avg. inches yield increase	3 month avg. inches yield increase	Acres	Acre Ft./Yr.	Acre Ft./Yr.
Camp Verde	1.81	2.11	1.8	0.07	0.22	0.08	0.25	0.07	0.22	0.23	0.69	29,279.88	558.27	1,674.81
Dewey Humboldt	2.87	3.28	2.07	0.11	0.34	0.13	0.39	0.08	0.25	0.33	0.99	11,998.29	328.75	986.26
Clarkdale	1.7	2.09	1.5	0.07	0.20	0.08	0.25	0.06	0.18	0.21	0.63	6,497.89	114.58	343.74
Cottonwood	1.7	2.09	1.5	0.07	0.20	0.08	0.25	0.06	0.18	0.21	0.63	13,249.68	233.64	700.91
Jerome	2.48	3.03	1.75	0.10	0.30	0.12	0.36	0.07	0.21	0.29	0.87	727.21	17.60	52.80
Prescott Valley	2.07	2.44	1.55	0.08	0.25	0.10	0.29	0.06	0.19	0.24	0.73	30,583.32	617.78	1,853.35
Chino Valley	1.7	2.01	1.59	0.07	0.20	0.08	0.24	0.06	0.19	0.21	0.64	36,887.29	651.68	1,955.03
Prescott	2.97	3.28	2.07	0.12	0.36	0.13	0.39	0.08	0.25	0.33	1.00	32,507.56	901.54	2,704.63
Sedona	1.65	1.9	1.94	0.07	0.20	0.08	0.23	0.08	0.23	0.22	0.66	13,739.40	251.43	754.29
Paulden CDP	1.7	2.01	1.59	0.07	0.20	0.08	0.24	0.06	0.19	0.21	0.64	36,481.64	644.51	1,933.53
Big Park CDP	1.65	1.9	1.94	0.07	0.20	0.08	0.23	0.08	0.23	0.22	0.66	2,989.00	54.70	164.10
Cornville CDP	1.7	2.01	1.59	0.07	0.20	0.08	0.24	0.06	0.19	0.21	0.64	8,535.06	150.79	452.36
Lake Montezuma CDP	1.67	2.15	1.93	0.07	0.20	0.09	0.26	0.08	0.23	0.23	0.69	7,638.16	146.40	439.19
Ctn-Verde Village CDP	1.7	2.09	1.5	0.07	0.20	0.08	0.25	0.06	0.18	0.21	0.63	1,814.31	31.99	95.98
Williamson CDP	1.7	2.01	1.59	0.07	0.20	0.08	0.24	0.06	0.19	0.21	0.64	36,193.14	639.41	1,918.24
Verde CCD	1.65	1.9	1.94	0.07	0.20	0.08	0.23	0.08	0.23	0.22	0.66	199,621.63	3,653.08	10,959.23
Prescott CCD	1.7	2.01	1.59	0.07	0.20	0.08	0.24	0.06	0.19	0.21	0.64	442,958.28	7,825.60	23,476.79
Mingus Mtn CCD	1.7	2.09	1.5	0.07	0.20	0.08	0.25	0.06	0.18	0.21	0.63	261,827.91	4,616.90	13,850.70
Humboldt CCD	1.81	2.11	1.8	0.07	0.22	0.08	0.25	0.07	0.22	0.23	0.69	24,166.52	460.77	1,382.32
Ashfork CCD	1.7	2.01	1.59	0.07	0.20	0.08	0.24	0.06	0.19	0.21	0.64	274,907.95	4,856.71	14,570.12

Precipitation data from website: www.homfacts.com/weather

WPA acreage calculated using GIS and the WPA boundaries

4% is the low average yield estimate and 12% is the high yield estimate for rain

July, August and September are summer months during the monsoon season that produce the highest rainfall

Total enhanced rainfall volumes do not account for losses that maybe up to 75% due to surface retention, infiltration, vegetation, evaporation, depth-area reductions and rainfall outside of WPA.

Cost

"The California DWR (DWR 2005) estimates that an additional 300,000 to 400,000 acre-feet of water could potentially be produced annually by more and improved cloud seeding in California. This increased amount of water would come at a cost of about $19 per acre-foot." *Optimizing Cloud Seeding for Water and Energy in California,* Steven M. Hunter, U.S. Bureau of Reclamation. California Energy Commission**,** March 2007

For cloud seeding projects in Texas, "the cost to produce this additional rainwater was estimated at less than $11 an acre-foot." (Website 2012- http://www.license.state.tx.us/weather/summary.htm)

For this alternative, a conservative price of $19.00 per acre-foot will be calculated for volumes increased for both a 4% and 12% increase in water yield from rainfall. It does not include any costs for infrastructure for recovery (Table 3.2.2).

Table 2. Increase Yield Volumes for 4% & 12%

Water Planning Area	Enhanced Volume 4% Increase Total	Enhanced Volume 12% Increase Total	$11.00 per Acre/Ft. Total Cost for 4% increase	$19.00 per Acre/Ft. Total Cost for 4% increase	$11.00 per Acre/Ft. Total Cost for 12% increase	$19.00 per Acre/Ft. Total Cost for 12% increase
	Acre Ft.	Acre Ft.				
Camp Verde	558.27	1674.81	$6,140.97	$10,607.12	$18,422.90	$31,821.37
Dewey Humboldt	328.75	986.26	$3,616.28	$6,246.31	$10,848.85	$18,738.93
Clarkdale	114.58	343.74	$1,260.37	$2,177.01	$3,781.12	$6,531.03
Cottonwood	233.64	700.91	$2,570.00	$4,439.09	$7,709.99	$13,317.26
Jerome	17.60	52.80	$193.58	$334.37	$580.75	$1,003.11
Prescott Valley	617.78	1853.35	$6,795.61	$11,737.88	$20,386.84	$35,213.64
Chino Valley	651.68	1955.03	$7,168.43	$12,381.83	$21,505.29	$37,145.50
Prescott	901.54	2704.63	$9,916.97	$17,129.31	$29,750.92	$51,387.94
Sedona	251.43	754.29	$2,765.74	$4,777.19	$8,297.22	$14,331.56
Paulden CDP	644.51	1933.53	$7,089.60	$12,245.67	$21,268.79	$36,737.01
Big Park CDP	54.70	164.10	$601.69	$1,039.28	$1,805.06	$3,117.83
Cornville CDP	150.79	452.36	$1,658.65	$2,864.93	$4,975.94	$8,594.80
Lake Montezuma CDP	146.40	439.19	$1,610.38	$2,781.56	$4,831.13	$8,344.69
Ctn-Verde Village CDP	31.99	95.98	$351.92	$607.86	$1,055.75	$1,823.57
Williamson CDP	639.41	1918.24	$7,033.53	$12,148.83	$21,100.60	$36,446.49
Verde CCD	3653.08	10959.23	$40,183.83	$69,408.44	$120,551.50	$208,225.32
Prescott CCD	7825.60	23476.79	$86,081.56	$148,686.33	$258,244.68	$446,058.99
Mingus Mtn CCD	4616.90	13850.70	$50,785.89	$87,721.08	$152,357.66	$263,163.24
Humboldt CCD	460.77	1382.32	$5,068.52	$8,754.72	$15,205.57	$26,264.17
Ashfork CCD	4856.71	14570.12	$53,423.78	$92,277.44	$160,271.34	$276,832.31

Only present worth costs will be estimated because there are no capital improvements and O&M costs associated with cloud seeding. Cloud seeding will have to be repeated annually.

Table 3.2.3. Annual Project Costs

Alternative Versions	Amortized Annual Costs ($)	Annual O&M Costs ($)	Annual Cost ($/AF)	Annual Cost ($/Kgal)
Alt.# 12 Cloud Seeding - 4% Avg. Yield Increase	$36,500	$767,315	$146.82	$0.45
Alt.# 12 Cloud Seeding - 12% Avg. Yield Increase	$109,500	$2,301,946	$146.82	$0.45

Table 3.2.4. Present Worth Project Costs

Alternative Versions	Field Cost ($)	Present Worth O&M Costs ($)	Present Worth Cost ($/AF)	Present Worth Cost ($/Kgal)
Alt.# 12 Cloud Seeding - 4% Avg. Yield Increase	$767,315	$16,136,684	$3,087.57	$9.48
Alt.# 12 Cloud Seeding - 12% Avg. Yield Increase	$2,301,946	$48,410,052	$3,087.57	$9.48

3.3 Alternative 13 – Watershed Management – Enhanced water yield through ponderosa pine forest restoration treatments

Planning Areas Considered

This study was conducted for the CYHWRMS area as a whole. Volumes were not calculated separately by planning area. The forest restoration treatments analyzed are within the Four Forest Restoration Initiative (4FRI) first EIS analysis project area (Figure 3.3.1), about half of which drains to the Verde Valley. 4FRI is a collaborative effort to restore forest ecosystems on portions of four national forests - Kaibab, Coconino, Tonto and Apache-Sitgreaves - along the Mogollon Rim in northern Arizona. 4FRI is a landscape-scale initiative designed to restore fire-adapted ecosystems through the use of mechanical forest thinning treatments and prescribed burning. The first analysis area includes the Tusayan and Williams District of the Kaibab National Forest and most of the Coconino National Forest but not the West Clear Creek watershed.

Limitations

The analysis provided below only addresses predicted enhancement to current surface water yield that could be obtained by treating ponderosa pine vegetation within the watershed area. No evaluation was made related to possible increases in aquifer recharge related to watershed management, although a graduate student at Northern Arizona University has revised recharge estimates relative to forest restoration treatments. In the 4FRI analysis area, approximately 90% of precipitation is lost to evaporation and transpiration (Tom Kolb, personal communication). Of the remaining 10% about 6-8% is surface water discharge and 2-4% is groundwater recharge (Pool 2011). In order to fully evaluate this alternative, more information will need to be collected regarding the mechanism of mountain front/mountain block recharge and its relationship to ET by vegetation and ground cover. Any water restored through restoration treatment actions is water that otherwise would have been available under historic forest densities and is therefore already claimed by downstream users with priority dates in the early 20th century or earlier.

There are several unknowns that could affect water yield response to forest restoration treatments. These unknowns include:

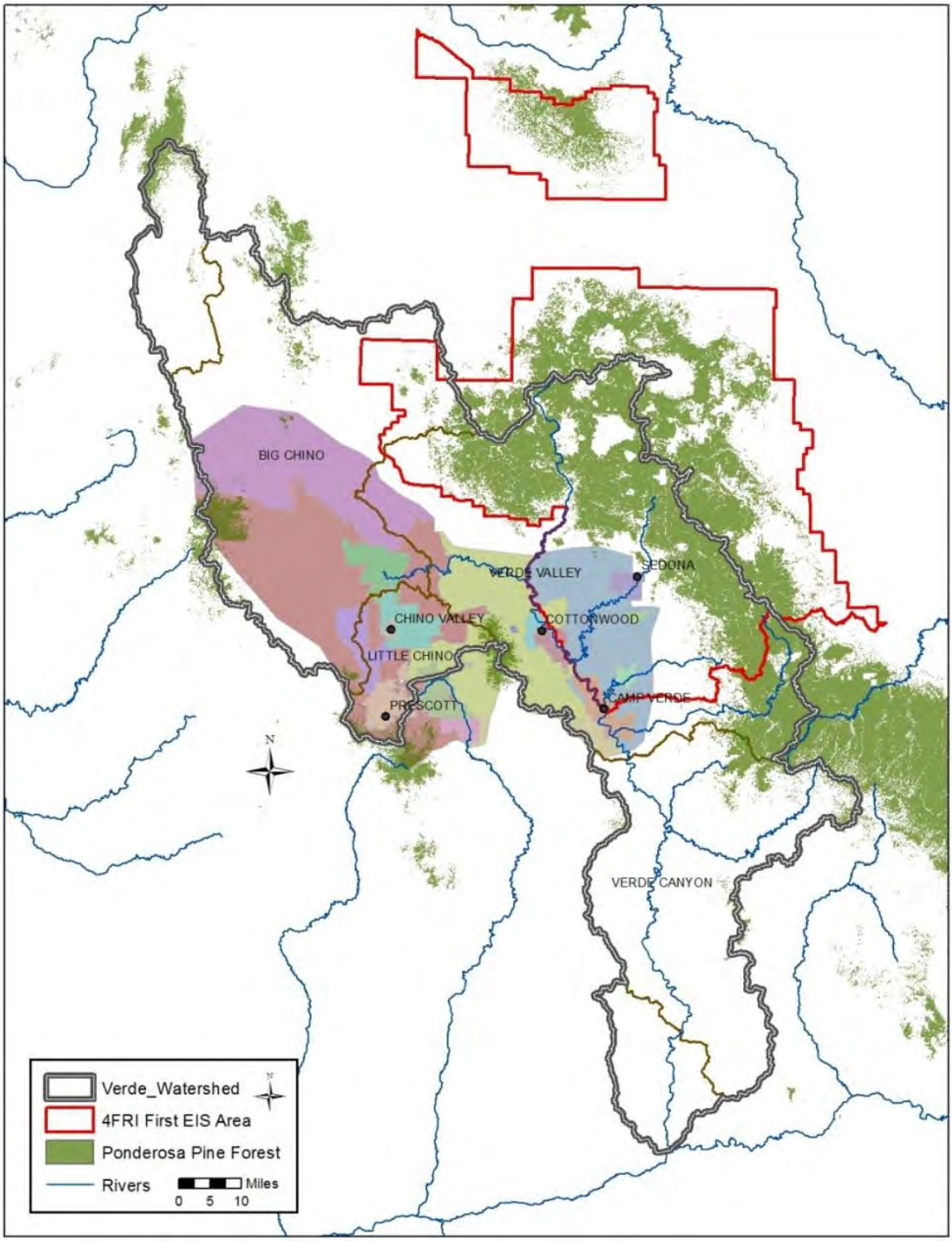
1. When shelf stock treatments will begin. Shelf stock comprises those forest treatment areas for which NEPA evaluation has already been completed or NEPA is in process, so that these areas were not included in the 4FRI NEPA analysis. Initiation of shelf stock treatments is dependent on the contracted mill at Winslow being built,
2. When the 4FRI Environmental Impact Statement (EIS) Record of Decision (ROD) will be issued and whether there will be litigation that slows implementation,
3. To what extent forest restoration treatments effects differ from past forest treatment types,
4. The extent to which follow-up burning treatments can recapture diminished yield due to growth of shrubs and small trees, and

5. How much enhanced water yield may go to groundwater recharge or be lost to evapotranspiration en route from the pine forest to downstream water use areas.

For the purposes of this analysis, the assumption was made that all treatments would happen in a 10-year time frame, with 2 sets of follow-up burning treatments at 7 year intervals from the date of initial mechanical treatment and burning. If this or other assumptions are incorrect (especially if implementation takes longer), the time period for the response would likely be lengthened and the average annual response would be decreased, while the overall cost would probably remain about the same (not accounting for inflation). Also, a basic assumption is that initial treatments would be paid for by the Forest Service and its contractor (in other words field costs are zero); only follow-up treatment costs are included in the cost of the alternative. Only a portion of the total treated area is "water yield effective", i.e., those treatments that result in at least 30% decrease in basal area are expected to lead to water yield enhancement.

A final limitation is that the actual 'deliverable' amount of water is difficult to estimate, because the amount of transmission loss is unknown. Some have estimated that as much as 50% of streamflow is lost between the Mogollon Rim and Phoenix. Perhaps on the order of 20% would be lost on the way to the Verde Valley.

Figure 3.3.1. Location map



Alternative Description

National forests were originally reserved with one of their primary purposes to protect water supplies. The Organic Act of 1905, established the National Forest System to "protect the land, secure favorable water flows, and provide a sustainable supply of goods and services". Nationwide 124 million people depend on water from national forests. In the Southwest, streamflow has decreased over the past century as forests have become denser (Covington and Moore 1994). Planned forest restoration treatments are anticipated to restore a portion of this decreased streamflow.

The Four Forest Restoration Initiative (4FRI) is a collaborative effort to restore forest ecosystems on portions of four National Forests - Kaibab, Coconino, Tonto, and Apache-Sitgreaves, - along the Mogollon Rim in northern Arizona. The vision of 4FRI is to restore forest ecosystems that support natural fire regimes, functioning populations of native plants and animals, and forests that pose little threat of destructive wildfire to thriving forest communities, as well as supporting sustainable forest industries that strengthen local economies while conserving natural resources and aesthetic values. A side benefit of the restoration will be enhanced water yield due to decreased evapotranspiration that occurs as a result of forest thinning. Using data from the 4FRI first analysis area, the estimated volume of enhanced (a.k.a. recovered or restored) water yield was calculated. The term "water yield" is used here (as opposed to "runoff" or other terms) because it is the parlance in papers published over 6 decades on which this analysis relies. To be clear, this analysis addresses surface water discharge only, not groundwater recharge which might be considered part of total water yield. Results indicate that enhanced water yield due to initial mechanical thinning combined with burning will range from 693 to 2,947acre-feet per year in the first ten years with an average of 2,166 acre-feet per year. In the absence of additional treatments, the enhanced yield will diminish to non-significance by year 16, because evapotranspiration would likely return to pretreatment rates as available water is captured by shrubs and herbaceous plants or by root invasion by remaining trees (Baker 2003). Follow-up burning treatments at approximately 7-year intervals are expected to extend the effect of initial treatments so that additional enhanced yield due to follow-up burning will range from 173 to 1,863 acre-feet per year over a 44-year period with an average of 1,186 acre-feet per year. Given a treatment cost of $100 per acre for follow-up

Ponderosa Pine Forests Central AZ
Ponderosa pine grows at elevations of 5,600 and 8,500 feet in the southwest (Schubert 1974). Ponderosa pine forests are a valuable source of water, timber, forage, and recreation (Baker 1999). Although ponderosa pine occupies only about 20% of the Salt-Verde River watershed, nearly 50% of the total water yield in this basin originates from the pine type (Barr 1956). These forests often contain other pine species as well as oak, aspen, or juniper trees (depending on the elevation) with grasses, forbs, and shrubs growing in the understory. A diversity of wildlife uses these forests for cover and food, both seasonally and yearlong. High transpiration rates and soil moisture deficiencies can curtail the growth of plants in ponderosa pine forests, which receive 18 to 30 inches of annual precipitation. High elevation forests tend to have greater frequencies and amounts of precipitation than low elevation forests, although this can be altered by storm patterns and topography. Usually only a small amount of summer rain is converted to streamflow. Winter precipitation is the major source of runoff. Basalt and cinders are the most common parent materials, though sedimentary soils are also found in these forests. Topography is characterized by extensive flat, rolling mesas, intermixed with steeper, mountainous terrain, and a diversity of slope and aspect combinations.

burning, half of which is anticipated to be paid by the Forest Service, the average annual cost for follow-up burn treatments to sustain enhanced water yield is expected to range from $685 to $6,740 per acre-foot with an average annual cost over 44 years of $1,594 per acre-foot. This analysis was completed at a coarse scale using water yield response to ponderosa pine forest treatment outcomes derived from research in the Beaver Creek Experimental Watershed from the 1950s through the early 1980s (Baker 2003).

Water Yield Opportunities

Watershed management in the form of vegetation manipulation has often been cited as a method to increase water yield in Arizona (Barr 1956, Baker 2003, Fflolliot and Thorud 1977). Water yield improvement with vegetation reduction is based on the premise that streamflow and/or groundwater recharge are increased by an amount equal to the net reduction in evapotranspiration (Hibbert 1979). According to Hibbert, the greatest opportunity to increase water yield by reducing transpiration exists where precipitation exceeds 18 inches and potential evapotranspiration exceeds 15 inches. This kind of climate promotes vigorous growth of vegetation capable of using large amounts of water. Where precipitation is less than about 18 inches and is exceeded by potential evapotranspiration, there is little opportunity to increase water yield by reducing transpiration, because precipitation does not penetrate far into the soil and one cover type is about as efficient as another in using the available water. Because there is a great deal of inter-annual variability in precipitation in Arizona, the potential to increase water yield also varies with moisture conditions, with greater responses in wet years and perhaps no response in drier years.

Ponderosa pine forest stretches almost continuously from the south rim of the Grand Canyon, across the Mogollon Rim, to the White Mountains in eastern Arizona (see Text Box and Figure 3.3.1). Prior to European Settlement, the natural fire return interval in Arizona ponderosa pine communities ranged from <5 to 17 years (Dieterich 1980, Fulé et al. 1997). This short fire return interval maintained an open forest with an herbaceous understory (Wright and Bailey 1982, Covington and Moore 1994). An active fire suppression policy as well as land use changes over the past 100 years resulted in a much reduced fire frequency, which is commonly associated with an increase in tree density (Moore and Deiter 1992, Naumberg et al. 2001, Moore et al. 2004), crown closure, and litter depth (Clary et al. 1968). The result is overgrown forests with thin, unhealthy trees and the threat of unnaturally severe wildfire. Since 2010, high intensity fires have burned more than 900,000 acres of Arizona forest lands. The largest in Arizona history, the Wallow Fire in the White Mountains, burned almost 539,000 acres.

The driving force for forest restoration is reducing the risk, and resultant costs, of high-intensity forest fire. The 4FRI is a collaborative effort to address these issues. A draft EIS has been developed that covers forest treatments in the first analysis area, which includes the Kaibab National Forest south of Grand Canyon and much of Coconino National Forest southward (Figure 3.3.1).

One of the many expected benefits from forest restoration is enhanced water yield from the current condition. The Forest Service's 4FRI interdisciplinary team has developed specific forest

treatment prescriptions that can be expressed in terms of reduced basal area. Basal area is the term used in forest management that defines the area of a given section of land that is occupied by the cross-section of tree trunks and stems measured at breast height. Basal area is generally expressed as ft^2/acre or m^2/ha. The Beaver Creek Experimental Watershed (BCEW) study related water yield of ponderosa pine forests to basal area, with water yield responding to percent reduction in basal area. While the BCEW treatments (clear cut, shelterwood, patch cut, strip cut, etc.) are not the same as restoration treatment types (uneven-aged thinning, intermediate thin, stand improvement thinning, savanna thinning, grassland thinning – see definitions in glossary at end of alternative description), the BCEW findings are the closest approximation available of what we might expect for water yield response to ponderosa pine restoration treatments.

Alternative Analysis

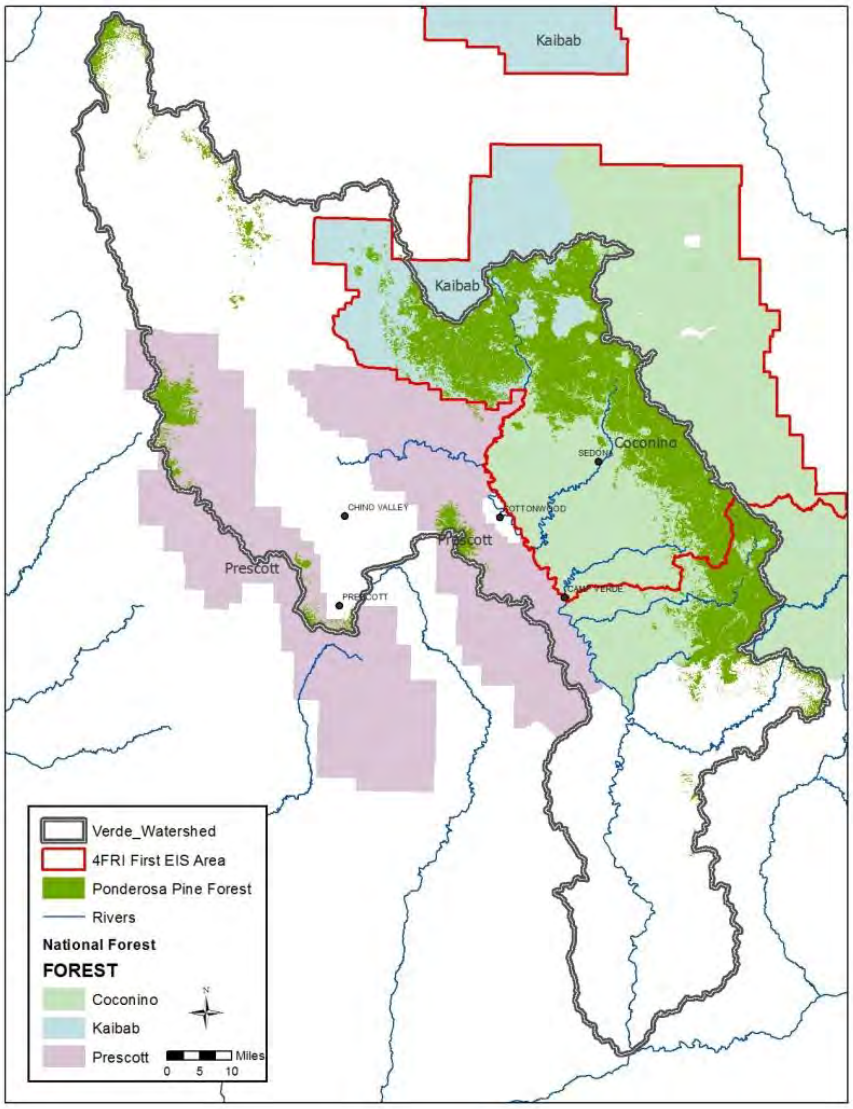
To estimate potential enhancement of water yield from forest treatment in the 4FRI first analysis area (Figure 3.3.1), the 4FRI Proposed Action (USDA 2011) and GIS data were consulted as well as documents and GIS data for adjacent "shelf stock" project areas. Shelf stock are those forest treatment areas for which NEPA evaluation has already been completed or NEPA is in process, so that these areas were not included in the 4FRI NEPA analysis The shelf stock in many cases will be treated in advance of the 4FRI units, either on individual contracts or as part of the Forest Service's contract for treatment of both shelf stock and 4FRI units. The two together – 4FRI first EIS analysis treatments plus shelf stock treatments – comprise the extent of treatments that are expected in the Ponderosa pine vegetation type that may affect water yield.

The 4FRI and shelf stock GIS files within the 4FRI first analysis area were clipped to the Verde watershed to only consider treatments in areas that drain to the CYHWRMS project area. Note that 4FRI does not include the Prescott National Forest. However, there is limited extent of ponderosa pine vegetation type in the Prescott National Forest within the Verde River basin (Table 3.3.1, Figure 3.3.2). For comparison purposes, Table 3.3.1 provides acres of ponderosa pine in the Prescott National Forest and the 4FRI first analysis area portions of the Coconino and Kaibab National Forests in the Verde watershed. For the purposes of this analysis "effective" acres are those areas of forest that will experience $\geq$30% reduction in basal area as a result of treatments, from which we would expect to see a response in water yield.

Table 3.3.1. Acres of ponderosa pine in the Verde River watershed

Ponderosa Pine in the Verde Watershed	acres
entire watershed	718,413
Coconino NF	421,747
Kaibab NF	181,688
Prescott NF	52,069
4FRI first analyis area treatments	276,506
WY-effective 4FRI treatments	159,759
shelf stock treatments	128,202
WY-effective shelf stock treatments	74,075
total effective treatment area	**233,834**

Figure 3.3.2. Map showing distribution of ponderosa pine in the Verde River watershed by National Forest



Untreated ponderosa pine forests (known from experimental watersheds1958 to 1983) yield an average of about 0.25 acre-feet/acre of water yield per year (Baker 2003, p. 165). With treatment, average water yield response correlates with percent reduction in the basal area. Baker (2003) reports that initial water yield increase of 15% to 30% results from basal area reductions of 30% to 100%. This relationship can be expressed in the following formula that was used to calculate water yield response to basal area change:

$$\text{if } dBA \geq \text{ to } 30, \text{ then}$$

$$WY_e = \left[\frac{(0.3571dBA + 4.2857)}{100}\right] * 0.25$$

where
WY_e = water yield enhancement in acre-feet per acre and
dBA = percent change in basal area.

Using this formula we then multiplied the water yield in acre-feet per acre by the number of acres that will receive treatments that result in each particular percent change in basal area (dBA) to give water yield in acre feet (Table 3.3.2). Then the water yields for the various dBA are totaled. These numbers apply to sites with shallow, basalt-derived soils, which is the dominant soil type in the area of interest. Baker (1986, p 71) found that water yield increase diminished following the first year of treatment and by year 7 was statistically insignificant on most Beaver Creek watersheds that had no follow-up maintenance treatments such as prescribed burning. Using values generated by the formula above, we adjusted anticipated water yield change to reflect the gradual diminishment of enhanced yields. Using an Excel spreadsheet (table 3), we calculated diminishment for each year of treatment over the course of 6 years at 1/6th diminishment per year. We then added regained water yield for follow-up burning treatments estimated at 7 year return intervals, using the assumption that 25% of lost water yield could be recaptured through these treatments (Table 3.3.3). It is unknown to what extent follow-up treatments may sustain water yield increases. A paired watershed study is being planned in part to investigate this question. In the meantime, 25% is a “best guess”. The actual percentage could be much more or much less, but we considered this a conservative estimate. Note that detailed data on basal area change at the stand level was available on 4FRI treatments but not all shelf stock treatments; therefore, shelf stock basal area reductions are estimated proportionate to 4FRI treatments.

Table 3.3.2. Anticipated water yield change in the Verde River watershed based on basal area change due to 4FRI (Alternative C) and shelf stock restoration treatments over 10 years. Values adjusted for diminishing effect over time are shown in the bottom cell of the table.

basal area reduction	average effective BA reduction	treatment area	proportion of total area	proportion of treatments effective or *not effective*	water yield increase w/o diminishment
%	*%*	*acres*	*%*	*%*	*acft*
4FRI					
Subzero	*0*	*17,810*	*6.44%*		*0*
0-29	*0*	*98,937*	*35.78%*	*42%*	*0*
30-39	34.5	47,011	17.00%		1,951
40-49	44.5	54,056	19.55%		2,727
50-59	55.5	33,720	12.20%		2,032
60-69	65.5	20,089	7.265%		1,390
70-79	75.5	4,807	1.738%		376
80-89	85.5	61	0.022%		5
90-97	93.5	15	0.005%	58%	1
4FRI total acres		276,506			
4FRI effective acres		**159,759**			
4FRI unadjusted water yield change					**8,482**
Shelf Stock					
Subzero	*0*	*8,256*	*6.44%*		*0*
0-29	*0*	*45,871*	*35.78%*	*42%*	*0*
30-39	34.5	21,794	17.00%		905
40-49	44.5	25,063	19.55%		1,264
50-59	55.5	15,641	12.20%		943
60-69	65.5	9,314	7.265%		644
70-79	75.5	2,228	1.738%		174
80-89	85.5	28	0.022%		2
90-97	93.5	6	0.005%	58%	1
S.S. total acres		128,202			
S.S. effective acres		**74,075**			
Shelf stock unadjusted water yield change					**3,933**
Total acres treated		404,708			
Total effective acres		233,834			
weighted average basal area change (%)					47.5
Total unadjusted increase in water yield					12,415
Adjusting for diminishing effects over time					
				unadjusted	**adjusted**
Total increase in water yield				12,415	2,898
current effective area water yield				58,459	58,459
percent change in water yield				21%	5%

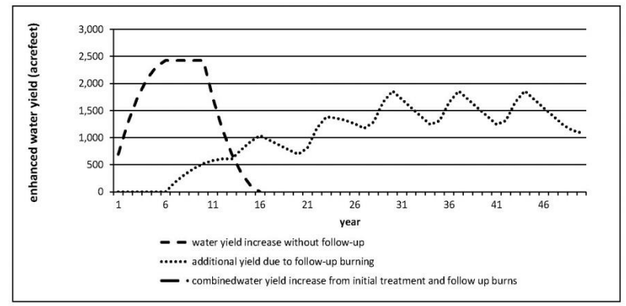
Table 3.3.3. Diminishing return calculation for increased water yield in the Verde River watershed due to ponderosa pine forest restoration treatments in the 4FRI first analysis area and adjacent shelf stock, taking into account the effects of follow-up burning which may extend treatment effects.

	4FRI	S.S.	Total
total acres treated w/ a	15	6	21
estimated acres per year			2

strength of effect by year

eatment ye	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1	0.8333	0.6666	0.5	0.3333	0.1666										
2		1	0.8333	0.6666	0.5	0.3333	0.1666									
3			1	0.8333	0.6666	0.5	0.3333	0.1666								
4				1	0.8333	0.6666	0.5	0.3333	0.1666							
5					1	0.8333	0.6666	0.5	0.3333	0.1666						
6						1	0.8333	0.6666	0.5	0.3333	0.1666					
7							1	0.8333	0.6666	0.5	0.3333	0.1666				
8								1	0.8333	0.6666	0.5	0.3333	0.1666			
9									1	0.8333	0.6666	0.5	0.3333	0.1666		
10										1	0.8333	0.6666	0.5	0.3333	0.1666	
average eff	1	0.91665	0.8333	0.749975	0.66664	0.5833	0.5833	0.5833	0.5833	0.5833	0.49996	0.416625	0.3333	0.24995	0.1666	0
effective a	2	4	6	9	11	13	13	13	13	13	11	9	6	4	2	0
estimated y	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
10-yr avera	**0**															
15-yr avera	**0**															
current yie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
estimated y	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.0%
15-yr avera	**#DIV/0!**															

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43



Partial recovery of diminished yield due to follow-up burning

llow-up treatment year

7	1	0.8333	0.6666	0.5	0.3333	0.1666										
8		1	0.8333	0.6666	0.5	0.3333	0.1666									
9			1	0.8333	0.6666	0.5	0.3333	0.1666								
10				1	0.8333	0.6666	0.5	0.3333	0.1666							
11					1	0.8333	0.6666	0.5	0.3333	0.1666						
12						1	0.8333	0.6666	0.5	0.3333	0.1666					
13							1	0.8333	0.6666	0.5	0.3333	0.1666				
14								1	0.8333	0.6666	0.5	0.3333	0.1666			
15									1	0.8333	0.6666	0.5	0.3333	0.1666		
16										1	0.8333	0.6666	0.5	0.3333	0.1666	
total followup treatment effect	1	0.91665	0.8333	0.749975	0.66664	0.5833	0.5833	0.5833	0.5833	0.5833	0.49996	0.416625	0.3333	0.24995	0.1666	0
prescribed burn or managed wildfire (acres)	2	4	6	9	11	13	13	13	13	13	11	9	6	4	2	0
assumed recovery of diminished water yield (25%)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
estimated yield increase due to followup treatment	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

llow-up treatment year

14	1	0.8333	0.6666	0.5	0.3333	0.1666									
15		1	0.8333	0.6666	0.5	0.3333	0.1666								
16			1	0.8333	0.6666	0.5	0.3333	0.1666							
17				1	0.8333	0.6666	0.5	0.3333	0.1666						
18					1	0.8333	0.6666	0.5	0.3333	0.1666					
19						1	0.8333	0.6666	0.5	0.3333	0.1666				
20							1	0.8333	0.6666	0.5	0.3333	0.1666			
21								1	0.8333	0.6666	0.5	0.3333	0.1666		
22									1	0.8333	0.6666	0.5	0.3333	0.1666	
23										1	0.8333	0.6666	0.5	0.3333	0.1666
total followup treatment effect	1	0.91665	0.8333	0.749975	0.66664	0.5833	0.5833	0.5833	0.5833	0.5833	0.49996	0.416625	0.3333	0.24995	0.1666
prescribed burn or managed wildfire (acres)	2	4	6	9	11	13	13	13	13	13	11	9	6	4	2
assumed recovery of diminished water yield (25%)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
estimated yield increase due to followup treatment	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

llow-up treatment year

21	1	0.8333	0.6666	0.5	0.3333	0.1666									
22		1	0.8333	0.6666	0.5	0.3333	0.1666								
23			1	0.8333	0.6666	0.5	0.3333	0.1666							
24				1	0.8333	0.6666	0.5	0.3333	0.1666						
25					1	0.8333	0.6666	0.5	0.3333	0.1666					
26						1	0.8333	0.6666	0.5	0.3333	0.1666				
27							1	0.8333	0.6666	0.5	0.3333	0.1666			
28								1	0.8333	0.6666	0.5	0.3333	0.1666		
29									1	0.8333	0.6666	0.5	0.3333	0.1666	
30										1	0.8333	0.6666	0.5	0.3333	0.1666
total followup treatment effect	1	0.91665	0.8333	0.749975	0.66664	0.5833	0.5833	0.5833	0.5833	0.5833	0.49996	0.416625	0.3333	0.24995	0.1666
prescribed burn or managed wildfire (acres)	2	4	6	9	11	13	13	13	13	13	11	9	6	4	2
assumed recovery of diminished water yield (25%)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
estimated yield increase due to followup treatment	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

prescribed burn or managed wildfire (acres)

assumed recovery of diminished water yield (25%)

Reported in Baker 2003

Initial water yields from ponderosa pine treatments - 15-40% when basal area is reduced 30-100%

Equation for increased water yield from relationship described by Baker is

$(((0.357142857 * \Delta WY_{ave.}) + 4.2875)/100) * (TA * E_{ave} * WY_0)$

where

0.357142857 is the slope of the line connecting the low high end of percent water yeild change as a function of percent basal area change

$\Delta WY_{ave.}$ is the weighted average of the percent change in water yield across all basal area changes equal to or greater than 30%.

4.2875 is the y-intercept in the slope formula for (40-15)/(100-30)

TA is effective treatment area (acres) [acres with ≥30% decrease in basal area]

E_{ave} is the average effect due to diminishment

WY_0 is the original water yield before treatments

0.25 acre-feet per acre = longterm water yield in ponderosa pine forest without treatments (acre-feet/acre)

Table 3.3.3. Continued. Diminishing return calculation for increased water yield in the Verde River watershed due to ponderosa pine forest restoration treatments in the 4FRI first analysis area and adjacent shelf stock, taking into account the effects of follow-up burning which may extend treatment effects.

4th round follow-up treatment year																																																							
28																												1	0.8333	0.6666	0.5	0.3333	0.1666																	
29																													1	0.8333	0.6666	0.5	0.3333	0.1666																
30																														1	0.8333	0.6666	0.5	0.3333	0.1666															
31																															1	0.8333	0.6666	0.5	0.3333	0.1666														
32																																1	0.8333	0.6666	0.5	0.3333	0.1666													
33																																	1	0.8333	0.6666	0.5	0.3333	0.1666												
34																																		1	0.8333	0.6666	0.5	0.3333	0.1666											
35																																			1	0.8333	0.6666	0.5	0.3333	0.1666										
36																																				1	0.8333	0.6666	0.5	0.3333	0.1666									
37																																					1	0.8333	0.6666	0.5	0.3333	0.1666								
total followup treatment effect																												1	0.91665	0.8333	0.749975	0.66664	0.5833	0.5833	0.5833	0.5833	0.5833	0.49996	0.416625	0.3333	0.24995	0.1666								
prescribed burn or managed wildfire (acres)																												23,383	46,767	70,150	93,534	116,917	140,300	140,300	140,300	140,300	140,300	116,917	93,534	70,150	46,767	23,383								
assumed recovery of diminished water yield (25%)																												0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25								
estimated yield increase due to followup treatment																												**173**	**569**	**776**	**932**	**1,035**	**1,087**	**1,087**	**1,087**	**1,087**	**1,087**	**776**	**517**	**310**	**155**	**52**								
5th round follow-up treatment year																																																							
35																																			1	0.8333	0.6666	0.5	0.3333	0.1666										
36																																				1	0.8333	0.6666	0.5	0.3333	0.1666									
37																																					1	0.8333	0.6666	0.5	0.3333	0.1666								
38																																						1	0.8333	0.6666	0.5	0.3333	0.1666							
39																																							1	0.8333	0.6666	0.5	0.3333	0.1666						
40																																								1	0.8333	0.6666	0.5	0.3333	0.1666					
41																																									1	0.8333	0.6666	0.5	0.3333	0.1666				
42																																										1	0.8333	0.6666	0.5	0.3333	0.1666			
43																																											1	0.8333	0.6666	0.5	0.3333	0.1666		
44																																												1	0.8333	0.6666	0.5	0.3333	0.1666	
total followup treatment effect																																			1	0.91665	0.8333	0.749975	0.66664	0.5833	0.5833	0.5833	0.5833	0.5833	0.49996	0.416625	0.3333	0.24995	0.1666	
prescribed burn or managed wildfire (acres)																																			23,383	46,767	70,150	93,534	116,917	140,300	140,300	140,300	140,300	140,300	116,917	93,534	70,150	46,767	23,383	
assumed recovery of diminished water yield (25%)																																			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	
estimated yield increase due to followup treatment																																			**173**	**569**	**776**	**932**	**1,035**	**1,087**	**1,087**	**1,087**	**1,087**	**1,087**	**776**	**517**	**310**	**155**	**52**	
6th round follow-up treatment year																																																							
42																																										1	0.8333	0.6666	0.5	0.3333	0.1666			
43																																											1	0.8333	0.6666	0.5	0.3333	0.1666		
44																																												1	0.8333	0.6666	0.5	0.3333	0.1666	
45																																													1	0.8333	0.6666	0.5	0.3333	0.1666
46																																														1	0.8333	0.6666	0.5	0.3333
47																																															1	0.8333	0.6666	0.5
48																																																1	0.8333	0.6666
49																																																	1	0.8333
50																																																		1
total followup treatment effect																																										1	0.91665	0.8333	0.749975	0.66664	0.5833	0.5833	0.5833	0.5833
prescribed burn or managed wildfire (acres)																																										23,383	46,767	70,150	93,534	116,917	140,300	140,300	140,300	140,300
assumed recovery of diminished water yield (25%)																																										0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
estimated yield increase due to followup treatment																																										**173**	**569**	**776**	**932**	**1,035**	**1,087**	**1,087**	**1,087**	**1,087**
Total Water Yield Increase (acft)	**693**	**1,271**	**1,733**	**2,080**	**2,311**	**2,426**	**2,600**	**2,744**	**2,860**	**2,947**	**2,311**	**1,762**	**1,300**	**1,127**	**1,041**	**1,041**	**954**	**867**	**781**	**694**	**809**	**1,176**	**1,383**	**1,365**	**1,324**	**1,260**	**1,173**	1,289	1,656	1,863	1,708	1,552	1,397	1,242	1,312	1,656	1,863	1,708	1,552	1,397	1,242	1,312	1,656	1,863	1,708	1,552	1,397	1,242	1,138	1,087
Initial 10-year average yield increase	**2,166**																																																						
50-yr average annual yield increase (acft)	**1,529**																																																						
current yield of effective acres	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459	58,459
estimated yield increase (%)	1.2%	2.2%	3.0%	3.6%	4.0%	4.2%	4.4%	4.7%	4.9%	5.0%	4.0%	3.0%	2.2%	1.9%	1.8%	1.8%	1.6%	1.5%	1.3%	1.2%	1.4%	2.0%	2.4%	2.3%	2.3%	2.2%	2.0%	2.2%	2.8%	3.2%	2.9%	2.7%	2.4%	2.1%	2.2%	2.8%	3.2%	2.9%	2.7%	2.4%	2.1%	2.2%	2.8%	3.2%	2.9%	2.7%	2.4%	2.1%	1.9%	1.9%
10-yr average yield increase (%)	**3.7%**																																																						
50-yr average yield increase (%)	**2.6%**																																																						
add'n yield due to follow-up (acft)	**0**	**0**	**0**	**0**	**0**	**0**	**173**	**318**	**434**	**520**	**578**	**607**	**607**	**781**	**925**	**1,041**	**954**	**867**	**781**	**694**	**809**	**1,176**	**1,383**	**1,365**	**1,324**	**1,260**	**1,173**	**1,289**	**1,656**	**1,863**	**1,708**	**1,552**	**1,397**	**1,242**	**1,312**	**1,656**	**1,863**	**1,708**	**1,552**	**1,397**	**1,242**	**1,312**	**1,656**	**1,863**	**1,708**	**1,552**	**1,397**	**1,242**	**1,138**	**1,087**

Potential Amount of Water and Cost

In summary, it is estimated that restoration treatments on 4FRI first analysis acres plus shelf stock acres in the Verde River watershed have the potential to enhance water yield in the range from 310 to 5,279 acre-feet per year over 25 years with a long-term average of 2,600 acre-feet per year when diminishing returns are considered. The cost for initial treatment, which is typically quoted at $800 per acre, will be borne by the U.S. Forest Service and its contractor who will implement the treatments and use resulting fiber to manufacture diversified products and bioenergy. To maintain water yield benefits, retreatment (maintenance burning) must be conducted within seven years following initial treatment. In reality, the interval between initial treatment and follow-up burn(s) will vary, depending on available resources and opportunities to use managed wildfire rather than prescribed burns. To the extent that planned prescribed burns are used, it is assumed that the downstream water users will pay half the cost of these follow-up treatments that will provide renewed enhancement of water yield. The Forest Service will pay for the other half of the cost, because there are other benefits from burning (forest health, wildlife & livestock forage, reduced wildfire hazard, etc).

For cost estimation purposes, it is assumed that treatment of the 233,834 acres with potential for water yield enhancement in the Verde River watershed will occur over a period of 10 years, with 23,383 acres being treated each year. A matrix was built to estimate the number of acres that must be treated each year, and a maintenance treatment cost of $100/acre was applied. Resulting treatment costs and water yield enhancement are shown in Table 3.3.4. Cost summary per USBR method is provided in table 5. Field costs are zero because the initial treatment costs will be paid for by the US Forest Service and its contractor. Operation and Maintenance costs (O&M) are the retreatment (maintenance) costs, which are estimated in the range of $2.3 to $4.7 million total cost per year, half of which would be paid by the Forest Service. Estimated total annual cost ranges from $646 to $3,765 per acre-foot of enhanced yield. In a 44-year period from when follow-up treatments start the overall average annual cost per acre-foot would be $1,594.

Table 3.3.4. Cost for follow-up burning treatments to sustain enhanced water yield due to forest restoration initial mechanical treatment and prescribed burning.

year	round 1 acres	round 2 acres	round 3	round 4	round 5	round 6	total acres	price per acre	total cost	Forest Service funding	Other funding	improved yield acft	cost per acft	ave. cost per acft
7	23,383						23,383	100	$2,338,341	$1,169,171	$1,169,171	173	$6,740	**$1,594**
8	23,383						23,383	100	$2,338,341	$1,169,171	$1,169,171	318	$3,677	
9	23,383						23,383	100	$2,338,341	$1,169,171	$1,169,171	434	$2,696	
10	23,383						23,383	100	$2,338,341	$1,169,171	$1,169,171	520	$2,247	
11	23,383						23,383	100	$2,338,341	$1,169,171	$1,169,171	578	$2,022	
12	23,383						23,383	100	$2,338,341	$1,169,171	$1,169,171	607	$1,926	
13	23,383						23,383	100	$2,338,341	$1,169,171	$1,169,171	607	$1,926	
14	23,383	23,383					46,767	100	$4,676,682	$2,338,341	$2,338,341	781	$2,996	
15	23,383	23,383					46,767	100	$4,676,682	$2,338,341	$2,338,341	925	$2,528	
16	23,383	23,383					46,767	100	$4,676,682	$2,338,341	$2,338,341	1,041	$2,247	
17		23,383					23,383	100	$2,338,341	$1,169,171	$1,169,171	954	$1,226	
18		23,383					23,383	100	$2,338,341	$1,169,171	$1,169,171	867	$1,348	
19		23,383					23,383	100	$2,338,341	$1,169,171	$1,169,171	781	$1,498	
20		23,383					23,383	100	$2,338,341	$1,169,171	$1,169,171	694	$1,685	
21		23,383	23,383				46,767	100	$4,676,682	$2,338,341	$2,338,341	809	$2,889	
22		23,383	23,383				46,767	100	$4,676,682	$2,338,341	$2,338,341	1,176	$1,988	
23		23,383	23,383				46,767	100	$4,676,682	$2,338,341	$2,338,341	1,383	$1,690	
24			23,383				23,383	100	$2,338,341	$1,169,171	$1,169,171	1,365	$856	
25			23,383				23,383	100	$2,338,341	$1,169,171	$1,169,171	1,324	$883	
26			23,383				23,383	100	$2,338,341	$1,169,171	$1,169,171	1,260	$928	
27			23,383				23,383	100	$2,338,341	$1,169,171	$1,169,171	1,173	$996	
28			23,383	23,383			46,767	100	$4,676,682	$2,338,341	$2,338,341	1,289	$1,814	
29			23,383	23,383			46,767	100	$4,676,682	$2,338,341	$2,338,341	1,656	$1,412	
30			23,383	23,383			46,767	100	$4,676,682	$2,338,341	$2,338,341	1,863	$1,255	
31				23,383			23,383	100	$2,338,341	$1,169,171	$1,169,171	1,708	$685	
32				23,383			23,383	100	$2,338,341	$1,169,171	$1,169,171	1,552	$753	
33				23,383			23,383	100	$2,338,341	$1,169,171	$1,169,171	1,397	$837	
34				23,383			23,383	100	$2,338,341	$1,169,171	$1,169,171	1,242	$941	
35				23,383	23,383		46,767	100	$4,676,682	$2,338,341	$2,338,341	1,312	$1,783	
36				23,383	23,383		46,767	100	$4,676,682	$2,338,341	$2,338,341	1,656	$1,412	
37				23,383	23,383		46,767	100	$4,676,682	$2,338,341	$2,338,341	1,863	$1,255	
38					23,383		23,383	100	$2,338,341	$1,169,171	$1,169,171	1,708	$685	
39					23,383		23,383	100	$2,338,341	$1,169,171	$1,169,171	1,552	$753	
40					23,383		23,383	100	$2,338,341	$1,169,171	$1,169,171	1,397	$837	
41					23,383		23,383	100	$2,338,341	$1,169,171	$1,169,171	1,242	$941	
42					23,383	23,383	46,767	100	$4,676,682	$2,338,341	$2,338,341	1,312	$1,783	
43					23,383	23,383	46,767	100	$4,676,682	$2,338,341	$2,338,341	1,656	$1,412	
44					23,383	23,383	46,767	100	$4,676,682	$2,338,341	$2,338,341	1,863	$1,255	
45						23,383	23,383	100	$2,338,341	$1,169,171	$1,169,171	1,708	$685	
46						23,383	23,383	100	$2,338,341	$1,169,171	$1,169,171	1,552	$753	
47						23,383	23,383	100	$2,338,341	$1,169,171	$1,169,171	1,397	$837	
48						23,383	23,383	100	$2,338,341	$1,169,171	$1,169,171	1,242	$941	
49						23,383	23,383	100	$2,338,341	$1,169,171	$1,169,171	1,138	$1,027	
50						23,383	23,383	100	$2,338,341	$1,169,171	$1,169,171	1,087	$1,076	
TOTAL	233,834	233,834	233,834	233,834	233,834	210,451	1,379,621		$49,105,164	$24,552,582	$68,981,064			
										Average	**$1,567,751**	**1,186**		

Table 3.3.5. Costs per USBR method.

Field costs	$0
Water Supply AF/YR (average)	1,035
Annual Costs	
Amortized Annual Cost (50 yrs @4.125%)	$0
Annual Operations & Maintenance Cost (average)	$1,113,496
Total Annual Cost	
Annual Cost per Acre Foot	$1,076
Annual Cost per 1,000 gallons	$3
Present Worth Project Costs	
Present Worth O&M Cost (50 yrs @ 4.125%)	$85,408,625
Present Worth Cost per acre foot	$42,204
Present Worth Cost per 1,000 gallons	$130

Infrastructure Requirements

There are no infrastructure requirements as this alternative description considers enhanced availability of water as a consequence of improved snowpack retention and reduced ET and assumes that the water will be delivered to the users via natural waterways.

Future Items for Evaluation

This analysis was completed at a coarse project level scale with regards to the shelf stock, whereas additional spatial data made available by the USFS for 4FRI allowed more detailed analysis, down to the stand level in the 4FRI area. If more detailed information is made available for the shelf stock areas, such as accurate accounting of existing basal area and desired future basal area, then a more precise estimate of water yield changes could be generated. Also, as the sequencing of treatments becomes known, the volume and timing of water yield enhancements can be more accurately predicted. As 4FRI monitoring is implemented, estimates of water yield increase per basal area reduction percent could be refined for the soils in the project area. A surface water model could be developed to route the enhanced yield to and through stream channels and account for transmission losses due to groundwater recharge along the channel bottom and uptake by riparian plants. A coupled groundwater model could be developed to estimate recharge.

Legal, Institutional, and Environmental

Because NEPA is being conducted (4FRI first analysis area EIS and some of the shelf stock) or has been conducted (most of the shelf stock) by the USFS, there are few legal, institutional, or environmental considerations for the treatment. The timeline for the EIS, as of December 5, 2012 is that the draft will be released in early 2013, there will be a 60-day comment period, and a record of decision is anticipated in mid-2013. If a payment for watershed services system were to be developed to support follow-up treatments to maintain water yields, roles and responsibilities of participating organizations would need to be defined through agreements

preferably during the early years of treatment so that a pool of funding could be collected and available for follow-up treatments starting in year 7.

In consideration of water rights, none of the water users in this study who have an increased projected demand in 2050 have the legal right to use the water from enhanced yield nor the infrastructure to take, divert, or treat the water. Because reduction in water yield due to thickening forest density has been occurring since the time of the earliest water right priority dates, and because water rights in the basin have been generally over allocated for a very long time, it is assumed that water made available through forest treatments is already claimed water.

Adaptive management was incorporated into the 4FRI process to provide flexibility to account for inaccurate initial assumptions, to adapt to changes in environmental conditions, and/ or to respond to subsequent monitoring information that indicates that desired conditions are not being met. As hydrologic data are obtained from implementation of 4FRI treatment in paired watershed studies, there may be potential to affect treatment implementation for enhanced water yield response. However, there are currently some procedural unknowns with adaptive management.

Conclusion

Water yield enhancement in the Verde River watershed is anticipated due to mechanical thinning and burning treatments that are part of the landscape-scale Four Forest Restoration Initiative. While the initial cost of treatments will be paid by the U.S. Forest Service and their contractor implementing the treatments, the Forest Service's current budget projections are that there will be a 50% funding need for follow-up burning treatments. The follow-up burning treatments, along with providing other forest health benefits, are expected to help extend the period of time in which water yields are enhanced post treatment, through reduced evapotranspiration by shrubs and small trees. Interested parties wishing to participate in payment for follow-up treatments could be called on to provide an average of $1,594 per acre-foot for an average of 1,186 acre-feet per year of enhanced water yield in years 7 through 27 following the start of mechanical treatments. These costs do not take into account the enhanced water yield due to initial mechanical treatments (1,618 acft/yr average) that will occur in the first 15 years. The cost and water volume estimates also do not account for possible transmission losses due to groundwater recharge or riparian water use between the forested areas yielding the water and the downstream water use areas. Estimates also do not include the cost of conveying the water by means other than stream channels.

Glossary

Grassland Thinning – This type of treatment involves tree removal to restore grasslands that have been encroached upon.

Intermediate Thinning (IT) – This type of thinning would be used to: (1) thin stands that are moderately to heavily infected with dwarf mistletoe to improve growth and vigor, (2) retain the best dominant and co-dominant trees with the least amount of mistletoe, and, (3) establish interspaces between residual tree groups and clumps. Improved growth and vigor of the best trees rather than sanitation is a primary objective.

Savanna Thinning - This type of treatment is specific to areas where soils developed under an open tree canopy and a robust herbaceous (grass/forb) understory. Thinning would be used to: (1) focus removal on those trees that have become established post-settlement using pre-settlement tree evidence as guidance, and, (2) attain the desired amount of interspaces between tree groups or individuals that range from 70 to 90 percent

Shelf stock – These are forest treatment areas for which NEPA analysis has already been completed or is in process at the national forest district level. They are, therefore, not included in the 4FRI NEPA analysis. Shelf stock in many cases will be treated in advance of the 4FRI treatment units. Treatment types for shelf stock are very similar to 4FRI treatment types.

Shelterwood Cut – Removing trees on the harvest area in a series of two or more cuttings so new seedlings can grow from the seed of older trees. This method produces an even-aged forest.

Stand Improvement Thinning (SI) – This type of thinning would be used to: (1) thin and improve the growth and vigor of young, even age plantations or stands dominated by trees <8.5" dbh; (2) begin the conversion to uneven age condition, and (3) establish interspaces between residual tree groups and clumps

Uneven-aged Thinning (UEA) – The objectives of this type of thinning is to: (1) establish interspaces between residual tree groups and clumps, (2) establish regeneration openings where seedling/sapling size class trees are under-represented, (3) establish interspaces between individual trees and clumps of trees within a group, (4) enhance growing space for younger age classes to become free to grow with limited competition, and, (5) meet Tusayan, Williams, and Flagstaff community wildfire protection plan (CWPP) desired conditions in the wildland urban interface (WUI).

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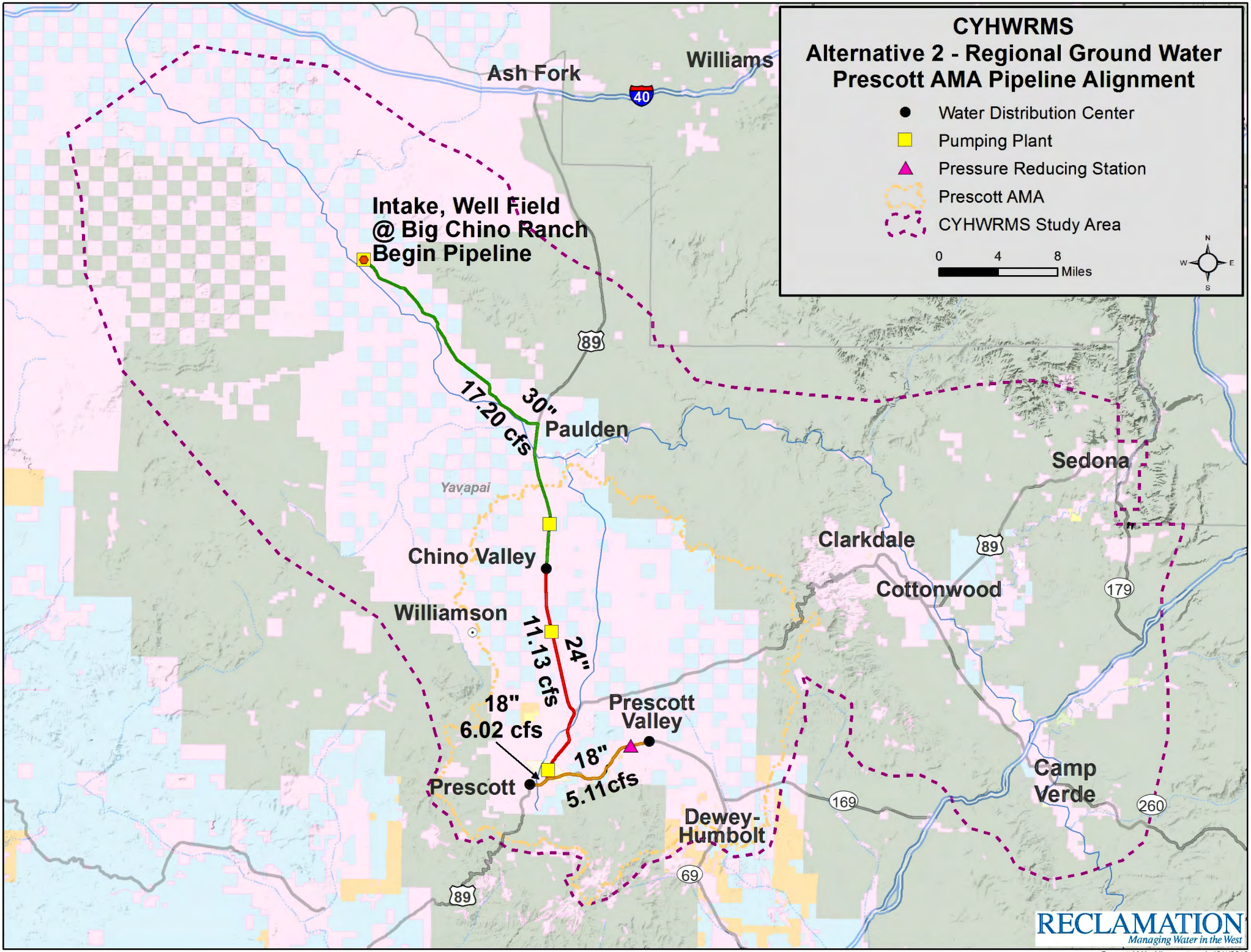
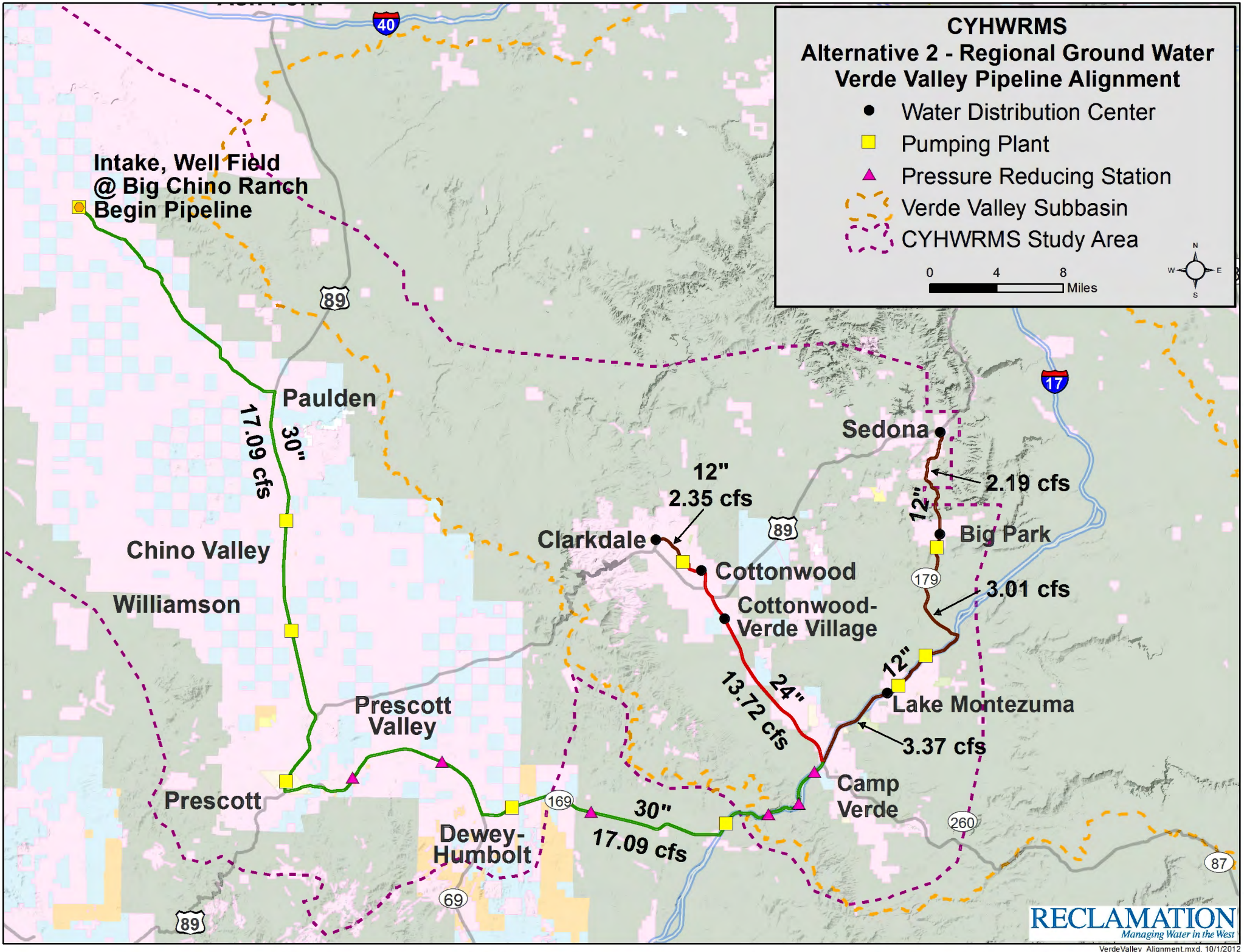
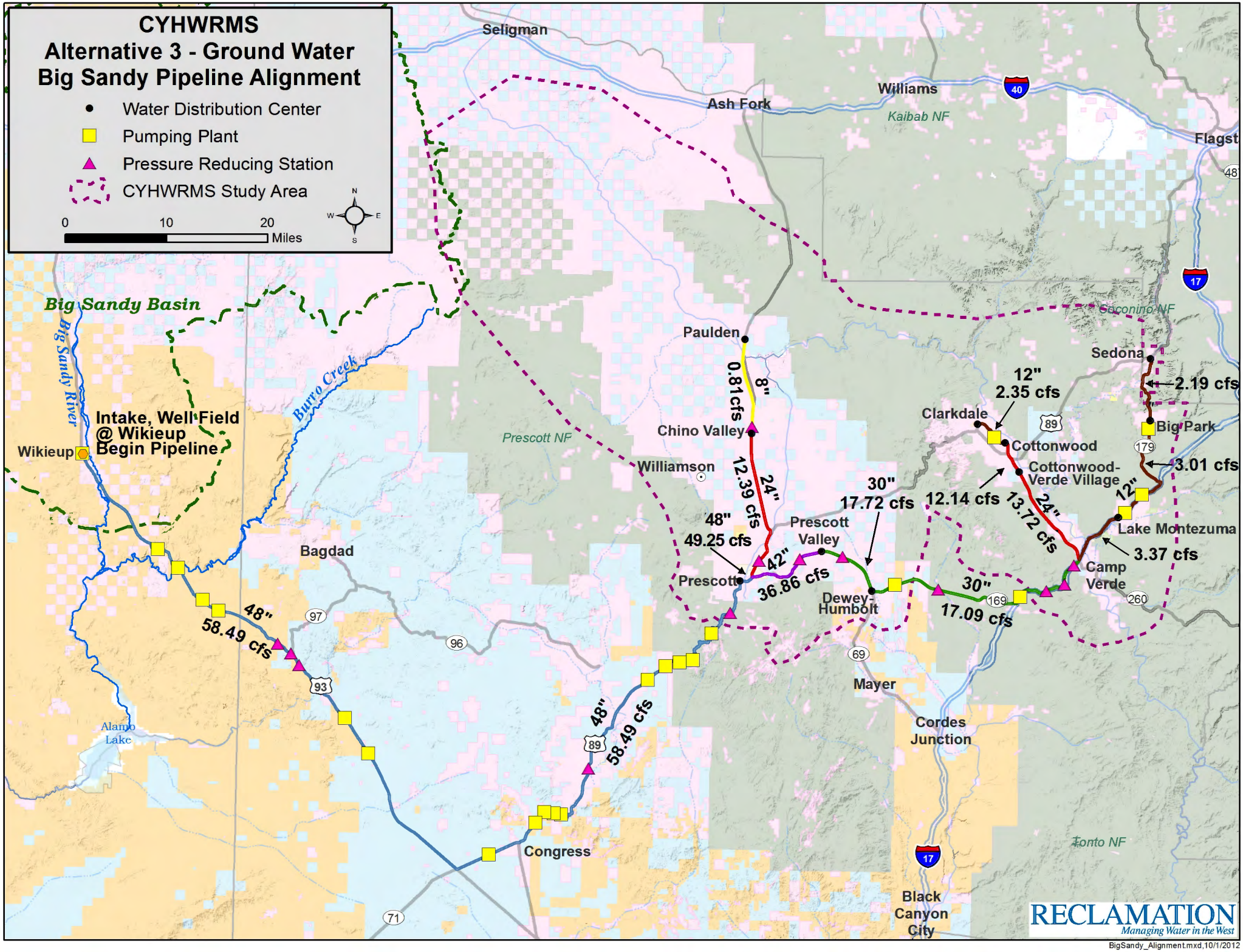
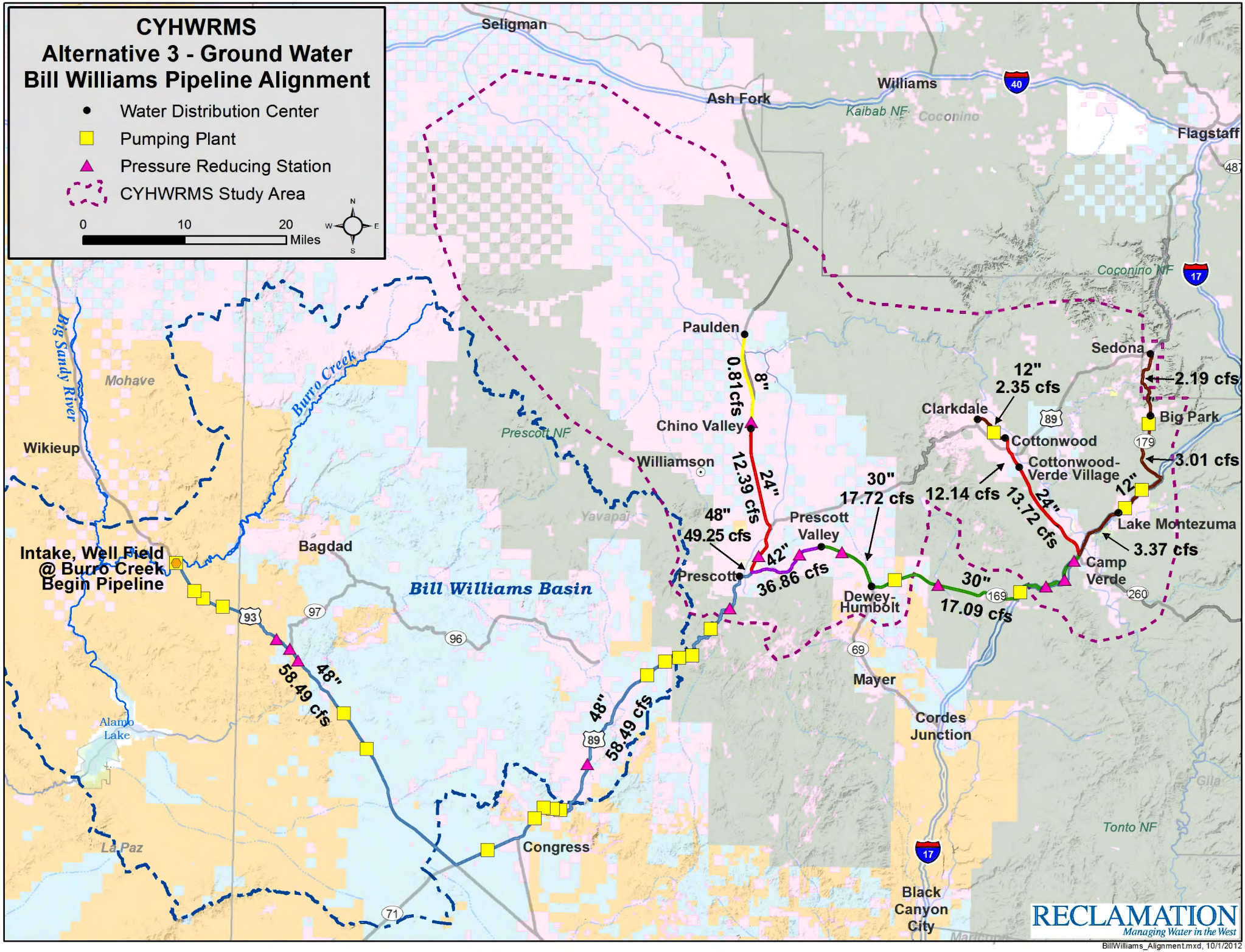
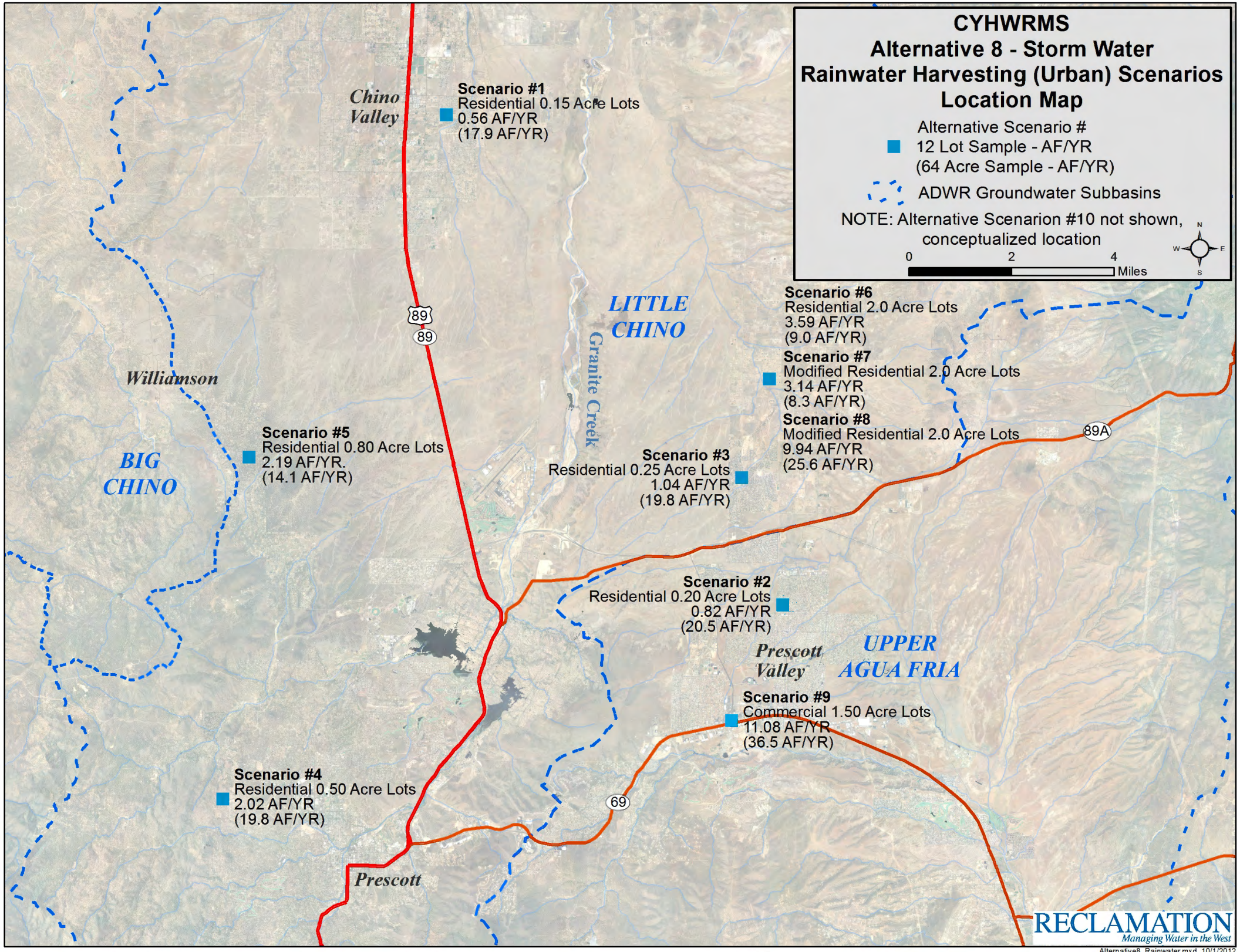
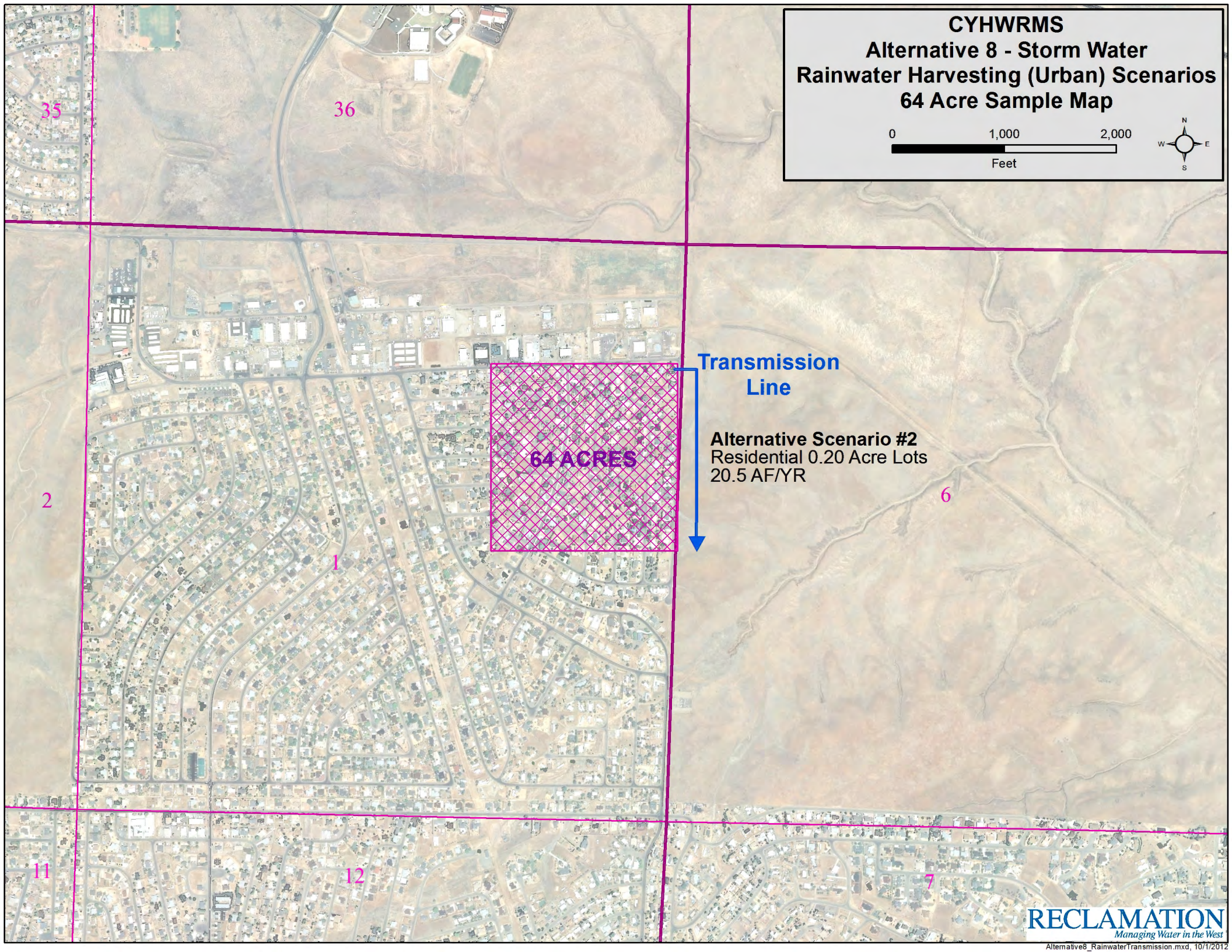

CYHWRMS
Alternative 2 - Regional Ground Water
Prescott AMA Pipeline Alignment
Water Distribution Center
Pumping Plant
Pressure Reducing Station
Prescott AMA
CYHWRMS Study Area
0 4 8
Miles
N
W
E
S
Ash Fork
Williams
40
Intake, Well Field
@ Big Chino Ranch
Begin Pipeline
89
17.20 cfs
30"
Paulden
Yavapai
Chino Valley
Williamson
11.13 cfs
24"
18"
6.02 cfs
Prescott
Prescott
Valley
18"
5.11cfs
Dewey-
Humbolt
69
169
Clarkdale
Cottonwood
Sedona
179
Camp
Verde
260
RECLAMATION
Managing Water in the West
PrescottAMA_Alignment.mxd, 10/1/2012

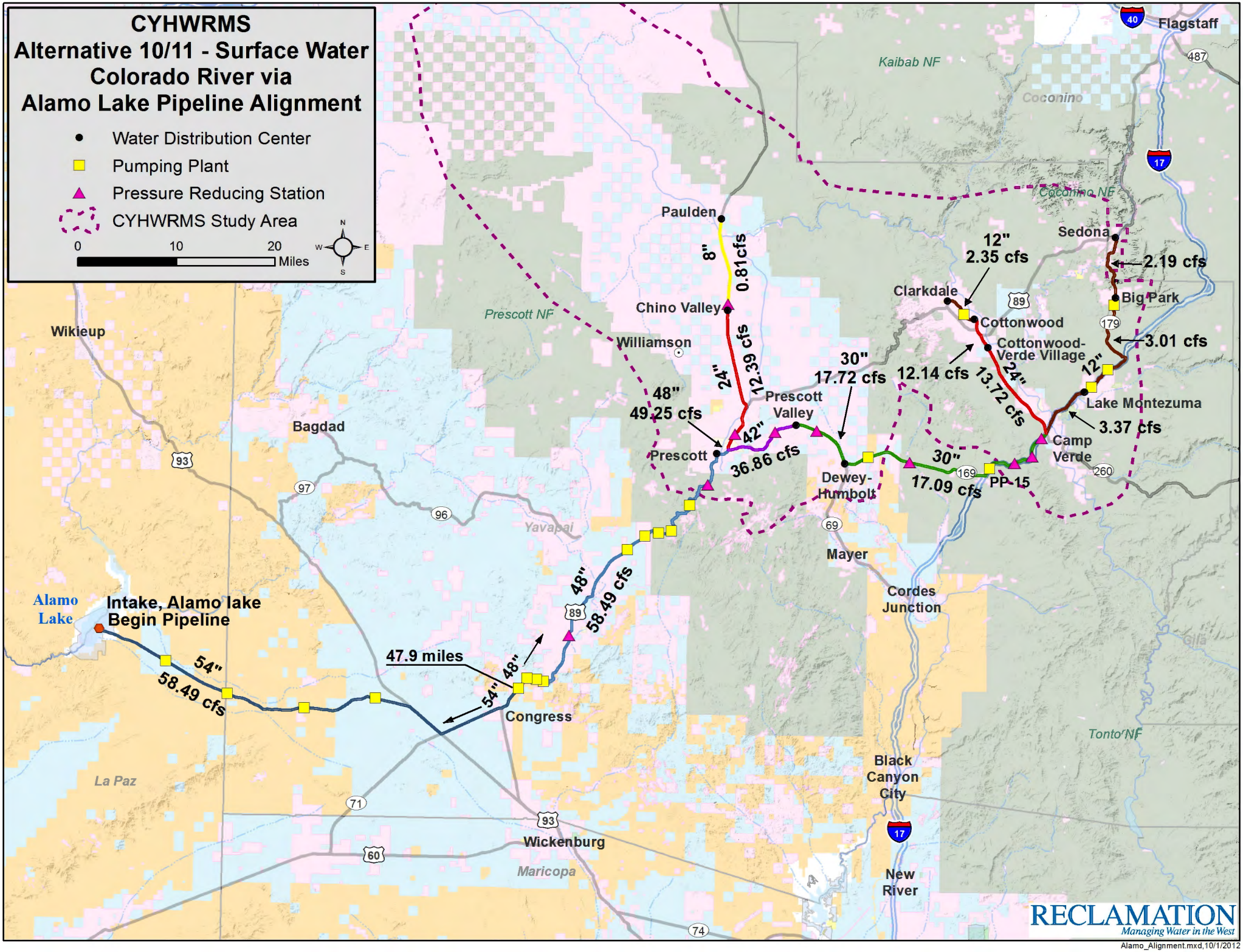

CYHWRMS
Alternative 2 - Regional Ground Water
Verde Valley Pipeline Alignment
Water Distribution Center
Pumping Plant
Pressure Reducing Station
Verde Valley Subbasin
CYHWRMS Study Area
0
4
8
Miles
N
W
E
S
Intake, Well Field
@ Big Chino Ranch
Begin Pipeline
Paulden
17.09 cfs
30"
Chino Valley
Williamson
Prescott Valley
Prescott
Dewey-Humbolt
30"
17.09 cfs
Clarkdale
12"
2.35 cfs
Cottonwood
Cottonwood-Verde Village
24"
13.72 cfs
Sedona
2.19 cfs
12"
Big Park
3.01 cfs
12"
Lake Montezuma
3.37 cfs
Camp Verde
40
89
17
179
169
69
260
87
RECLAMATION
Managing Water in the West
VerdeValley_Alignment.mxd, 10/1/2012

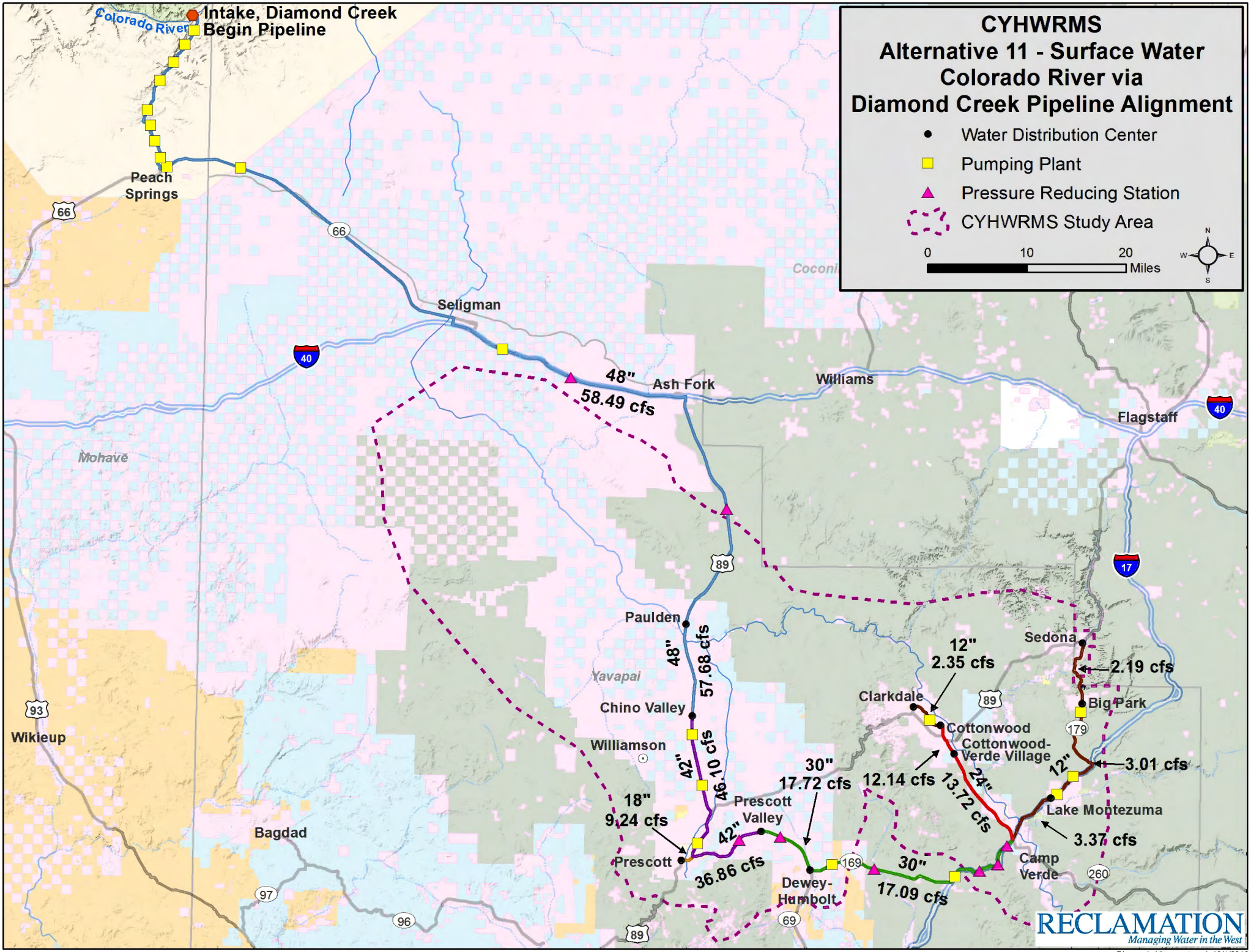

CYHWRMS
Alternative 3 - Ground Water
Big Sandy Pipeline Alignment
Water Distribution Center
Pumping Plant
Pressure Reducing Station
CYHWRMS Study Area
0
10
20
Miles
N
W
E
S
Seligman
Ash Fork
Williams
Kaibab NF
Flagst
Big Sandy Basin
Big Sandy River
Burro Creek
Intake, Well Field
@ Wikieup
Begin Pipeline
Wikieup
Prescott NF
Paulden
Chino Valley
Williamson
Bagdad
Prescott
Prescott Valley
Dewey-Humbolt
Mayer
Cordes Junction
Congress
Alamo Lake
Black Canyon City
Tonto NF
Coconino NF
Sedona
Clarkdale
Cottonwood
Cottonwood-Verde Village
Big Park
Lake Montezuma
Camp Verde
0.81cfs
8"
12.39 cfs
24"
48"
49.25 cfs
42"
36.86 cfs
30"
17.72 cfs
12"
2.35 cfs
12.14 cfs
13.72 cfs
24"
2.19 cfs
3.01 cfs
12"
3.37 cfs
30"
17.09 cfs
48"
58.49 cfs
48"
58.49 cfs
RECLAMATION
Managing Water in the West
BigSandy_Alignment.mxd,10/1/2012

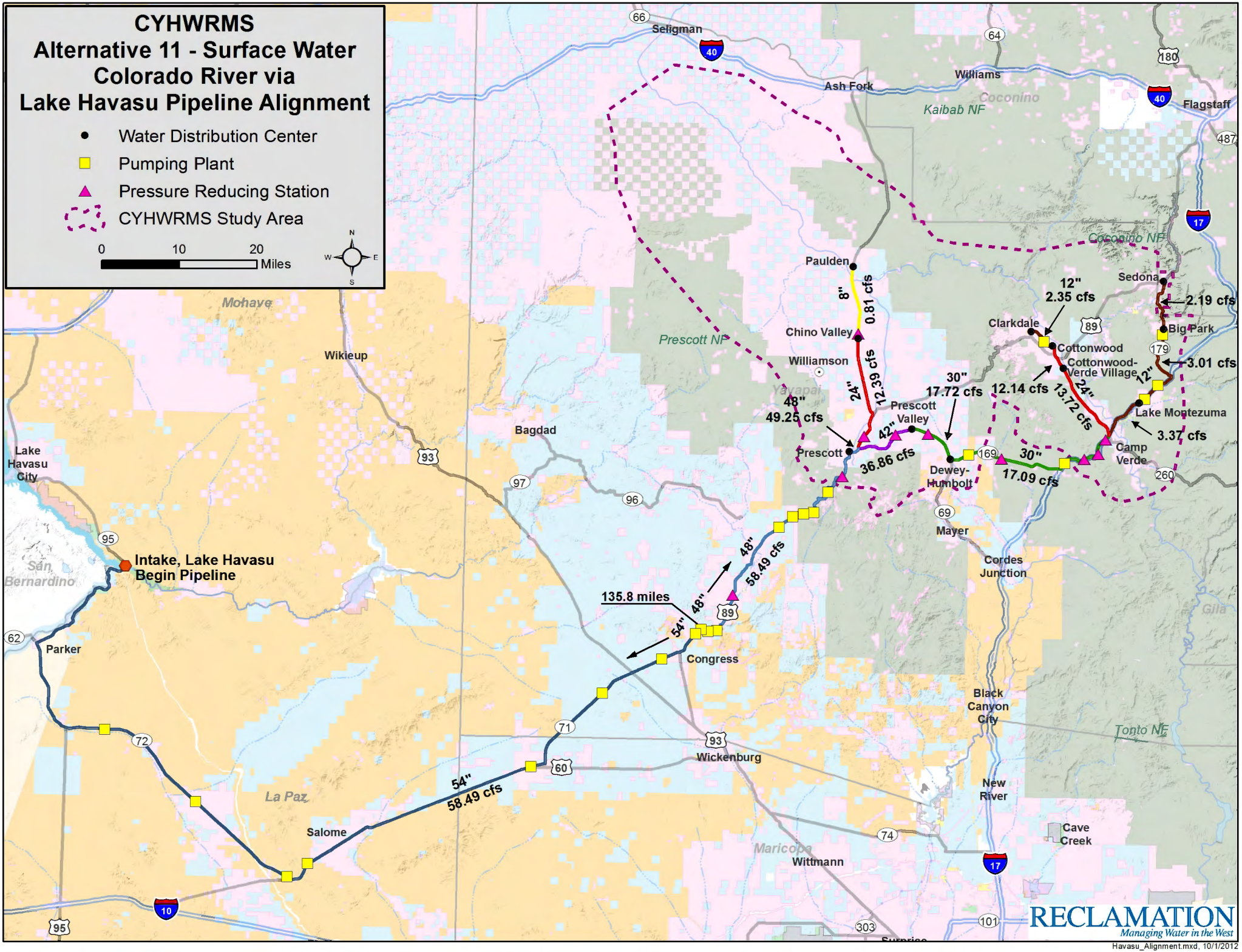

CYHWRMS
Alternative 3 - Ground Water
Bill Williams Pipeline Alignment
Water Distribution Center
Pumping Plant
Pressure Reducing Station
CYHWRMS Study Area
0
10
20
Miles
N
W
E
S
Seligman
Ash Fork
Williams
Kaibab NF
Coconino
Flagstaff
Coconino NF
Paulden
Chino Valley
Prescott NF
Williamson
Yavapai
Prescott
Prescott Valley
Dewey-Humbolt
Mayer
Cordes Junction
Black Canyon City
Sedona
Clarkdale
Cottonwood
Cottonwood-Verde Village
Big Park
Lake Montezuma
Camp Verde
Bagdad
Congress
Wikieup
Mohave
La Paz
Big Sandy River
Burro Creek
Alamo Lake
Bill Williams Basin
Tonto NF
Gila
Intake, Well Field
@ Burro Creek
Begin Pipeline
0.81cfs
8"
12.39 cfs
24"
48"
49.25 cfs
42"
36.86 cfs
30"
17.72 cfs
12.14 cfs
13.72 cfs
24"
12"
2.35 cfs
2.19 cfs
3.01 cfs
3.37 cfs
30"
17.09 cfs
48"
58.49 cfs
48"
58.49 cfs
RECLAMATION
Managing Water in the West
BillWilliams_Alignment.mxd, 10/1/2012

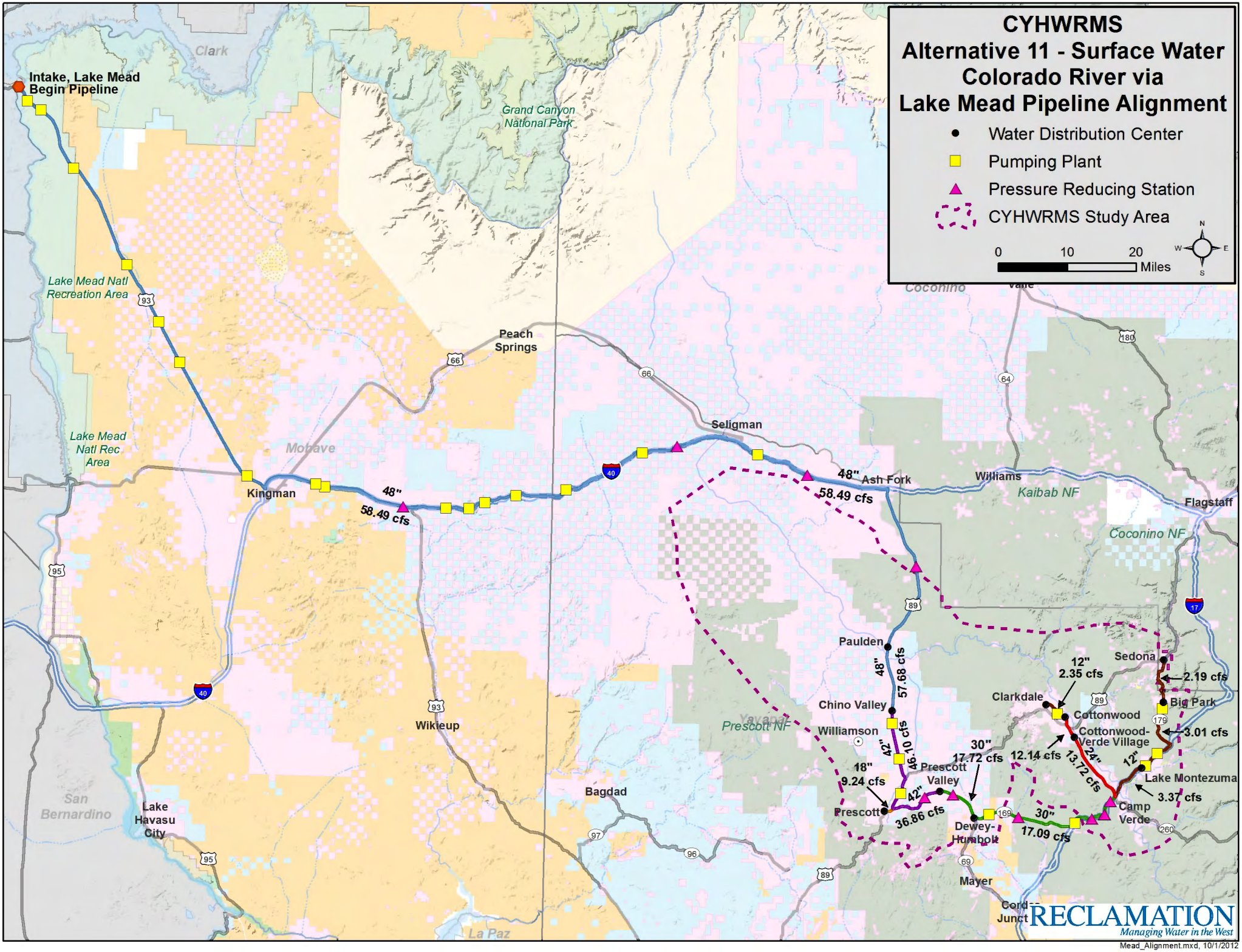

CYHWRMS
Alternative 8 - Storm Water
Rainwater Harvesting (Urban) Scenarios
Location Map
Alternative Scenario #
12 Lot Sample - AF/YR
(64 Acre Sample - AF/YR)
ADWR Groundwater Subbasins
NOTE: Alternative Scenarion #10 not shown, conceptualized location
0
2
4
Miles
N
W
E
S
Chino Valley
Scenario #1
Residential 0.15 Acre Lots
0.56 AF/YR
(17.9 AF/YR)
LITTLE CHINO
Granite Creek
Scenario #6
Residential 2.0 Acre Lots
3.59 AF/YR
(9.0 AF/YR)
Scenario #7
Modified Residential 2.0 Acre Lots
3.14 AF/YR
(8.3 AF/YR)
Scenario #8
Modified Residential 2.0 Acre Lots
9.94 AF/YR
(25.6 AF/YR)
89
89
89A
Williamson
BIG CHINO
Scenario #5
Residential 0.80 Acre Lots
2.19 AF/YR.
(14.1 AF/YR)
Scenario #3
Residential 0.25 Acre Lots
1.04 AF/YR
(19.8 AF/YR)
Scenario #2
Residential 0.20 Acre Lots
0.82 AF/YR
(20.5 AF/YR)
Prescott Valley
UPPER AGUA FRIA
Scenario #9
Commercial 1.50 Acre Lots
11.08 AF/YR
(36.5 AF/YR)
Scenario #4
Residential 0.50 Acre Lots
2.02 AF/YR
(19.8 AF/YR)
69
Prescott
RECLAMATION
Managing Water in the West
Alternative8_Rainwater.mxd, 10/1/2012

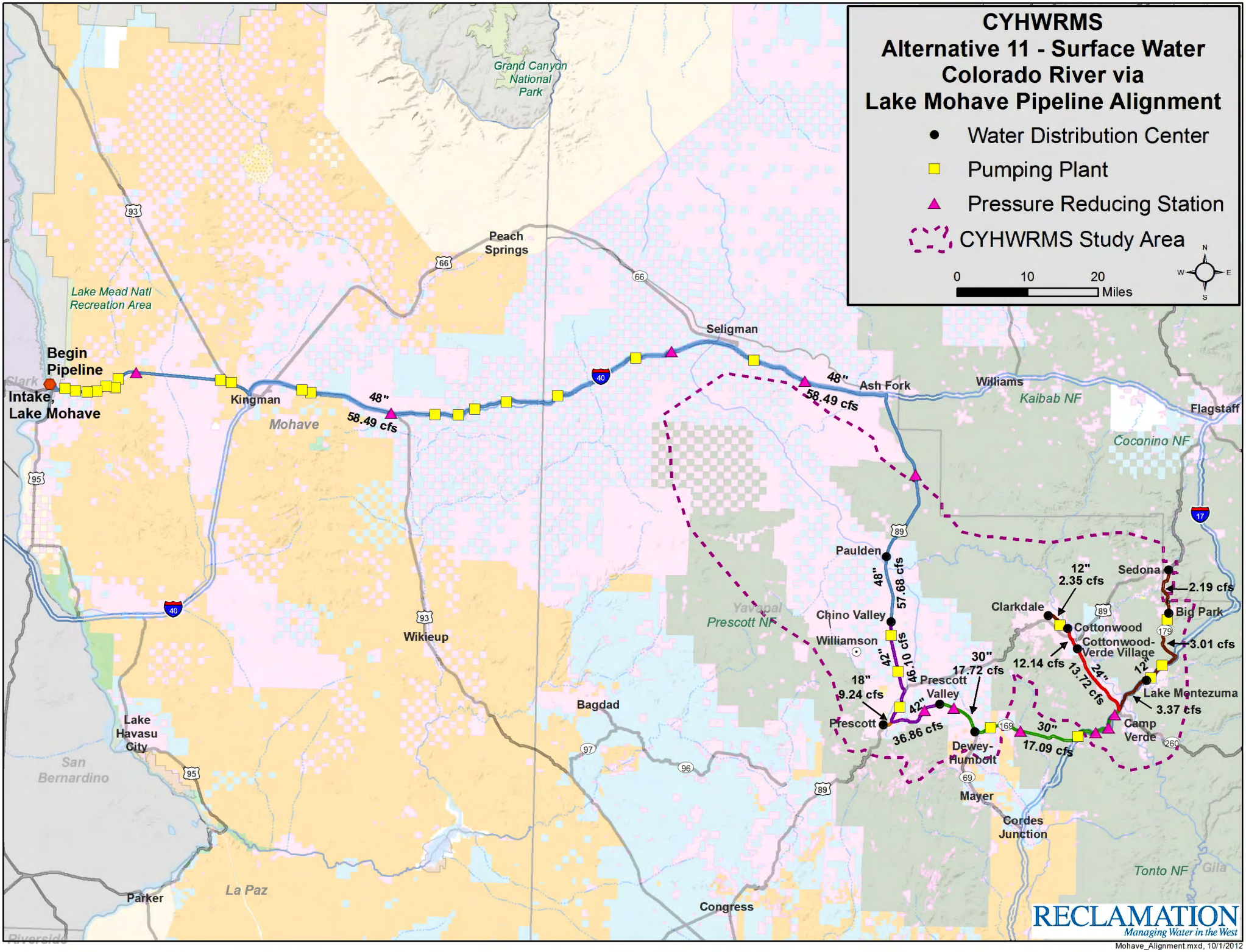

CYHWRMS
Alternative 8 - Storm Water
Rainwater Harvesting (Urban) Scenarios
64 Acre Sample Map
0
1,000
2,000
Feet
N
W
E
S
35
36
2
1
6
11
12
7
64 ACRES
Transmission Line
Alternative Scenario #2
Residential 0.20 Acre Lots
20.5 AF/YR
RECLAMATION
Managing Water in the West
Alternative8_RainwaterTransmission.mxd, 10/1/2012

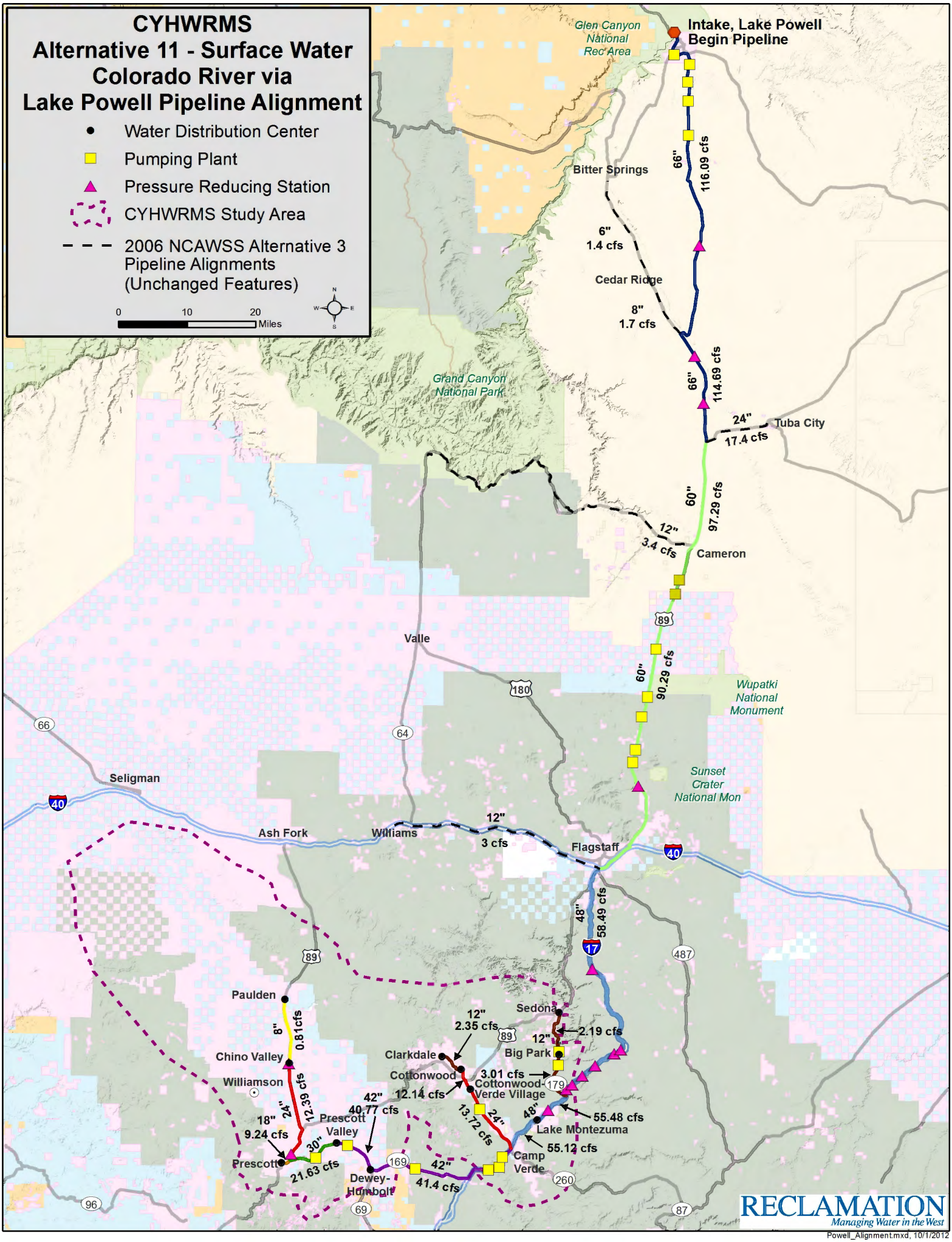

CYHWRMS
Alternative 10/11 - Surface Water
Colorado River via
Alamo Lake Pipeline Alignment
Water Distribution Center
Pumping Plant
Pressure Reducing Station
CYHWRMS Study Area
0
10
20
Miles
N
W
E
S
Flagstaff
Kaibab NF
Coconino
Coconino NF
Prescott NF
Yavapai
Tonto NF
La Paz
Maricopa
Gila
Wikieup
Bagdad
Paulden
Chino Valley
Williamson
Prescott
Prescott Valley
Dewey-Humbolt
Mayer
Cordes Junction
Clarkdale
Cottonwood
Cottonwood-Verde Village
Sedona
Big Park
Lake Montezuma
Camp Verde
PP-15
Congress
Wickenburg
Black Canyon City
New River
Alamo Lake
Intake, Alamo lake
Begin Pipeline
47.9 miles
54"
58.49 cfs
48"
58.49 cfs
48"
54"
8"
0.81cfs
24"
12.39 cfs
48"
49.25 cfs
42"
36.86 cfs
30"
17.72 cfs
30"
17.09 cfs
12"
2.35 cfs
12.14 cfs
24"
13.72 cfs
12"
3.01 cfs
2.19 cfs
3.37 cfs
RECLAMATION
Managing Water in the West
Alamo_Alignment.mxd,10/1/2012

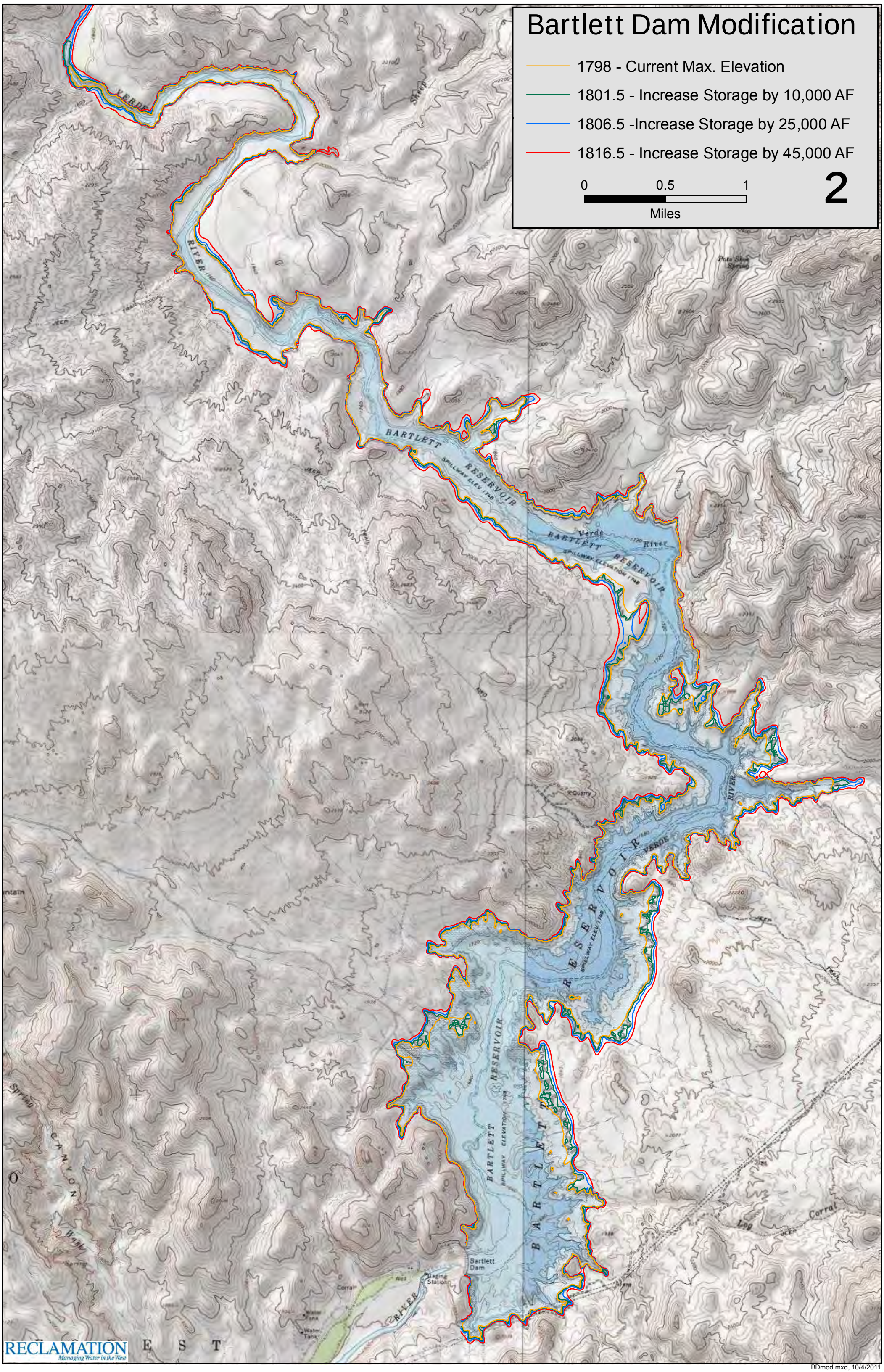

CYHWRMS
Alternative 11 - Surface Water
Colorado River via
Diamond Creek Pipeline Alignment
Water Distribution Center
Pumping Plant
Pressure Reducing Station
CYHWRMS Study Area
0
10
20
Miles
N
W
E
S
Intake, Diamond Creek
Begin Pipeline
Colorado River
Peach Springs
66
Seligman
40
48"
58.49 cfs
Ash Fork
Williams
Flagstaff
Mohave
Coconi
89
17
Paulden
48"
57.68 cfs
Yavapai
Chino Valley
Williamson
42"
46.10 cfs
93
Wikieup
Bagdad
97
96
18"
9.24 cfs
Prescott
42"
36.86 cfs
Prescott Valley
30"
17.72 cfs
Dewey-Humbolt
69
169
30"
17.09 cfs
12.14 cfs
13.72 cfs
24"
Clarkdale
12"
2.35 cfs
Cottonwood
Cottonwood-Verde Village
Sedona
2.19 cfs
Big Park
179
12"
3.01 cfs
Lake Montezuma
3.37 cfs
Camp Verde
260
RECLAMATION
Managing Water in the West
Diamond_Alignment.mxd, 10/1/2012


CYHWRMS
Alternative 11 - Surface Water
Colorado River via
Lake Havasu Pipeline Alignment
Water Distribution Center
Pumping Plant
Pressure Reducing Station
CYHWRMS Study Area
0
10
20
Miles
N
W
E
S
Seligman
Ash Fork
Williams
Flagstaff
Kaibab NF
Coconino
Coconino NF
Prescott NF
Yavapai
Mohave
Paulden
Chino Valley
Williamson
Prescott
Prescott Valley
Dewey-Humbolt
Mayer
Cordes Junction
Clarkdale
Cottonwood
Cottonwood-Verde Village
Sedona
Big Park
Lake Montezuma
Camp Verde
Wikieup
Bagdad
Lake Havasu City
San Bernardino
Parker
La Paz
Salome
Congress
Wickenburg
Wittmann
Maricopa
Black Canyon City
New River
Cave Creek
Tonto NF
Gila
Intake, Lake Havasu
Begin Pipeline
135.8 miles
8"
0.81 cfs
24"
12.39 cfs
48"
49.25 cfs
42"
36.86 cfs
30"
17.72 cfs
12"
2.35 cfs
12.14 cfs
24"
13.72 cfs
12"
3.01 cfs
2.19 cfs
3.37 cfs
30"
17.09 cfs
48"
58.49 cfs
48"
54"
54"
58.49 cfs
RECLAMATION
Managing Water in the West
Havasu_Alignment.mxd, 10/1/2012

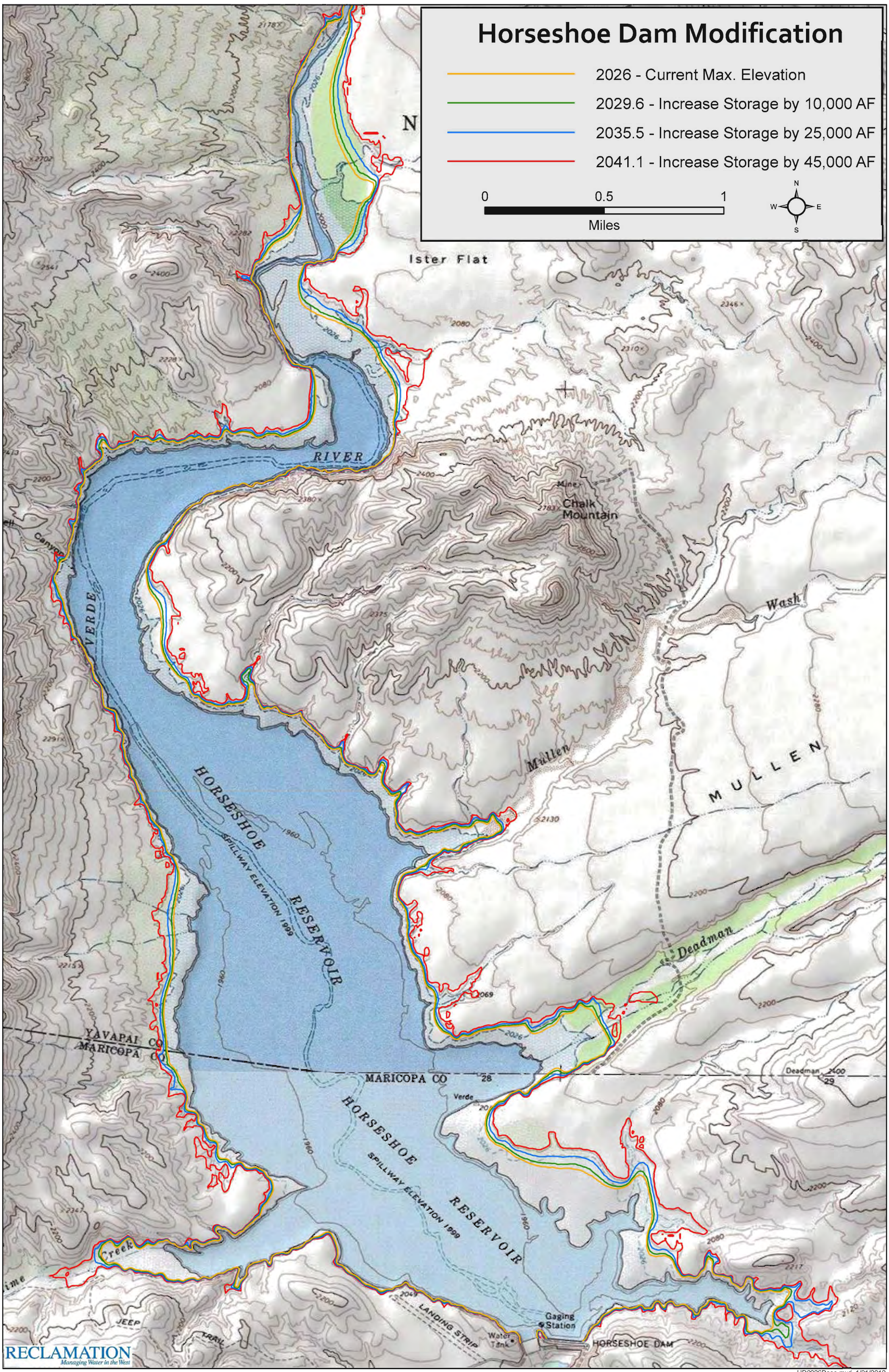

CYHWRMS
Alternative 11 - Surface Water
Colorado River via
Lake Mead Pipeline Alignment
Water Distribution Center
Pumping Plant
Pressure Reducing Station
CYHWRMS Study Area
0
10
20
Miles
Intake, Lake Mead
Begin Pipeline
Clark
Grand Canyon National Park
Lake Mead Natl Recreation Area
Lake Mead Natl Rec Area
Mohave
Kingman
48"
58.49 cfs
Peach Springs
Seligman
48"
Ash Fork
58.49 cfs
Williams
Kaibab NF
Flagstaff
Coconino NF
Coconino
Paulden
48"
57.68 cfs
Chino Valley
Williamson
Prescott NF
Yavapai
42"
46.10 cfs
18"
9.24 cfs
Prescott
42"
36.86 cfs
Prescott Valley
30"
17.72 cfs
Dewey-Humbolt
Mayer
Bagdad
Wikieup
Lake Havasu City
San Bernardino
La Paz
Clarkdale
12"
2.35 cfs
Cottonwood
Cottonwood-Verde Village
12.14 cfs
24"
13.72 cfs
30"
17.09 cfs
Camp Verde
Sedona
2.19 cfs
Big Park
3.01 cfs
12"
Lake Montezuma
3.37 cfs
Cordes Junct
RECLAMATION
Managing Water in the West
Mead_Alignment.mxd, 10/1/2012


CYHWRMS
Alternative 11 - Surface Water
Colorado River via
Lake Mohave Pipeline Alignment
Water Distribution Center
Pumping Plant
Pressure Reducing Station
CYHWRMS Study Area
0
10
20
Miles
N
S
W
E
Grand Canyon National Park
Peach Springs
Lake Mead Natl Recreation Area
Seligman
Begin Pipeline
Intake, Lake Mohave
Kingman
Mohave
48"
58.49 cfs
48"
58.49 cfs
Ash Fork
Williams
Kaibab NF
Flagstaff
Coconino NF
Paulden
48"
57.68 cfs
Chino Valley
Williamson
42"
46.10 cfs
Yavapai
Prescott NF
Wikieup
Bagdad
18"
9.24 cfs
Prescott
42"
36.86 cfs
Prescott Valley
30"
17.72 cfs
Dewey-Humbolt
Mayer
Cordes Junction
30"
17.09 cfs
Clarkdale
12"
2.35 cfs
Cottonwood
Cottonwood-Verde Village
12.14 cfs
24"
13.72 cfs
Sedona
2.19 cfs
Big Park
3.01 cfs
12"
Lake Montezuma
3.37 cfs
Camp Verde
Tonto NF
Gila
Lake Havasu City
San Bernardino
Parker
La Paz
Congress
Riverside
RECLAMATION
Managing Water in the West
Mohave_Alignment.mxd, 10/1/2012

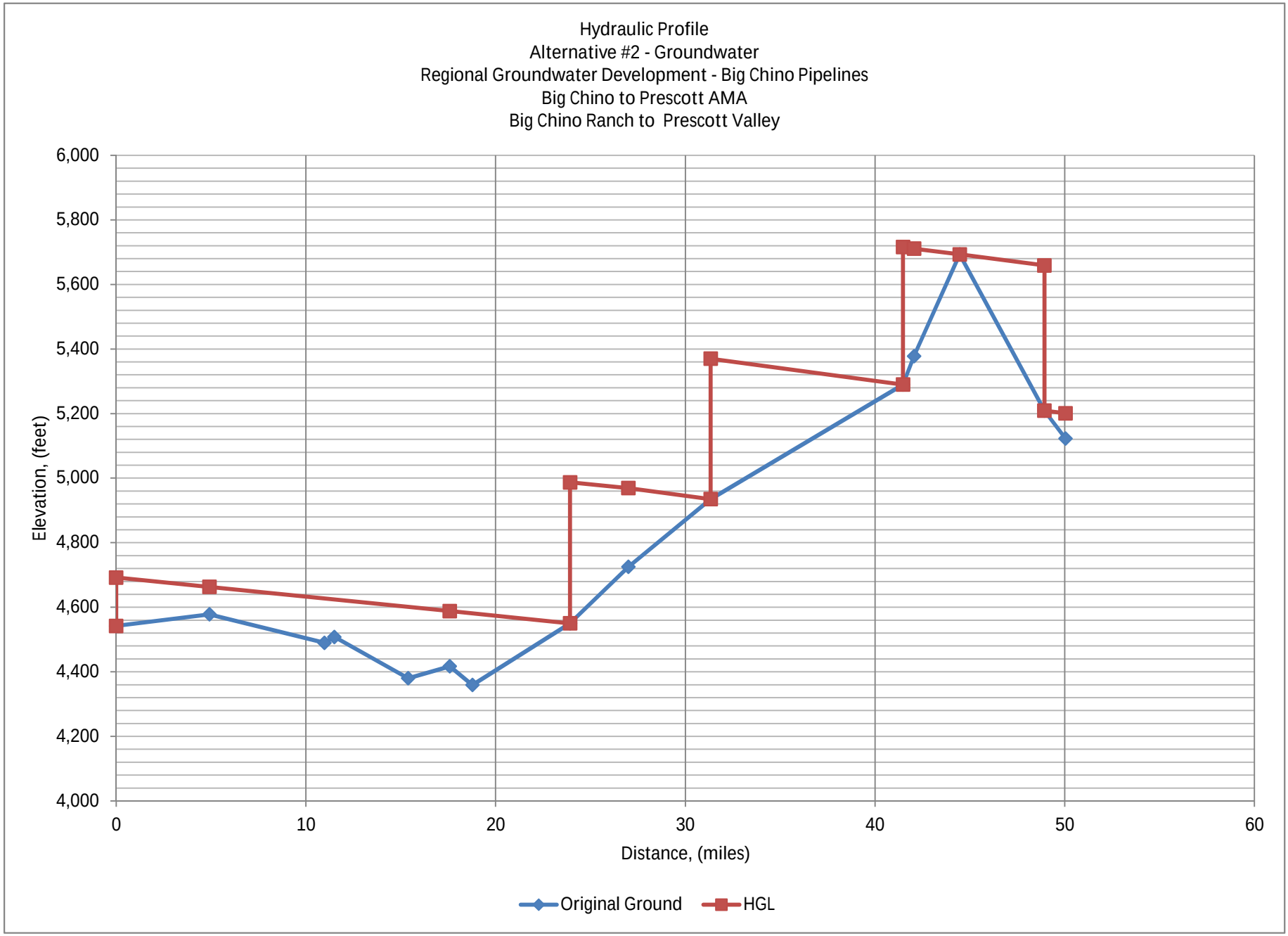

CYHWRMS
Alternative 11 - Surface Water
Colorado River via
Lake Powell Pipeline Alignment
Water Distribution Center
Pumping Plant
Pressure Reducing Station
CYHWRMS Study Area
2006 NCAWSS Alternative 3
Pipeline Alignments
(Unchanged Features)
0
10
20
Miles
N
W
E
S
Glen Canyon
National
Rec Area
Intake, Lake Powell
Begin Pipeline
66"
116.09 cfs
Bitter Springs
6"
1.4 cfs
Cedar Ridge
8"
1.7 cfs
66"
114.69 cfs
Grand Canyon
National Park
24"
17.4 cfs
Tuba City
60"
97.29 cfs
12"
3.4 cfs
Cameron
89
Valle
60"
90.29 cfs
180
Wupatki
National
Monument
66
64
Sunset
Crater
National Mon
Seligman
40
Ash Fork
Williams
12"
3 cfs
Flagstaff
40
48"
58.49 cfs
17
487
89
Paulden
8"
0.81cfs
Sedona
12"
2.35 cfs
89
12"
2.19 cfs
Chino Valley
Clarkdale
Big Park
Williamson
Cottonwood
3.01 cfs
Cottonwood-
Verde Village
179
12.14 cfs
24"
12.39 cfs
42"
40.77 cfs
13.72 cfs
24"
48"
55.48 cfs
18"
9.24 cfs
Prescott
Valley
Lake Montezuma
30"
55.12 cfs
Prescott
21.63 cfs
169
Camp
Verde
42"
Dewey-
Humbolt
41.4 cfs
260
96
69
87
RECLAMATION
Managing Water in the West
Powell_Alignment.mxd, 10/1/2012

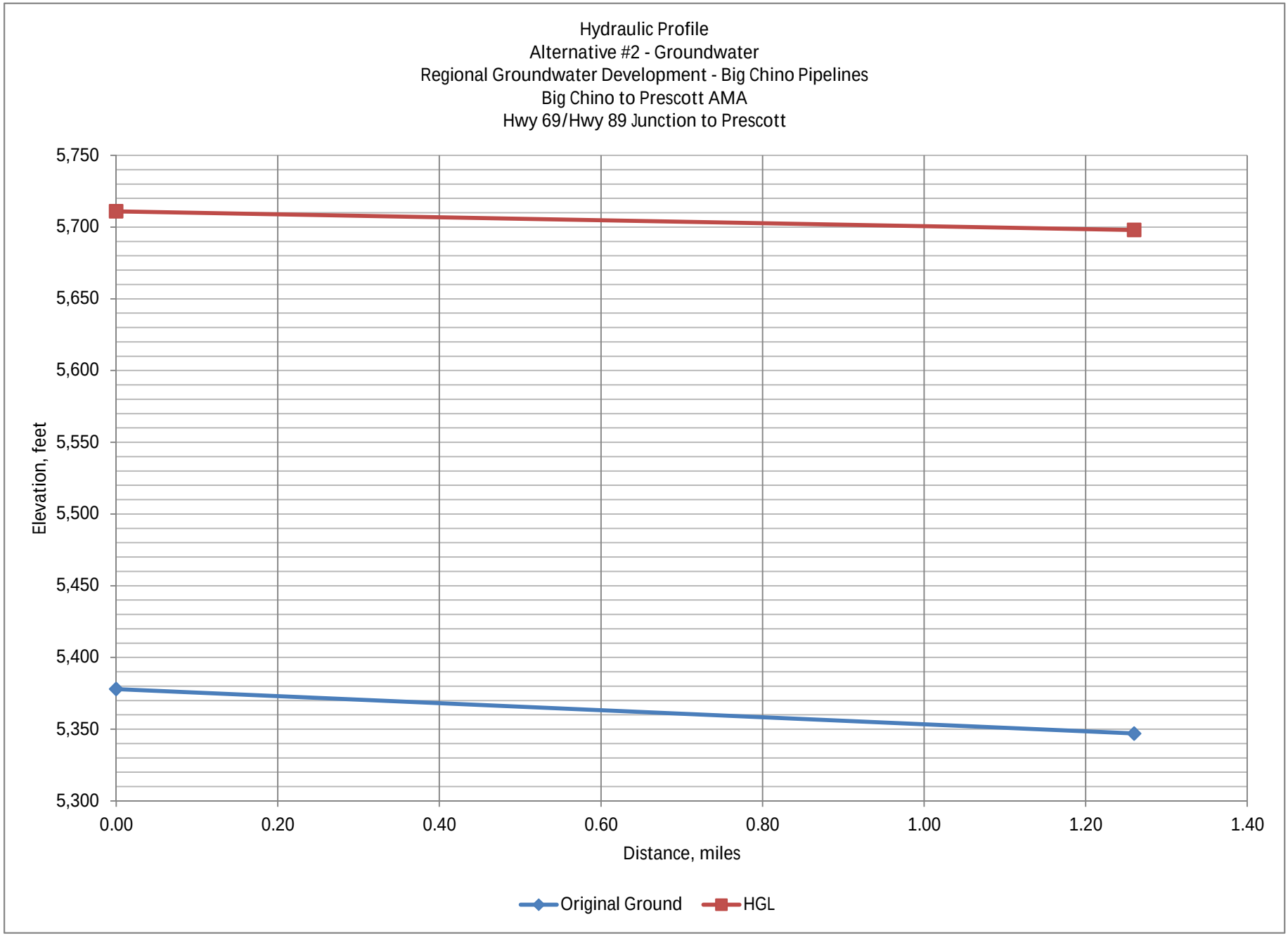


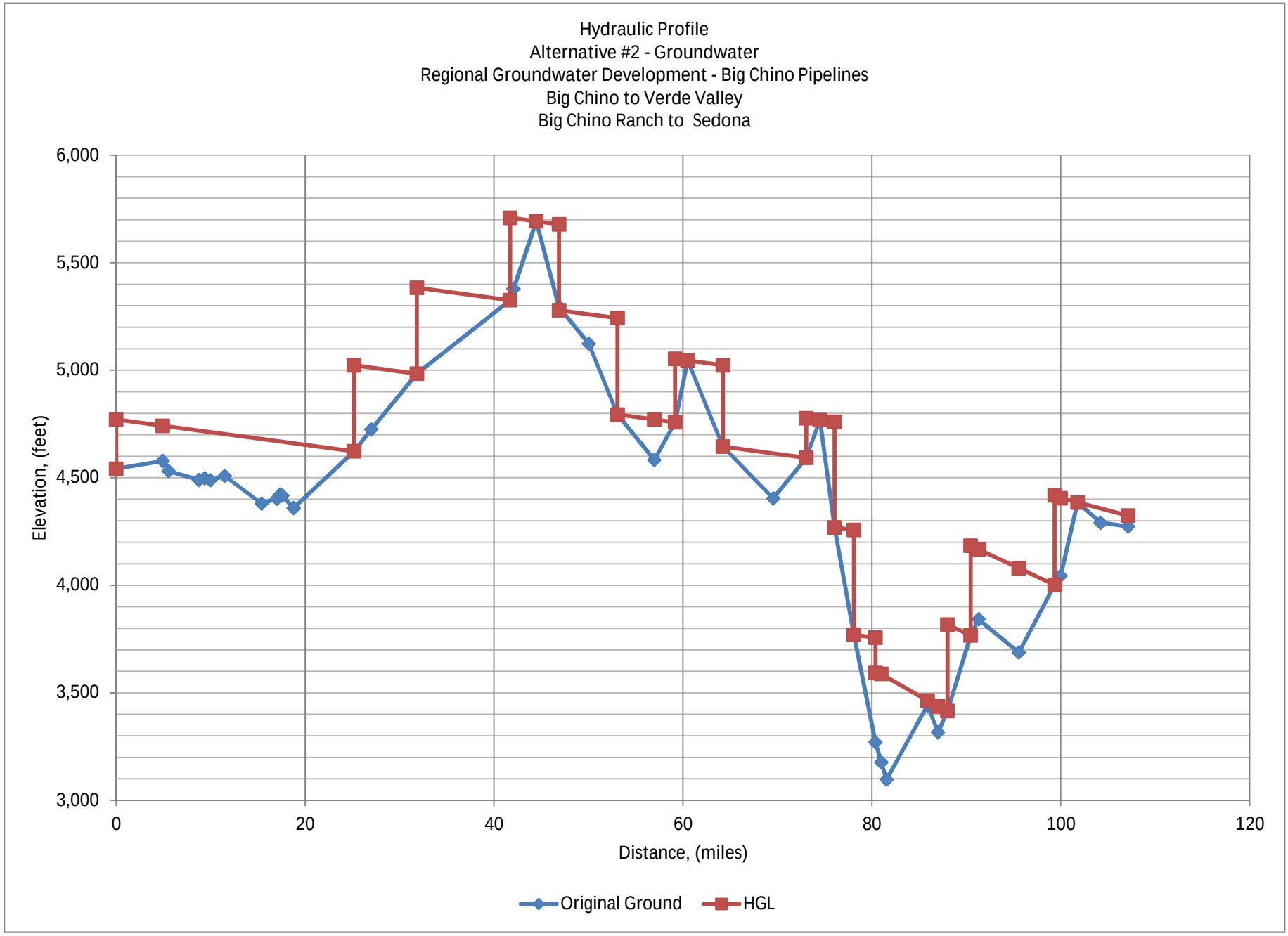
BDmod.mxd, 10/4/2011

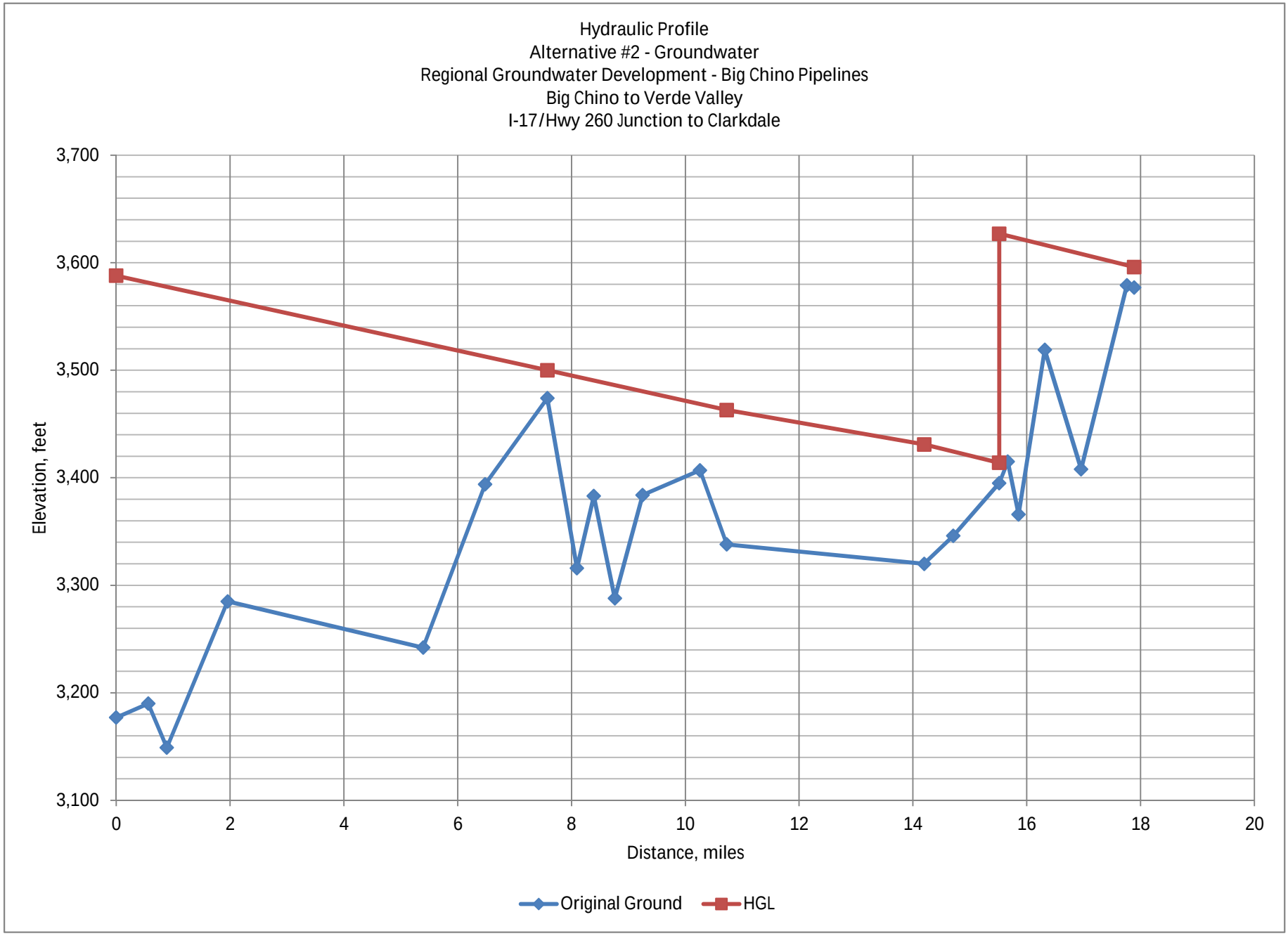


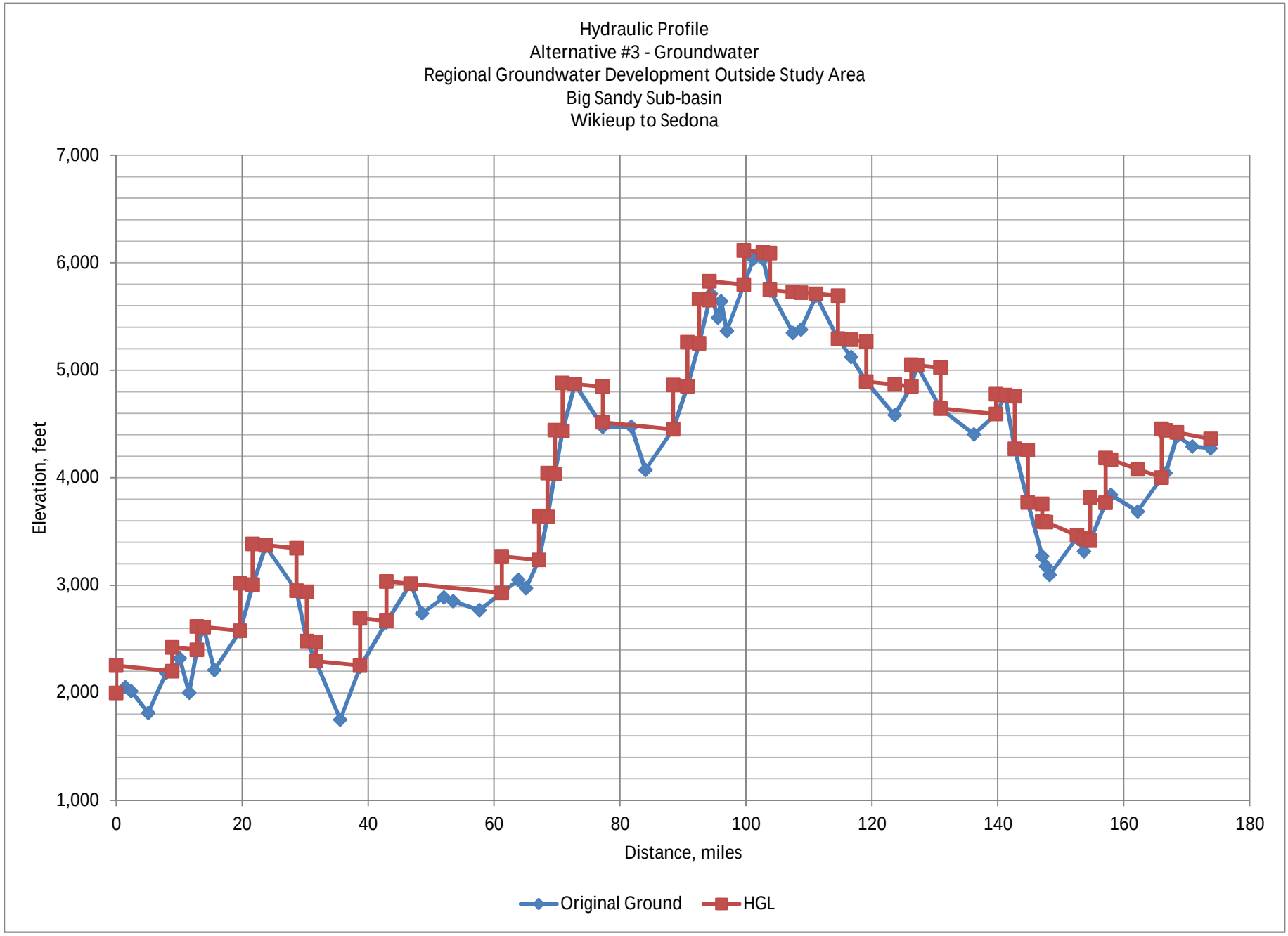
HD2026Base.mxd, 1/31/2012

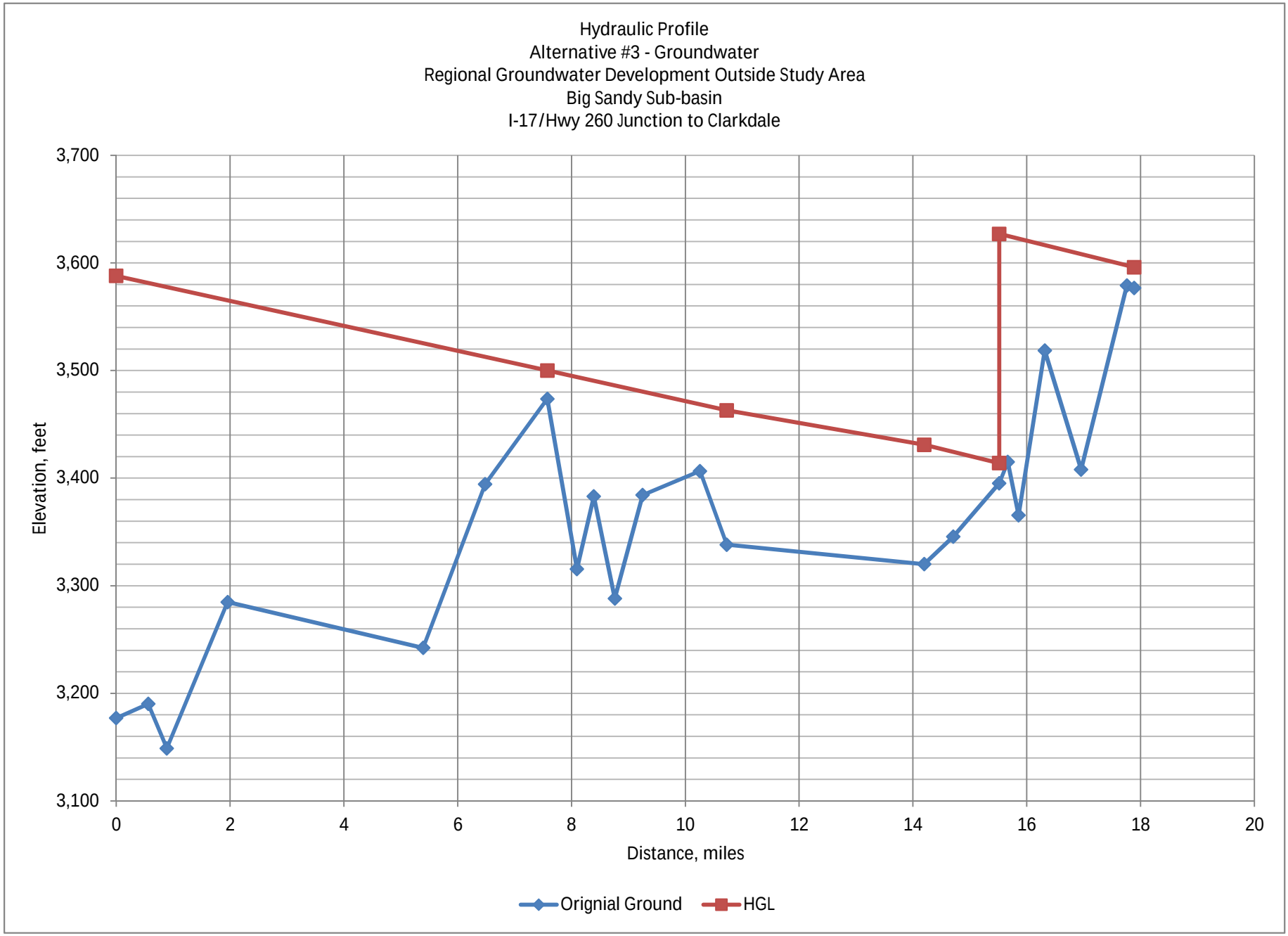

Hydraulic Profile
Alternative #2 - Groundwater
Regional Groundwater Development - Big Chino Pipelines
Big Chino to Prescott AMA
Big Chino Ranch to Prescott Valley
6,000
5,800
5,600
5,400
5,200
5,000
4,800
4,600
4,400
4,200
4,000
Elevation, (feet)
0
10
20
30
40
50
60
Distance, (miles)
Original Ground
HGL

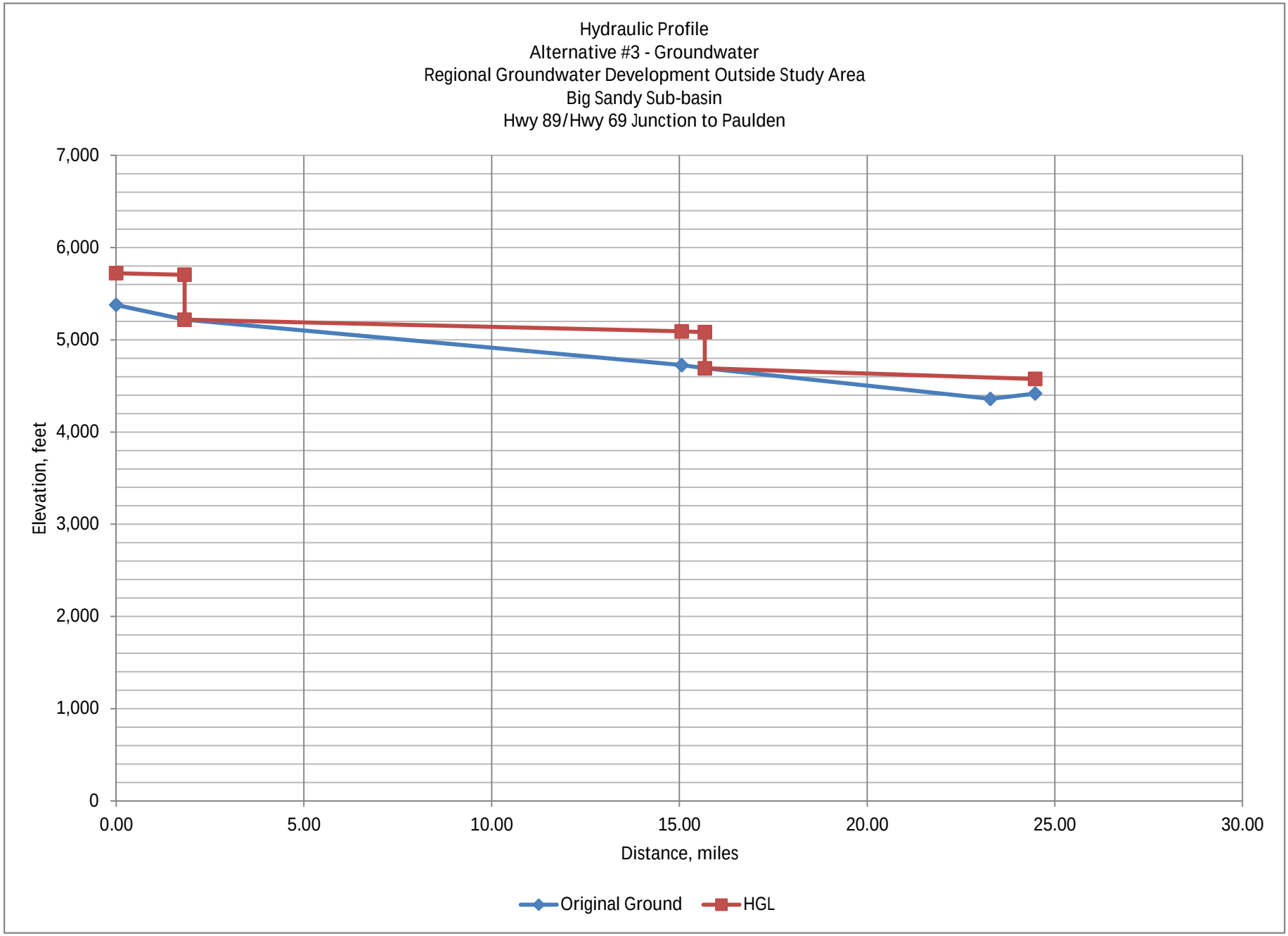

Hydraulic Profile
Alternative #2 - Groundwater
Regional Groundwater Development - Big Chino Pipelines
Big Chino to Prescott AMA
Hwy 69/Hwy 89 Junction to Prescott
Elevation, feet
5,750
5,700
5,650
5,600
5,550
5,500
5,450
5,400
5,350
5,300
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Distance, miles
Original Ground
HGL

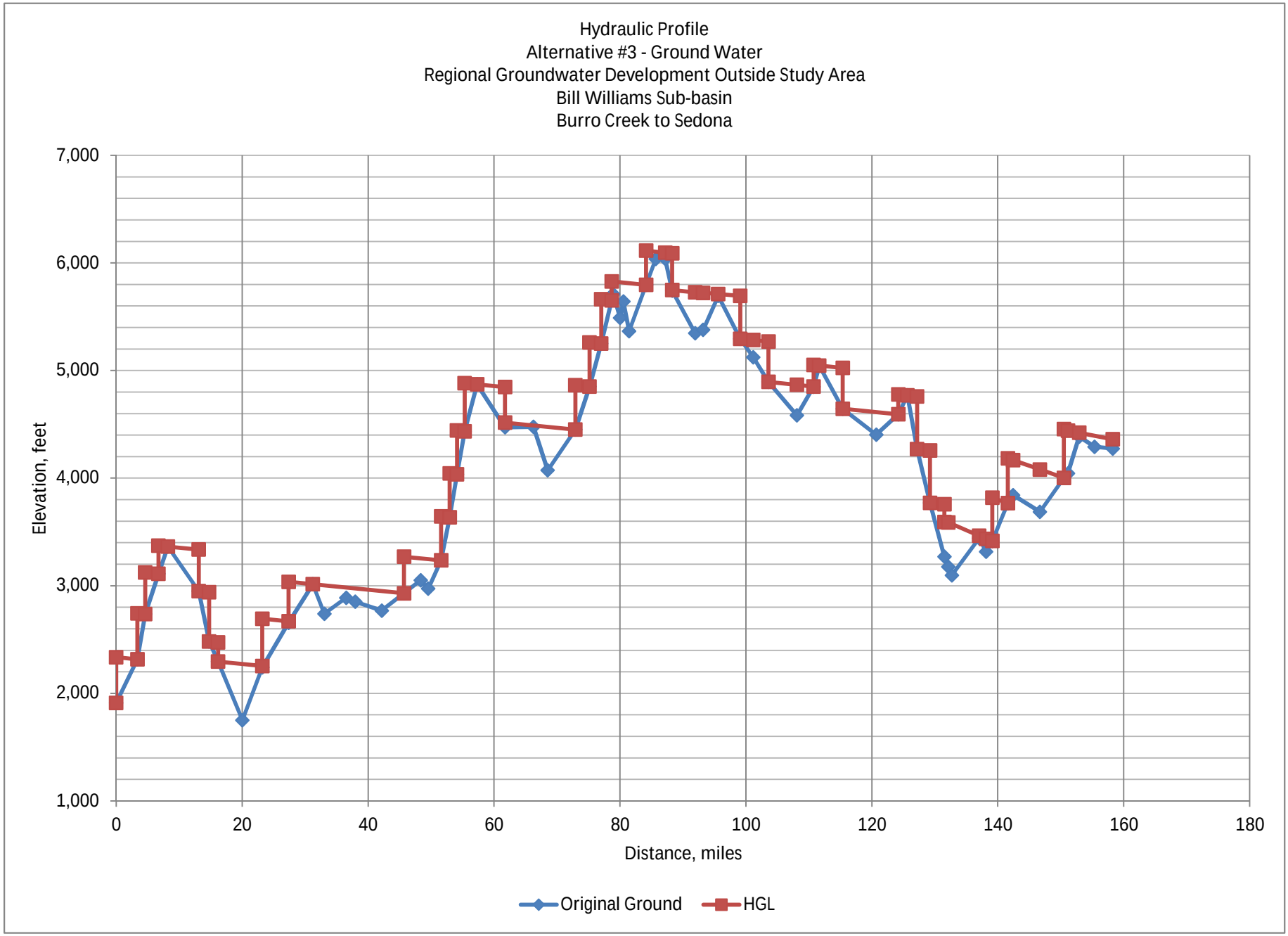

Hydraulic Profile
Alternative #2 - Groundwater
Regional Groundwater Development - Big Chino Pipelines
Big Chino to Verde Valley
Big Chino Ranch to Sedona
6,000
5,500
5,000
4,500
4,000
3,500
3,000
Elevation, (feet)
0
20
40
60
80
100
120
Distance, (miles)
Original Ground
HGL

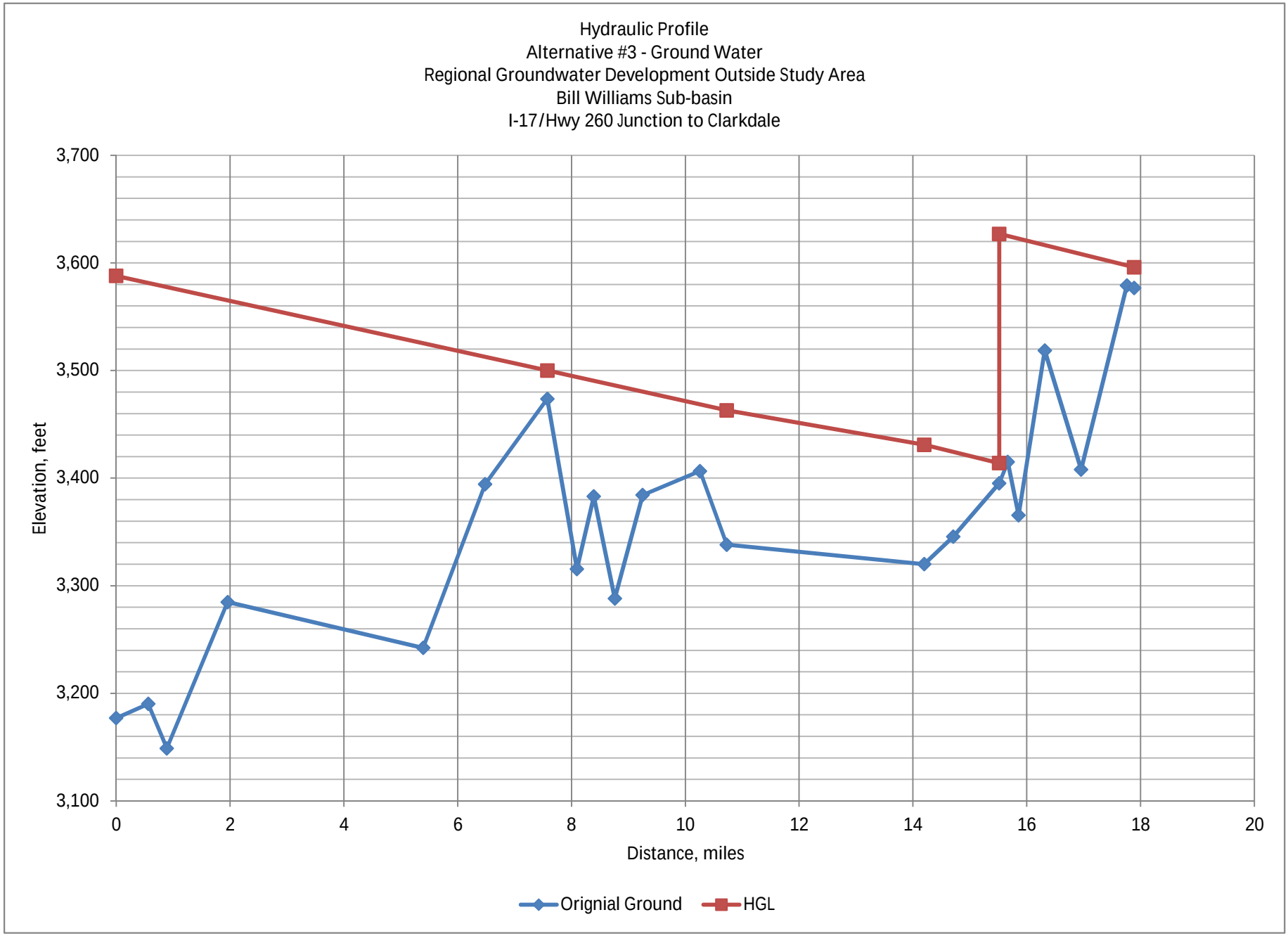

Hydraulic Profile
Alternative #2 - Groundwater
Regional Groundwater Development - Big Chino Pipelines
Big Chino to Verde Valley
I-17/Hwy 260 Junction to Clarkdale
3,700
3,600
3,500
3,400
3,300
3,200
3,100
Elevation, feet
0
2
4
6
8
10
12
14
16
18
20
Distance, miles
Original Ground
HGL

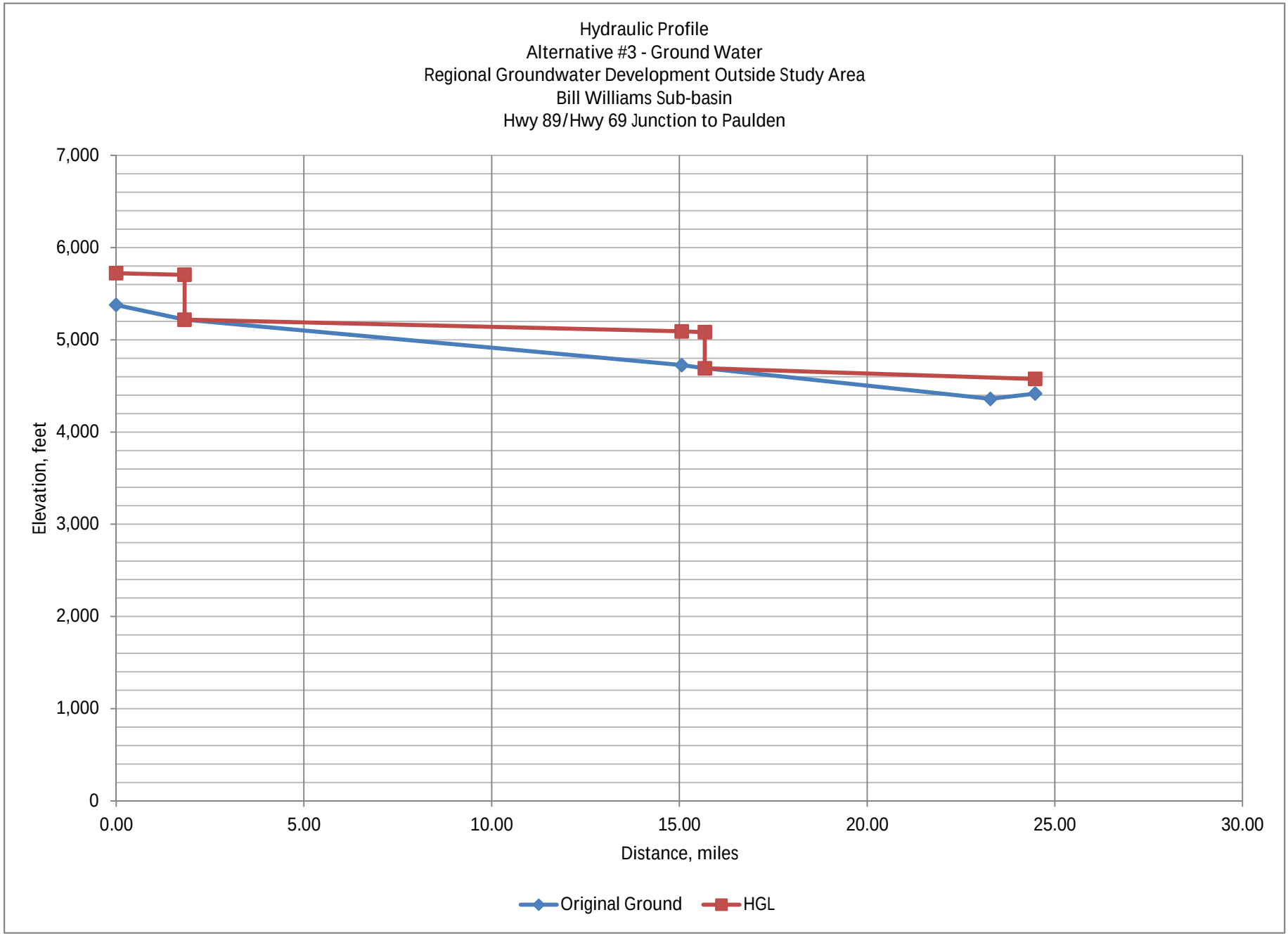

Hydraulic Profile
Alternative #3 - Groundwater
Regional Groundwater Development Outside Study Area
Big Sandy Sub-basin
Wikieup to Sedona
7,000
6,000
5,000
4,000
3,000
2,000
1,000
Elevation, feet
0
20
40
60
80
100
120
140
160
180
Distance, miles
Original Ground
HGL

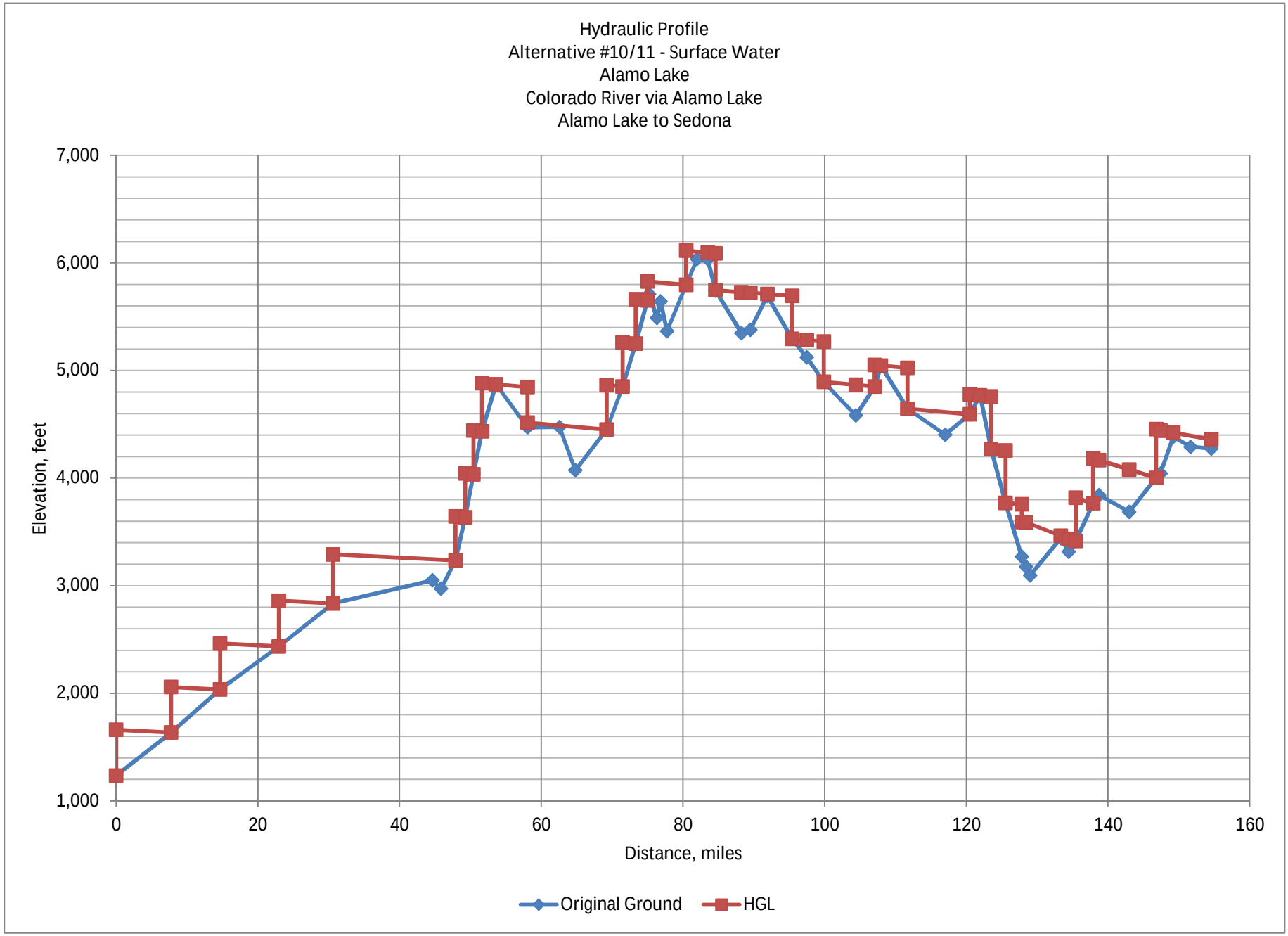

Hydraulic Profile
Alternative #3 - Groundwater
Regional Groundwater Development Outside Study Area
Big Sandy Sub-basin
I-17/Hwy 260 Junction to Clarkdale
3,700
3,600
3,500
3,400
3,300
3,200
3,100
Elevation, feet
0
2
4
6
8
10
12
14
16
18
20
Distance, miles
Orignial Ground
HGL

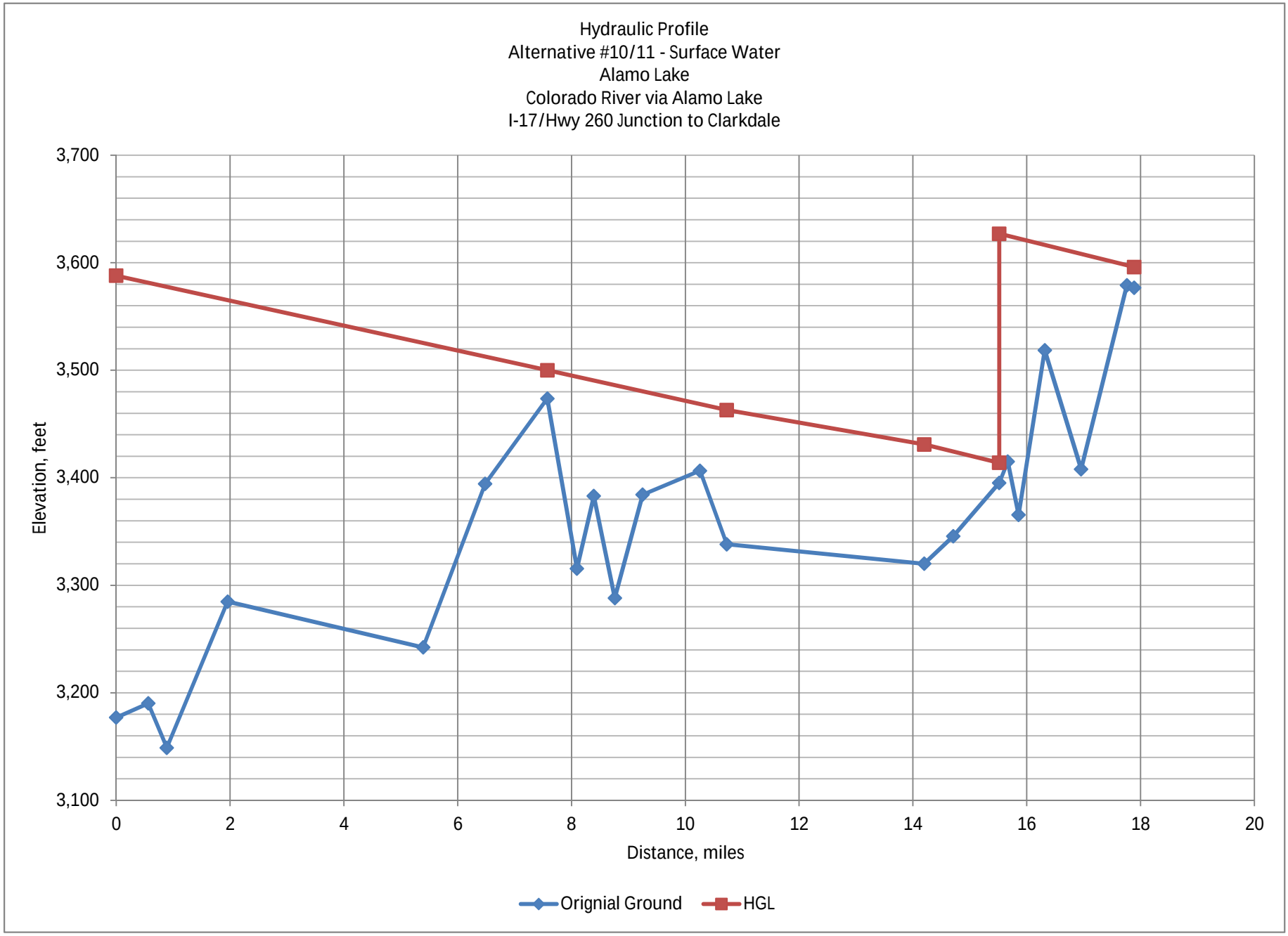

Hydraulic Profile
Alternative #3 - Groundwater
Regional Groundwater Development Outside Study Area
Big Sandy Sub-basin
Hwy 89/Hwy 69 Junction to Paulden
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Elevation, feet
0.00
5.00
10.00
15.00
20.00
25.00
30.00
Distance, miles
Original Ground
HGL

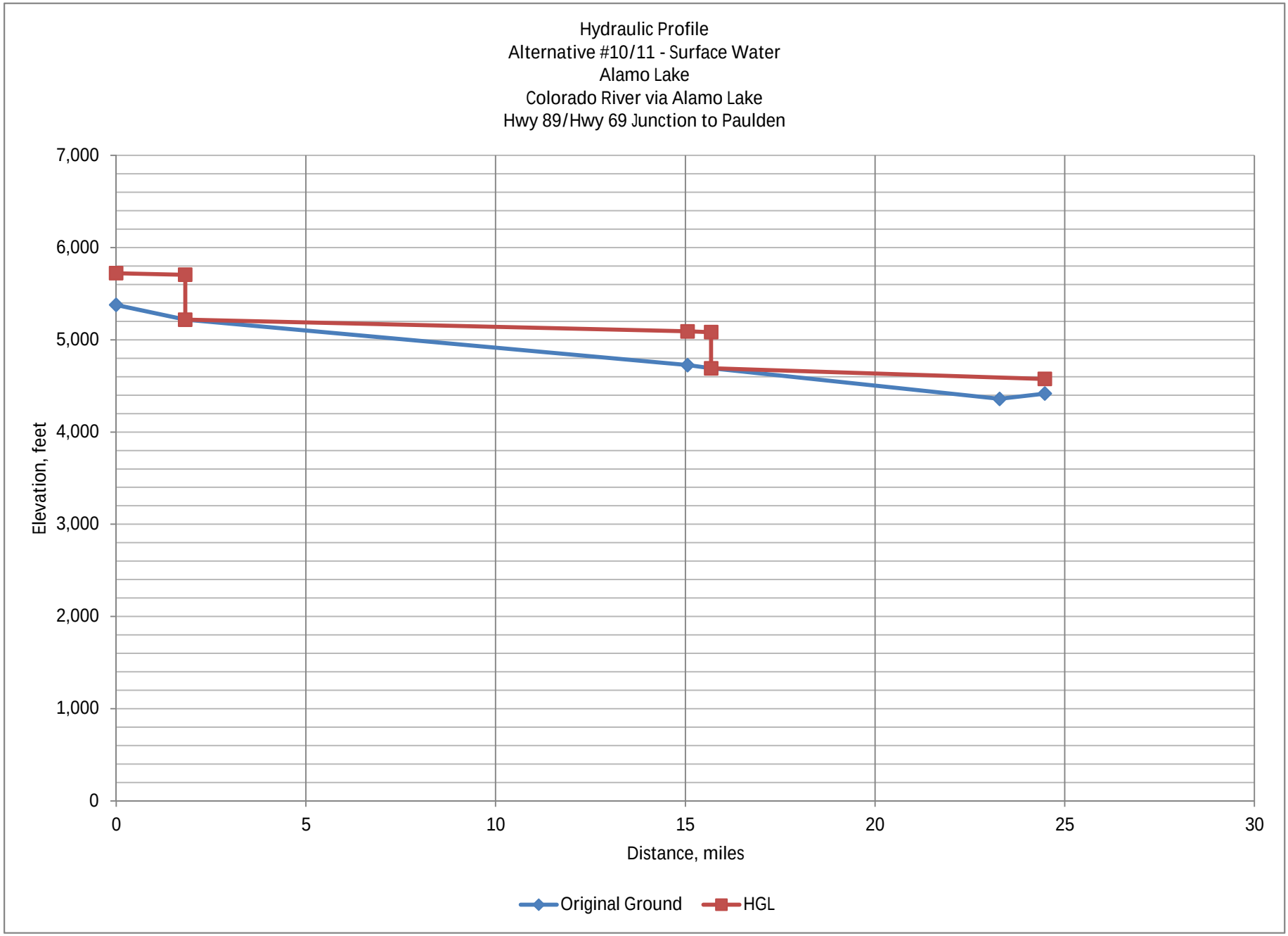

Hydraulic Profile
Alternative #3 - Ground Water
Regional Groundwater Development Outside Study Area
Bill Williams Sub-basin
Burro Creek to Sedona
7,000
6,000
5,000
4,000
3,000
2,000
1,000
Elevation, feet
0
20
40
60
80
100
120
140
160
180
Distance, miles
Original Ground
HGL

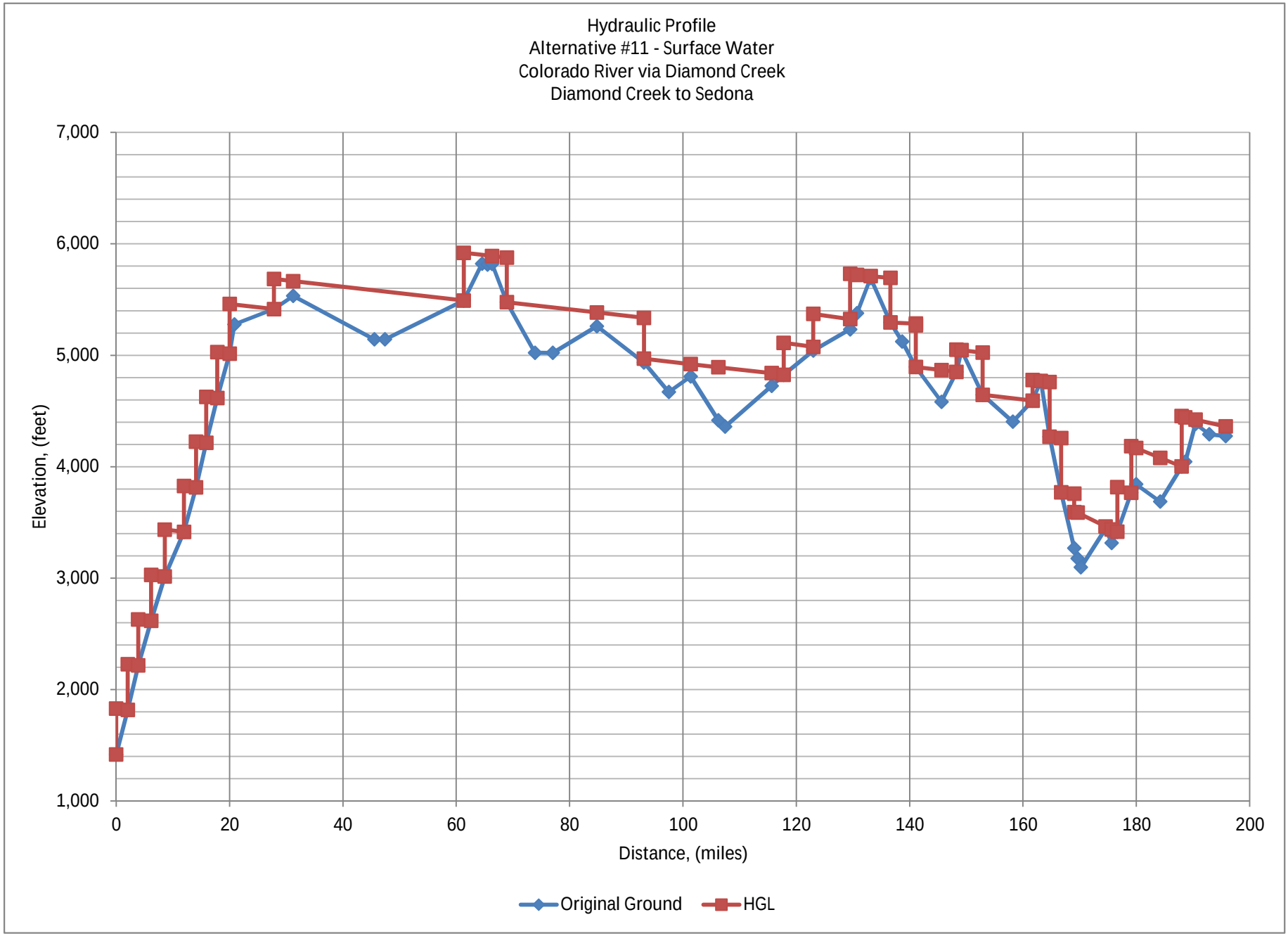

Hydraulic Profile
Alternative #3 - Ground Water
Regional Groundwater Development Outside Study Area
Bill Williams Sub-basin
I-17/Hwy 260 Junction to Clarkdale
Elevation, feet
3,700
3,600
3,500
3,400
3,300
3,200
3,100
0
2
4
6
8
10
12
14
16
18
20
Distance, miles
Orignial Ground
HGL

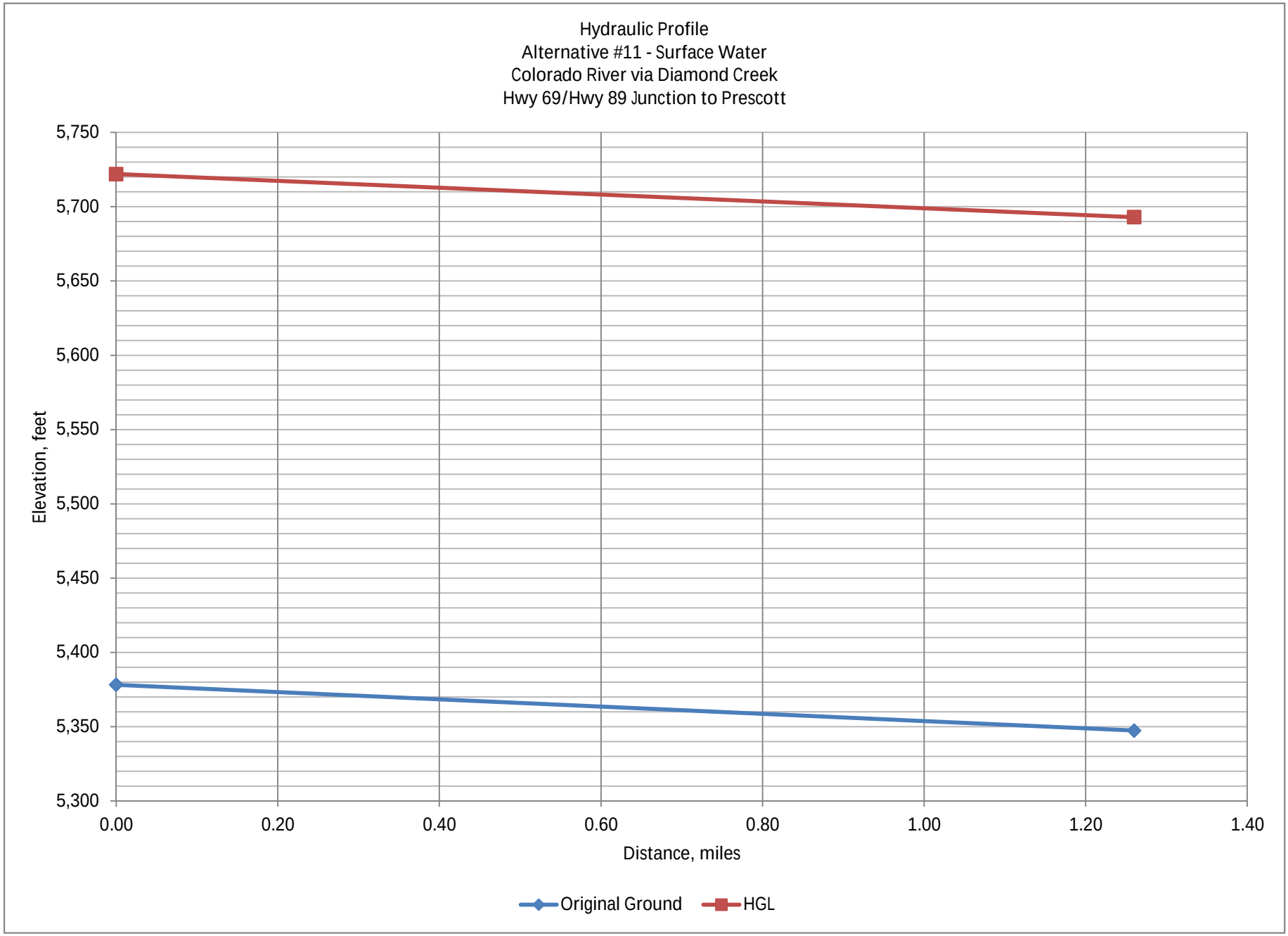

Hydraulic Profile
Alternative #3 - Ground Water
Regional Groundwater Development Outside Study Area
Bill Williams Sub-basin
Hwy 89/Hwy 69 Junction to Paulden
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Elevation, feet
0.00
5.00
10.00
15.00
20.00
25.00
30.00
Distance, miles
Original Ground
HGL

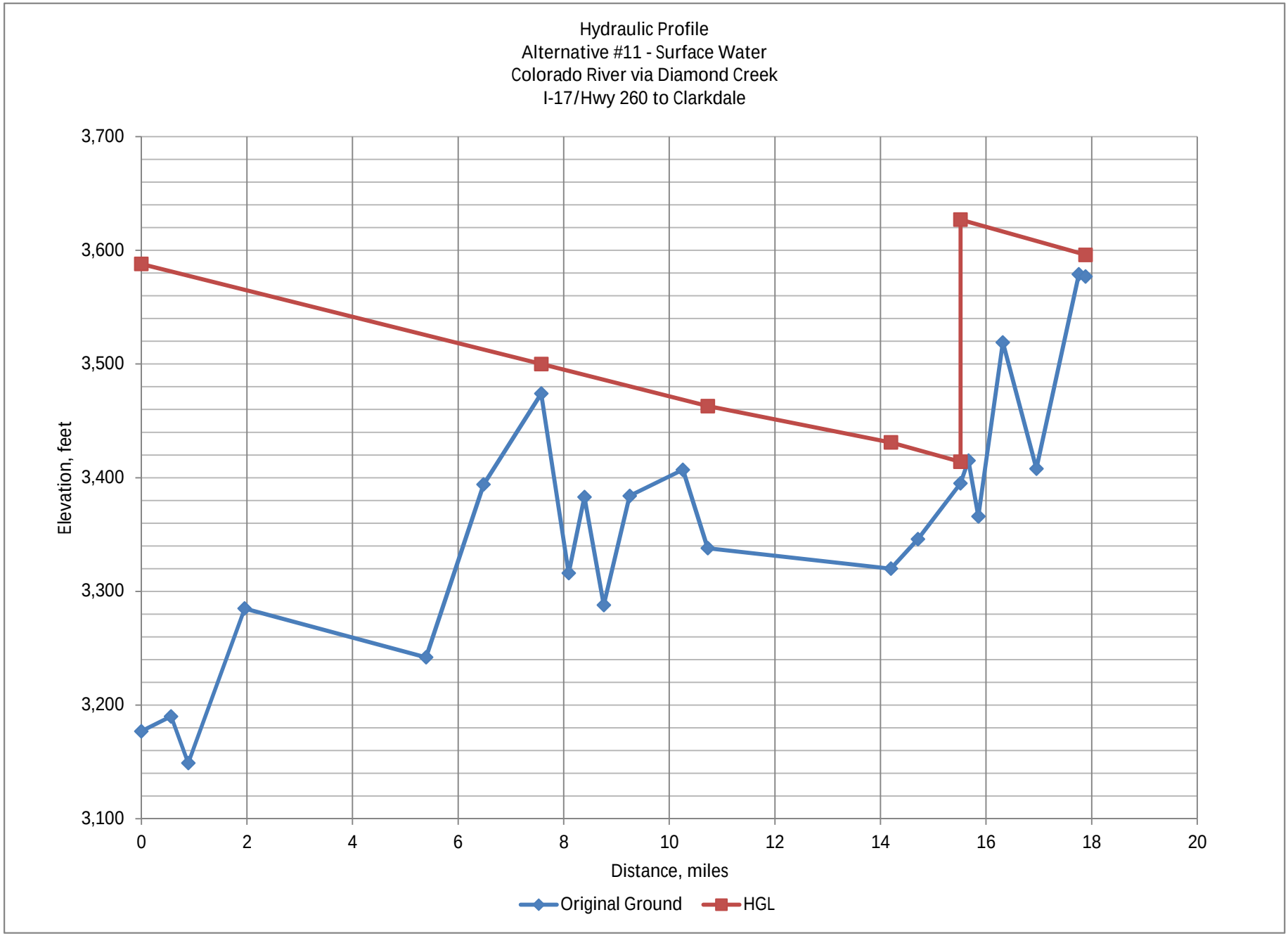

Hydraulic Profile
Alternative #10/11 - Surface Water
Alamo Lake
Colorado River via Alamo Lake
Alamo Lake to Sedona
7,000
6,000
5,000
4,000
3,000
2,000
1,000
Elevation, feet
0
20
40
60
80
100
120
140
160
Distance, miles
Original Ground
HGL

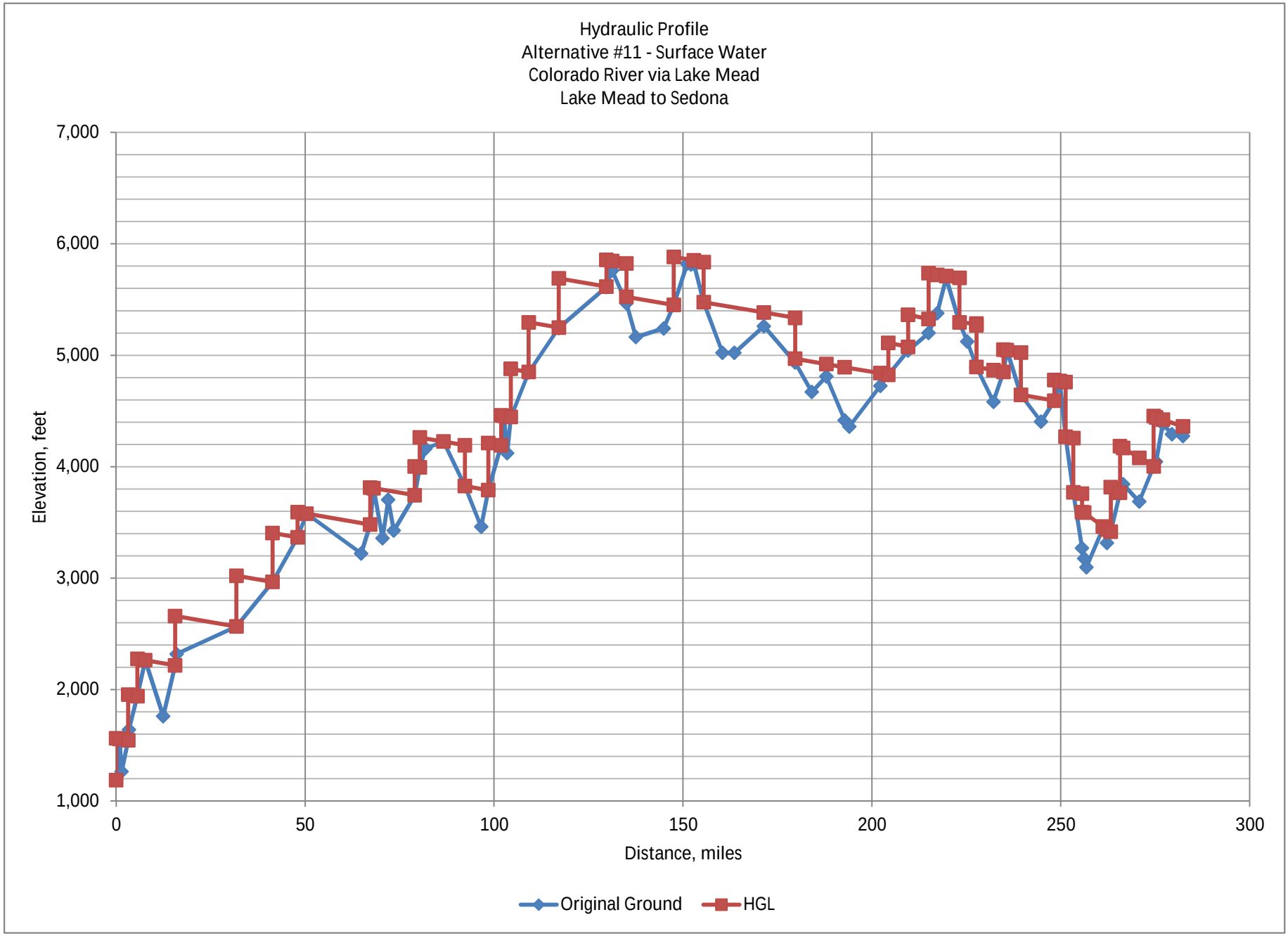

Hydraulic Profile
Alternative #10/11 - Surface Water
Alamo Lake
Colorado River via Alamo Lake
I-17/Hwy 260 Junction to Clarkdale
3,700
3,600
3,500
3,400
3,300
3,200
3,100
Elevation, feet
0
2
4
6
8
10
12
14
16
18
20
Distance, miles
Orignial Ground
HGL

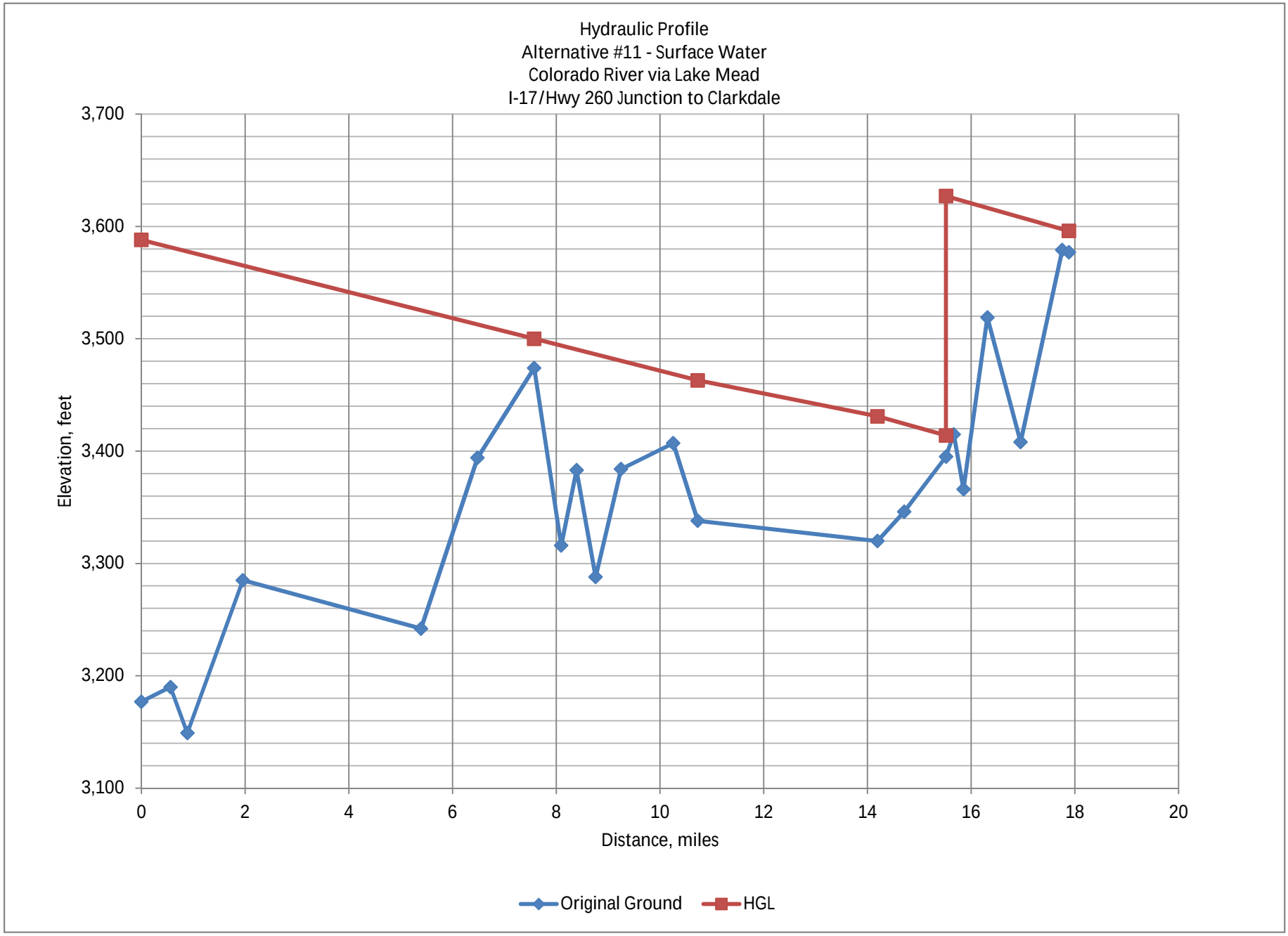

Hydraulic Profile
Alternative #10/11 - Surface Water
Alamo Lake
Colorado River via Alamo Lake
Hwy 89/Hwy 69 Junction to Paulden
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Elevation, feet
0
5
10
15
20
25
30
Distance, miles
Original Ground
HGL

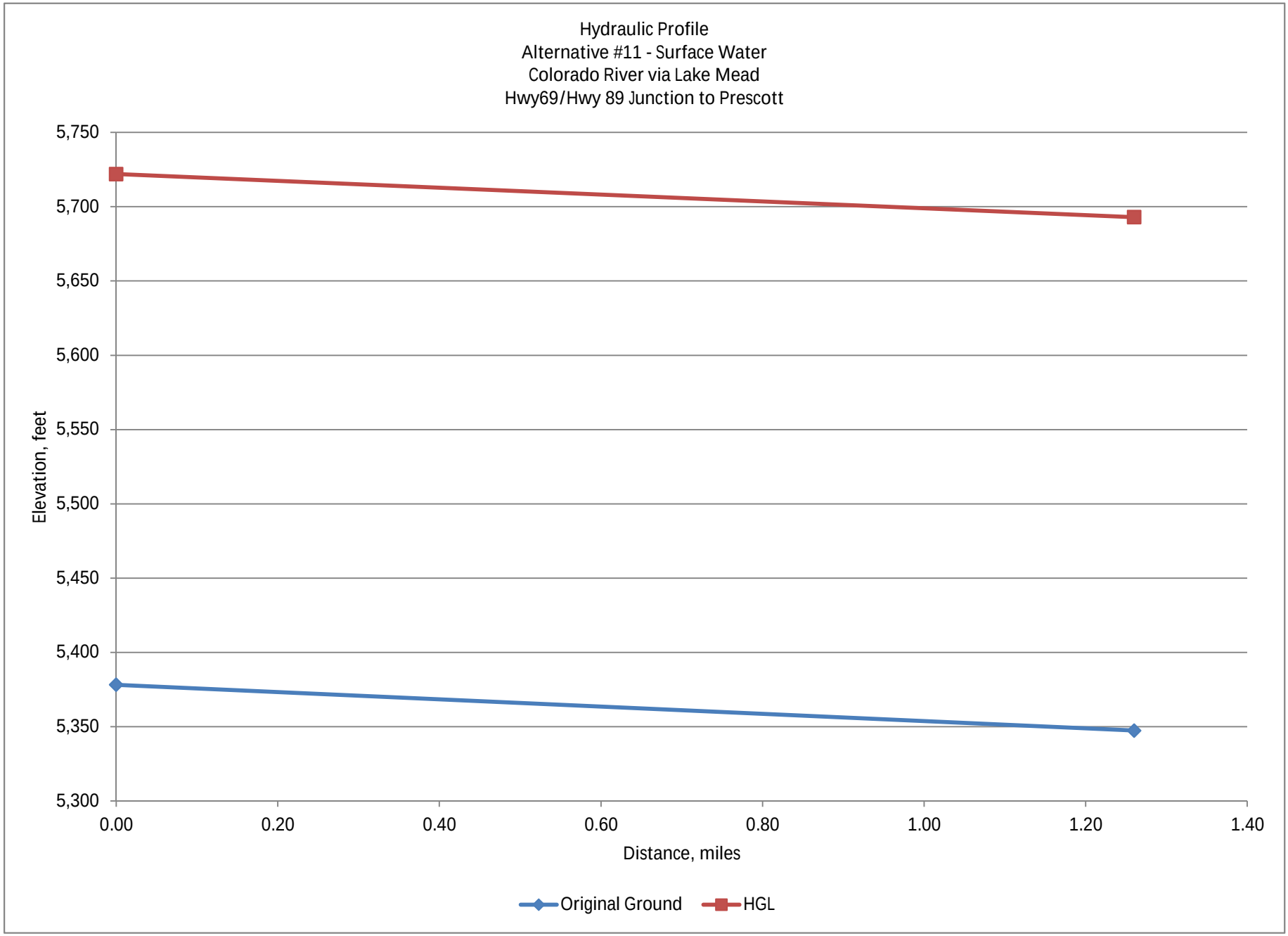

Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Diamond Creek
Diamond Creek to Sedona
7,000
6,000
5,000
4,000
3,000
2,000
1,000
Elevation, (feet)
0
20
40
60
80
100
120
140
160
180
200
Distance, (miles)
Original Ground
HGL

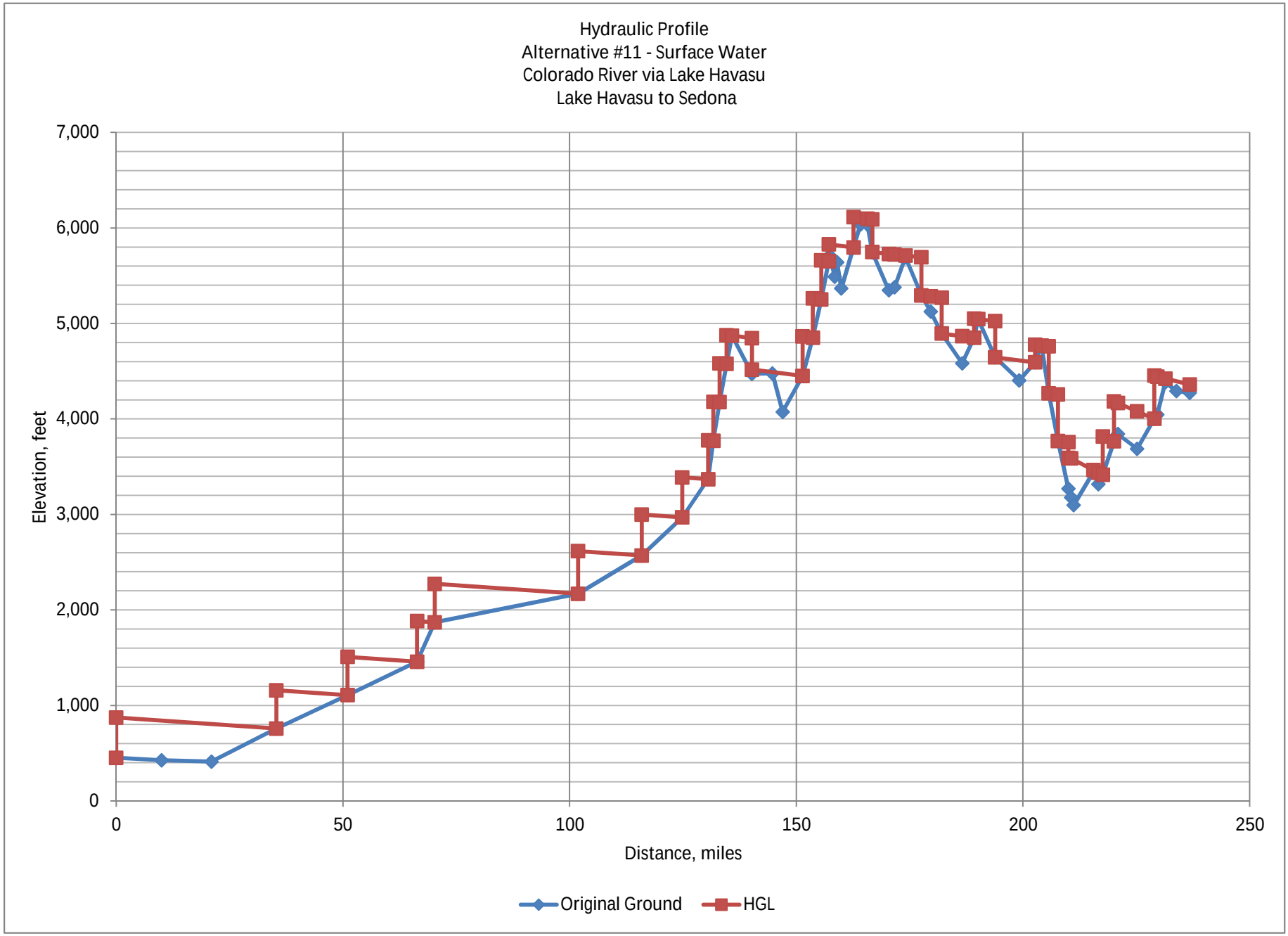

Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Diamond Creek
Hwy 69/Hwy 89 Junction to Prescott
5,750
5,700
5,650
5,600
5,550
5,500
5,450
5,400
5,350
5,300
Elevation, feet
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Distance, miles
Original Ground
HGL

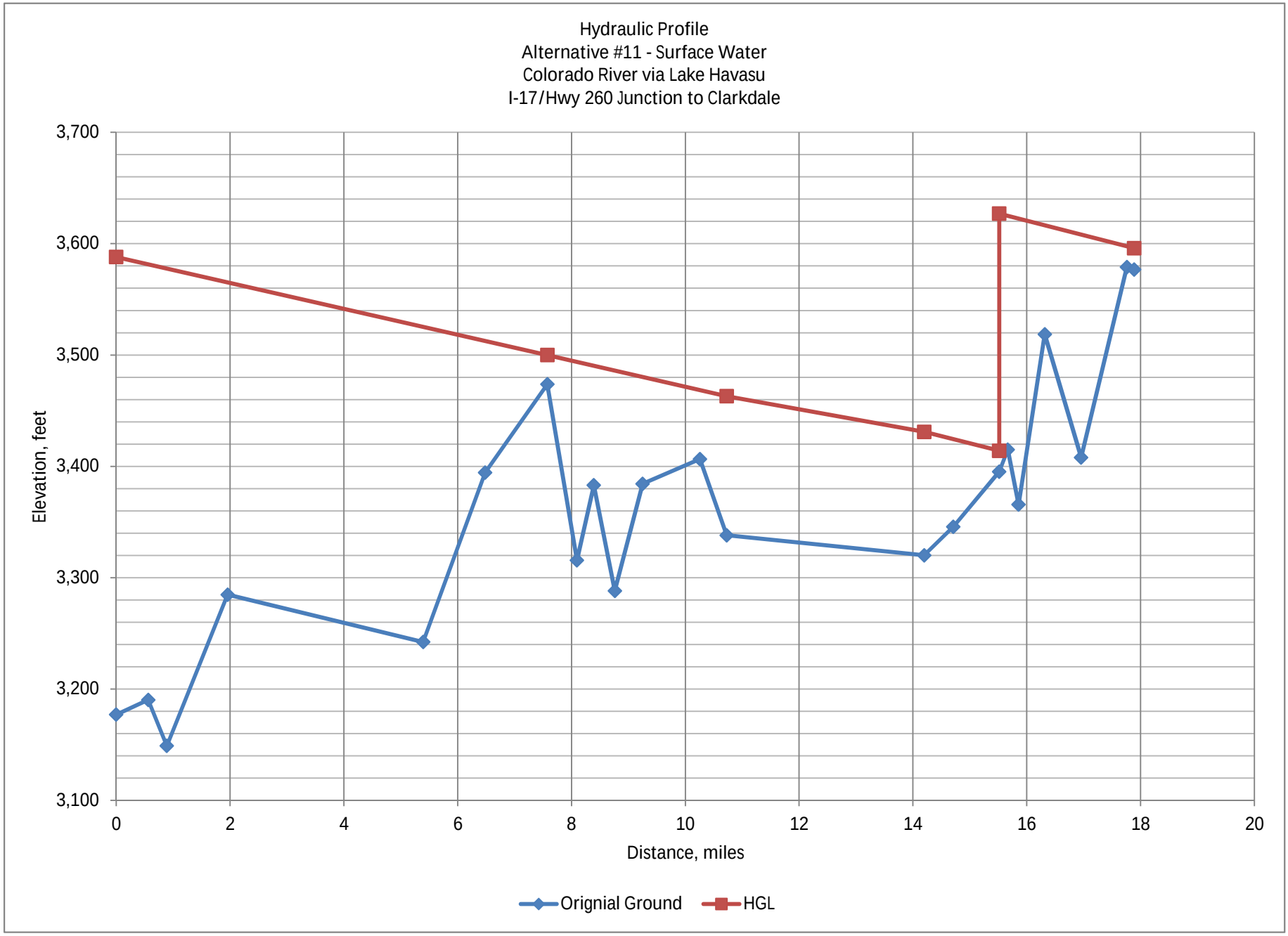

Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Diamond Creek
I-17/Hwy 260 to Clarkdale
Elevation, feet
3,700
3,600
3,500
3,400
3,300
3,200
3,100
0
2
4
6
8
10
12
14
16
18
20
Distance, miles
Original Ground
HGL

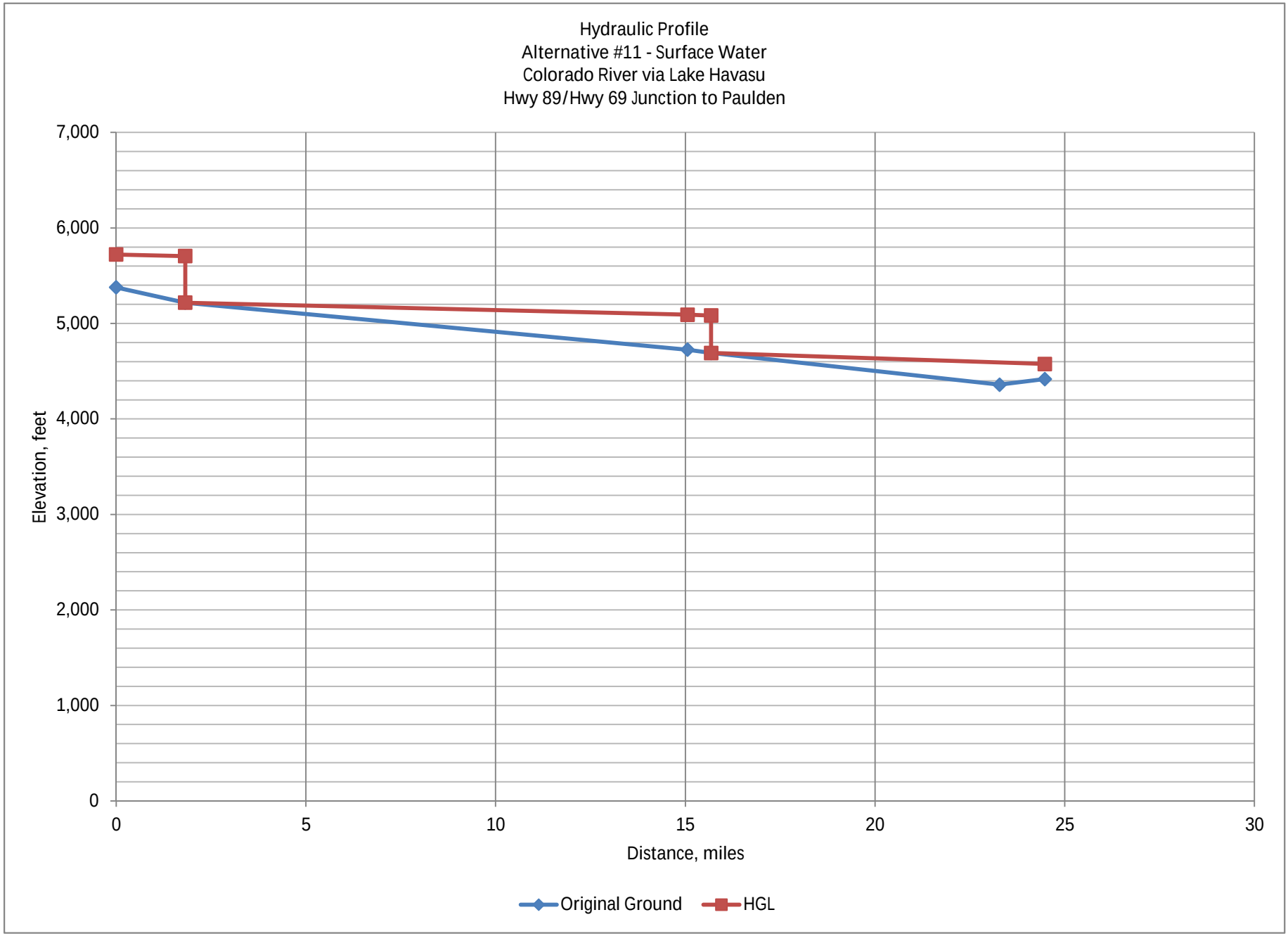

Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Lake Mead
Lake Mead to Sedona
7,000
6,000
5,000
4,000
3,000
2,000
1,000
Elevation, feet
0
50
100
150
200
250
300
Distance, miles
Original Ground
HGL

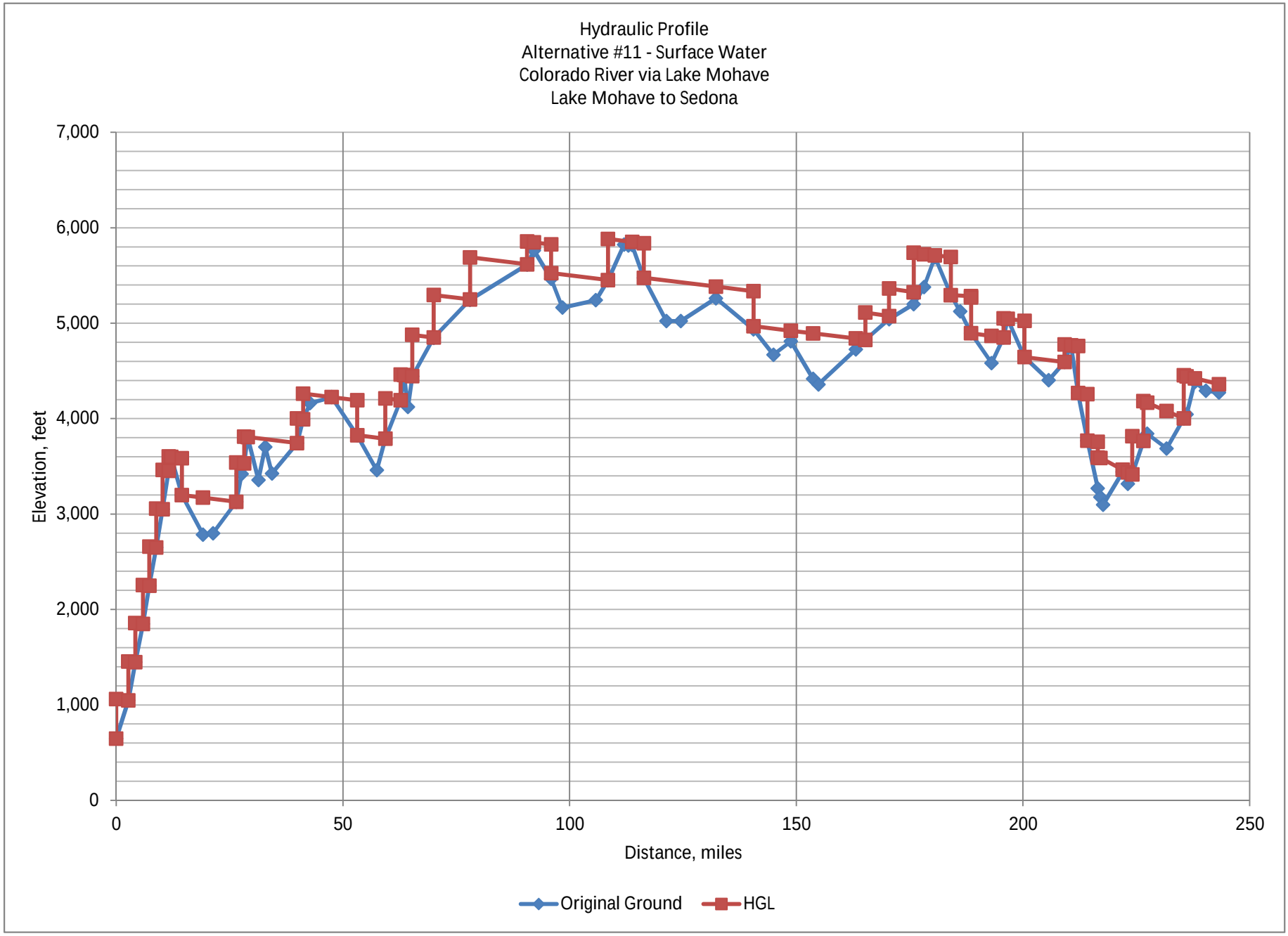

Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Lake Mead
I-17/Hwy 260 Junction to Clarkdale
Elevation, feet
3,700
3,600
3,500
3,400
3,300
3,200
3,100
0
2
4
6
8
10
12
14
16
18
20
Distance, miles
Original Ground
HGL

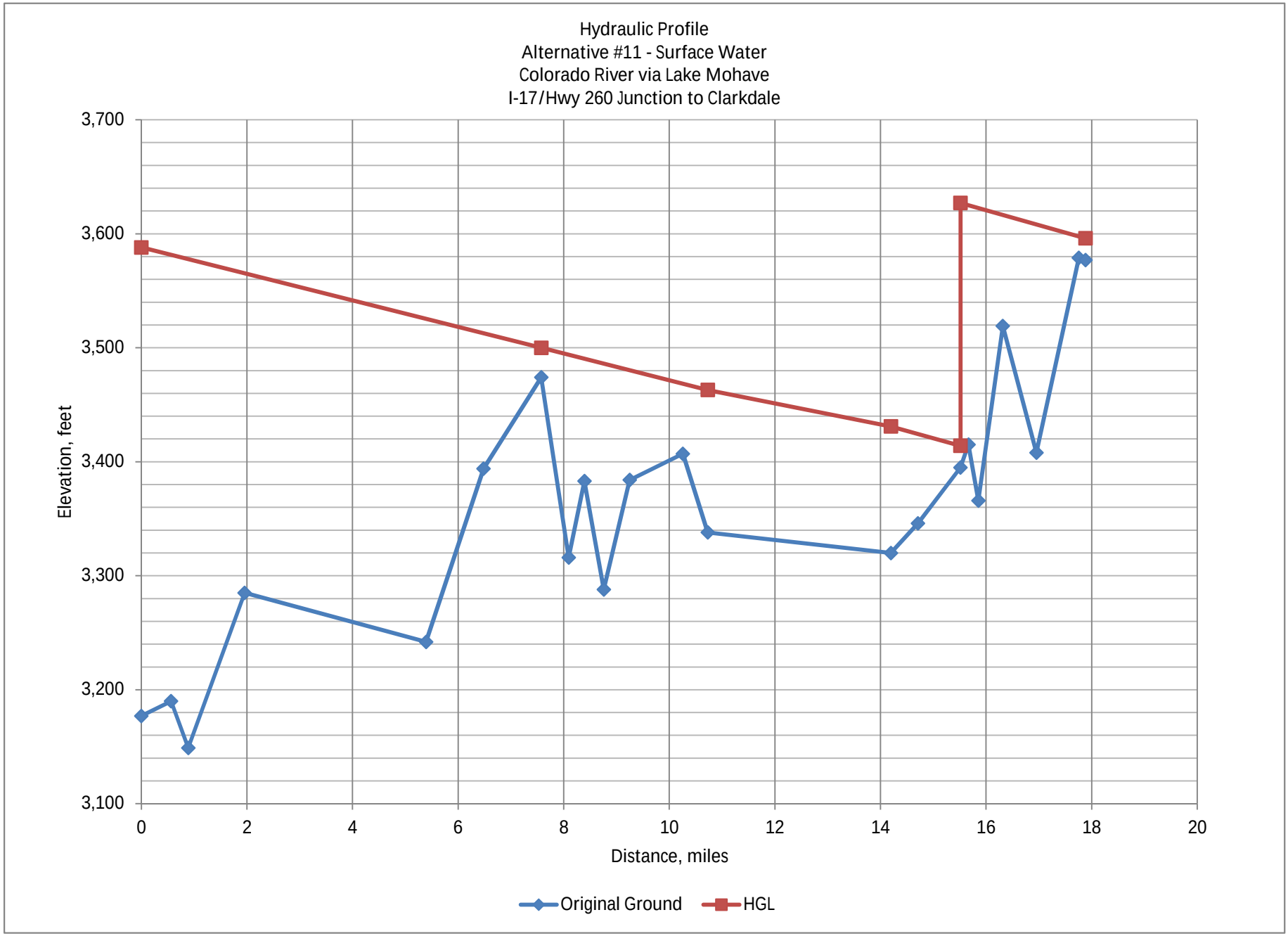

Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Lake Mead
Hwy69/Hwy 89 Junction to Prescott
Elevation, feet
5,750
5,700
5,650
5,600
5,550
5,500
5,450
5,400
5,350
5,300
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Distance, miles
Original Ground
HGL

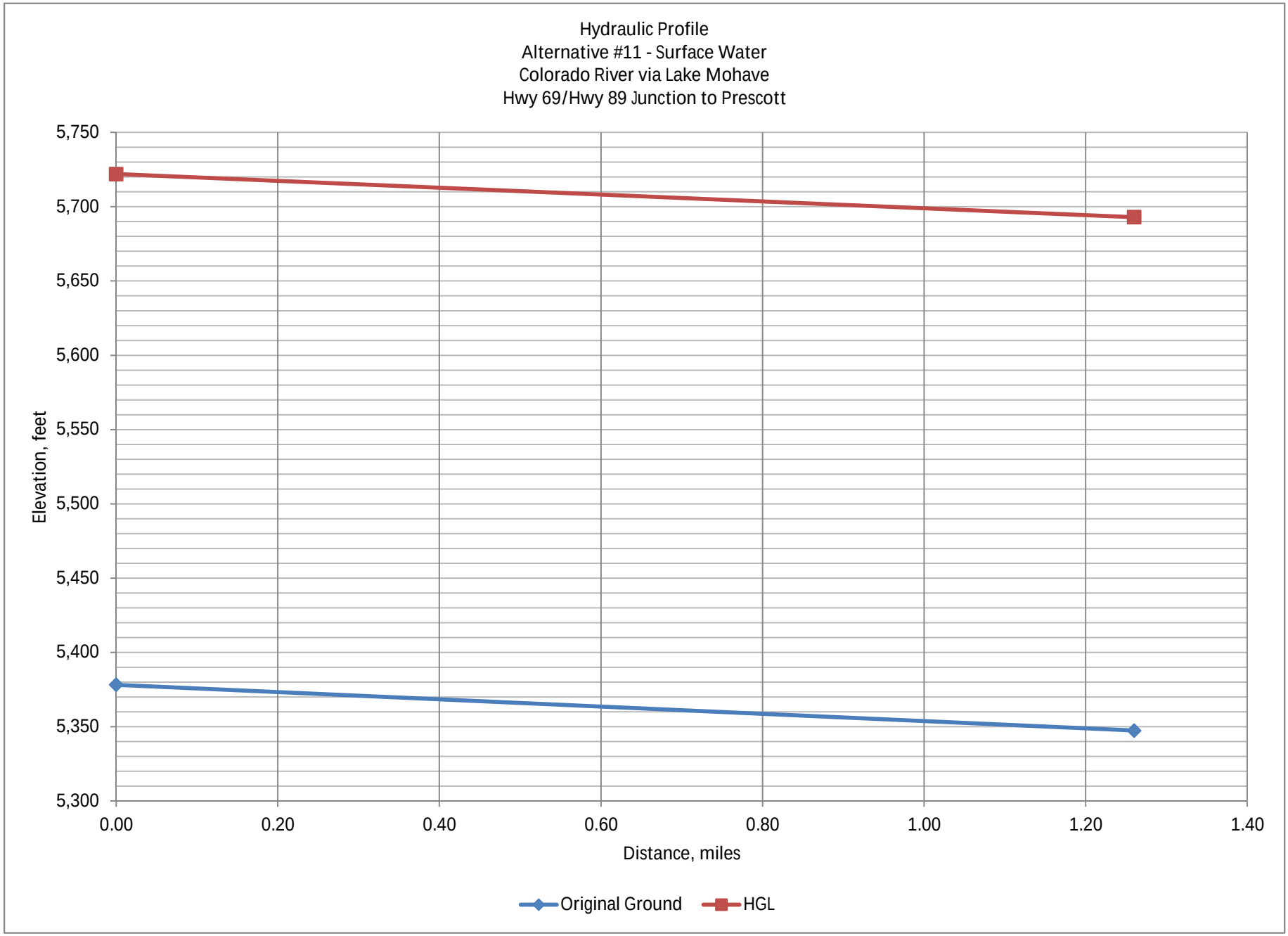

Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Lake Havasu
Lake Havasu to Sedona
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Elevation, feet
0
50
100
150
200
250
Distance, miles
Original Ground
HGL

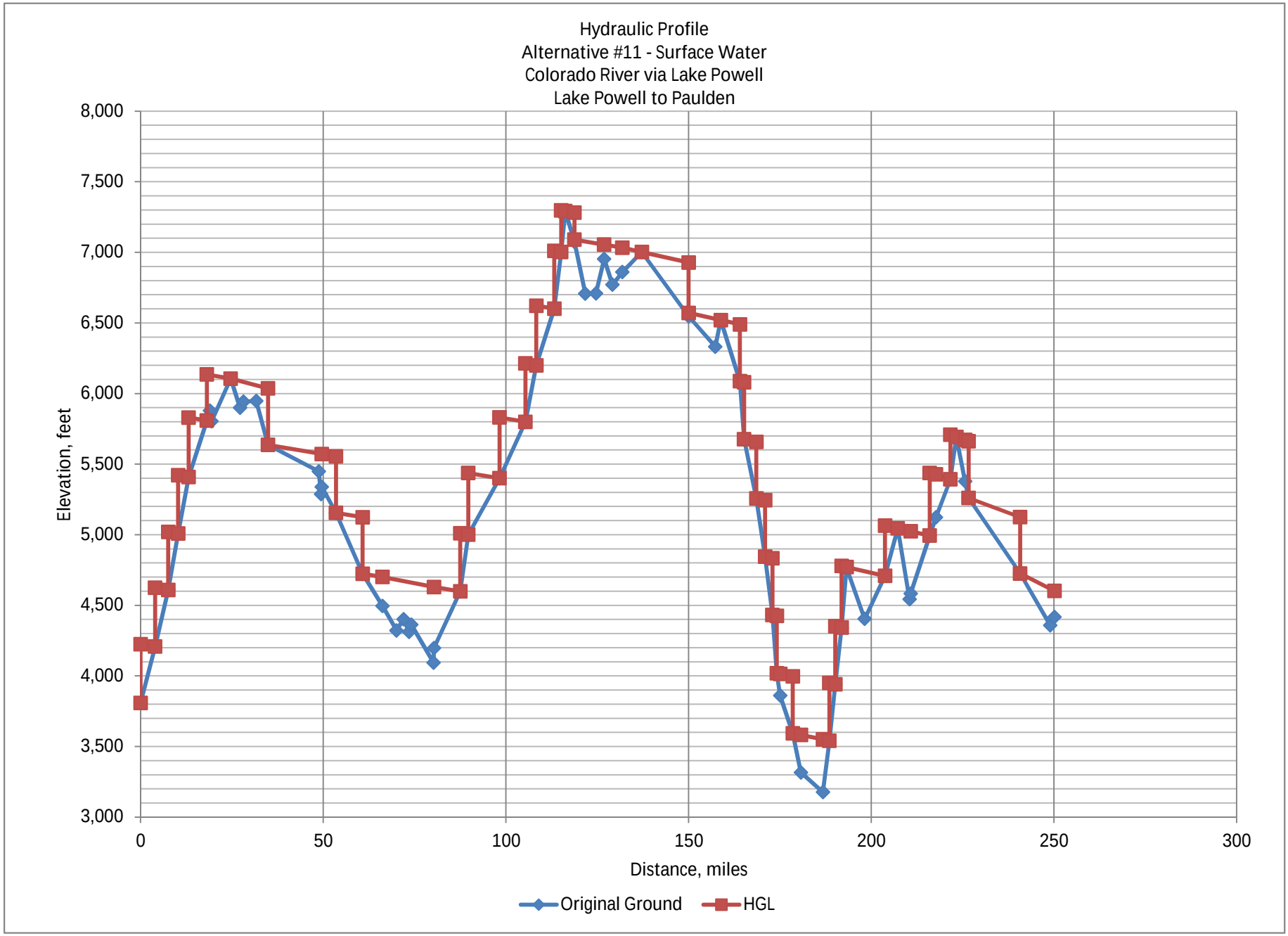

Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Lake Havasu
I-17/Hwy 260 Junction to Clarkdale
3,700
3,600
3,500
3,400
3,300
3,200
3,100
Elevation, feet
0
2
4
6
8
10
12
14
16
18
20
Distance, miles
Orignial Ground
HGL

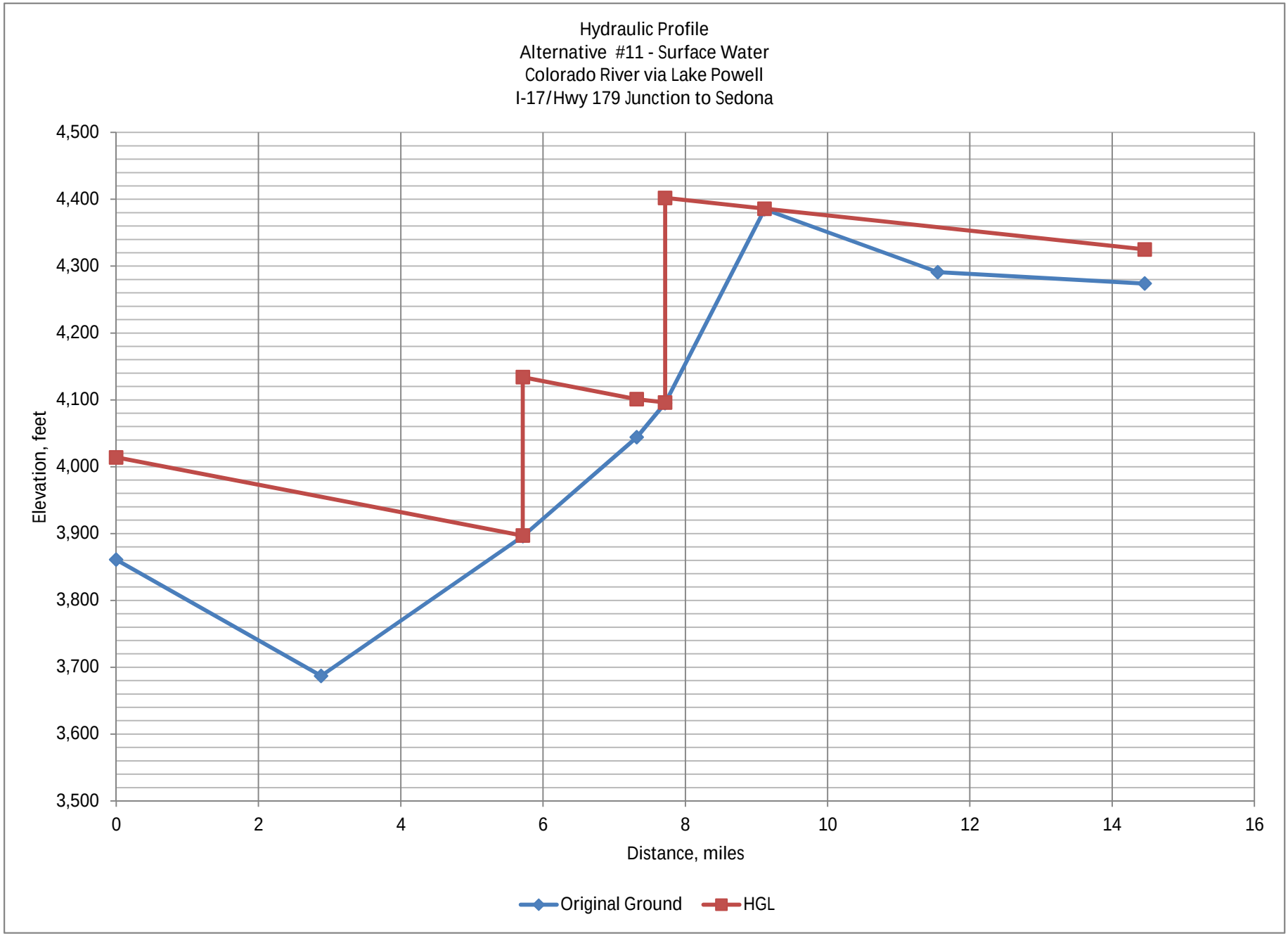

Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Lake Havasu
Hwy 89/Hwy 69 Junction to Paulden
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Elevation, feet
0
5
10
15
20
25
30
Distance, miles
Original Ground
HGL

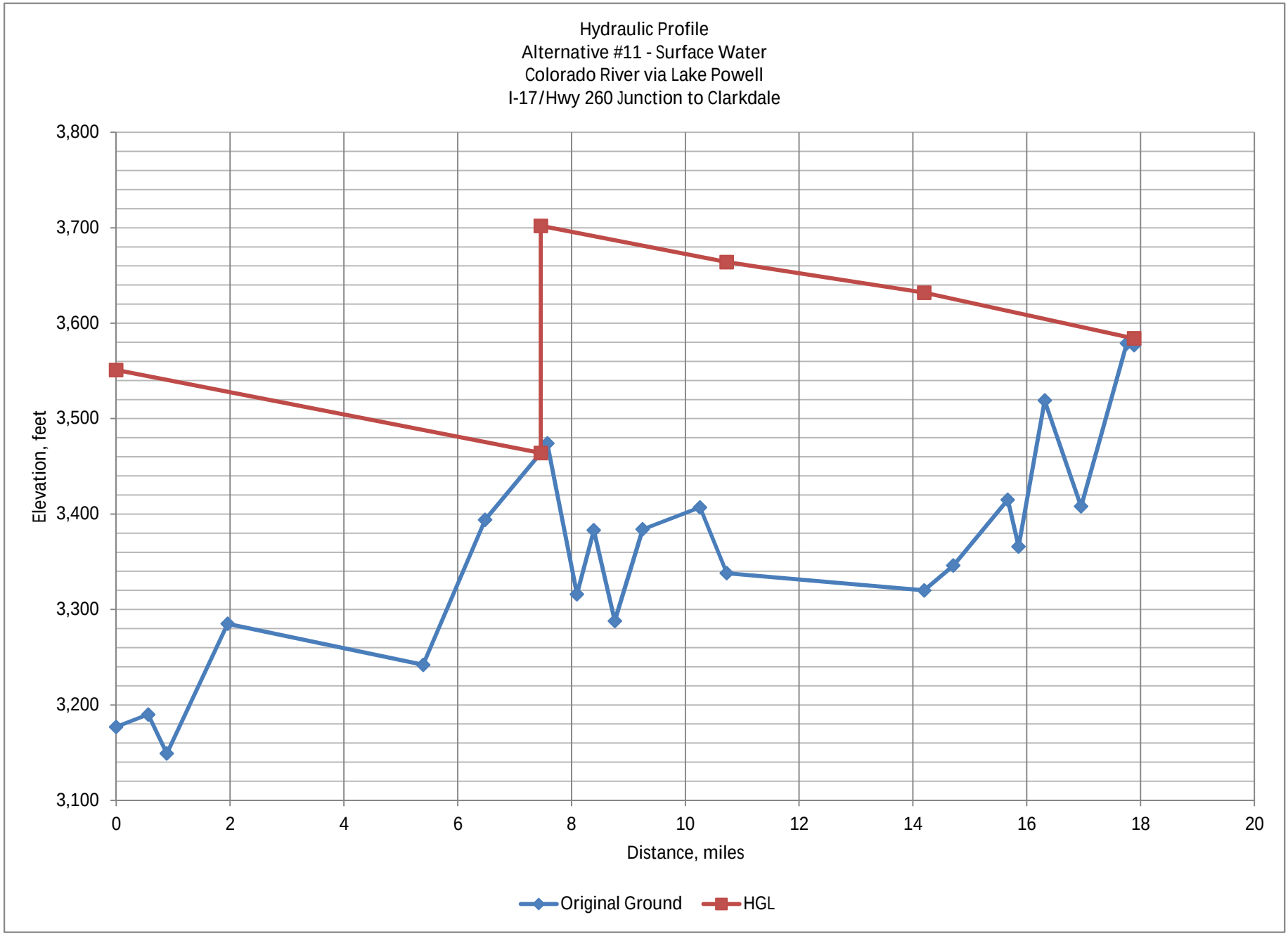

Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Lake Mohave
Lake Mohave to Sedona
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Elevation, feet
0
50
100
150
200
250
Distance, miles
Original Ground
HGL

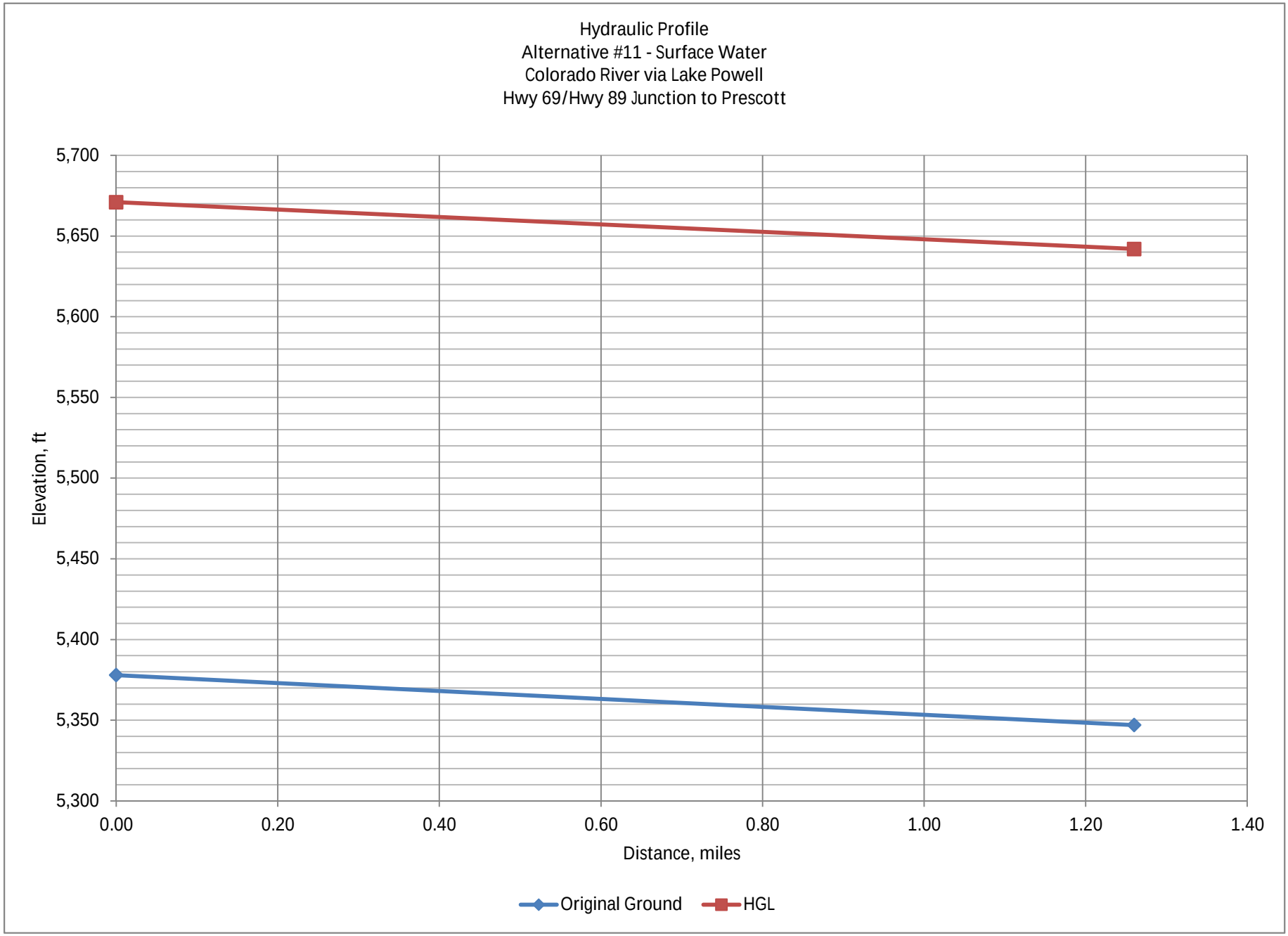

Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Lake Mohave
I-17/Hwy 260 Junction to Clarkdale
Elevation, feet
3,700
3,600
3,500
3,400
3,300
3,200
3,100
0
2
4
6
8
10
12
14
16
18
20
Distance, miles
Original Ground
HGL


Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Lake Mohave
Hwy 69/Hwy 89 Junction to Prescott
5,750
5,700
5,650
5,600
5,550
5,500
5,450
5,400
5,350
5,300
Elevation, feet
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Distance, miles
Original Ground
HGL


Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Lake Powell
Lake Powell to Paulden
Elevation, feet
8,000
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
3,500
3,000
0
50
100
150
200
250
300
Distance, miles
Original Ground
HGL


Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Lake Powell
I-17/Hwy 179 Junction to Sedona
Elevation, feet
4,500
4,400
4,300
4,200
4,100
4,000
3,900
3,800
3,700
3,600
3,500
0
2
4
6
8
10
12
14
16
Distance, miles
Original Ground
HGL


Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Lake Powell
I-17/Hwy 260 Junction to Clarkdale
Elevation, feet
3,800
3,700
3,600
3,500
3,400
3,300
3,200
3,100
0
2
4
6
8
10
12
14
16
18
20
Distance, miles
Original Ground
HGL


Hydraulic Profile
Alternative #11 - Surface Water
Colorado River via Lake Powell
Hwy 69/Hwy 89 Junction to Prescott
5,700
5,650
5,600
5,550
5,500
5,450
5,400
5,350
5,300
Elevation, ft
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Distance, miles
Original Ground
HGL

Water Supply Alternative Evaluation
Alt. #1 Local Groundwater Development within the WPA (Outside the PRAMA)

Description

This alternative relies solely on the continued development of groundwater to meet the water supply deficit in 2050 with either urban non-exempt wells, rural exempt wells or a combination thereof for WPAs outside the Prescott AMA (PRAMA). For each WPA, an analysis was done to determine what percentage of municipal demand is provided either by a water provider or by private domestic wells. It was assumed that groundwater in rural areas is generally accessed by private domestic wells that are referred to as exempt wells. Conversely, it was assumed that urban areas are generally served by water providers of varying sizes by non-exempt wells. The proportion of non-exempt wells and exempt wells reflects an approximation of rural and urban populations in each planning area. It is assumed that the present pattern for rural or urban areas will be similar in future growth. For this option, WPAs considered in this alternative are those that show a 2050 water supply deficit and are outside the PRAMA. There are thirteen WPA's considered; Clarkdale, Cottonwood, Jerome, Paulden, Sedona, Big Park, Lake Montezuma, Cottonwood-Verde Village, Williamson, Verde CCD, Prescott CCD, Mingus Mtn. CCD and Ashfork CCD.

Environmental Issues

Primary environmental issues of concern with development of groundwater to meet the 2050 deficit include potential impacts to surface water supplies where there is a groundwater-surface water connection. Anticipated issues include eventual declines and loss of stream and spring flows, changes in stream flow magnitude, duration and flood events, and the impact to groundwater availability. Activities affecting hydrology of the system also affect the biologic dynamics of the riparian and spring systems. Detrimental effects of loss of flow (and other hydrologic parameters) anticipated on native vegetation and plant communities, native wildlife habitat and species productivity, and the potential loss of native aquatic species. Habitat degradation due to changes in water availability may also lead to the establishment of unwanted exotic and non-native invasive plants and animal species. Other potential issues may arise if groundwater pumping were to affect groundwater levels and surface water flows including problems associated with land subsidence, and increasing issues in water quality including concentration of contaminants. Refer to Appendix XX for additional information and maps showing specific water-dependent natural resources known to occur within each WPA.

Legal and Institutional Issues

Requirements for groundwater development within a WPA that is outside of the PRAMA may include right of way permissions and approval by the ACC. WIFA funding may be available. Depending on the outcome of the general adjudication of surface water rights, certain well locations could be subject to adjudication requirements. New groundwater development would be subject to NOI requirements, statutory limits on groundwater transportation, and well spacing requirements. Potable water deliveries would be subject to potable water facilities, SDWA and Water Treatment regulations. Depending on new well locations, groundwater development may be subject to Federal Reserved Rights for Indian Tribes.

Public Perception

New groundwater pumping could cause groundwater overdraft, potentially impact existing wells and surface water supplies, and subject to reliability concerns.

Cost

Alt #	Description of Alternative	Volume (AF/yr)	Costs				
			Field Cost ($)	Ammortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
1	Local GW Development Outside AMA –Urban Wells	12,178	$8,144,135	$387,300		$31.80	$0.10
1	Local GW Development Outside AMA – Rural Wells	7,592	$607,708,336	$28,897,100		$3,806.26	$11.68
1	**TOTAL - Local GW Development Outside AMA (urban & rural wells)**	**19,770**	**$615,852,471**	**$29,284,400**		**$3,838.06**	**$11.78**

*This alternative comprises of both rural and urban volumes and costs added together.

Evaluation

Acceptability (yes)
Effectiveness (yes)
Efficiency (yes)
Completeness (yes)

Findings

Viable: Continued use of groundwater to meet future demands will likely be, at minimum, a component of the future water supplies for these WPAs. There is concern over the effectiveness because it's not a sustainable solution and there will be impacts if it continues.

Water Supply Alternative Evaluation
Alt. #1 Local Groundwater Development within the WPA (Inside the PRAMA)

Description

This alternative relies solely on the development of groundwater to meet the water supply deficit in 2050 with urban non-exempt wells and rural exempt wells for WPAs inside the Prescott AMA (PRAMA). For this option, WPAs considered are City of Prescott, Chino Valley, Dewey-Humboldt and Prescott Valley. The development of groundwater to meet municipal demand inside the Prescott Active Management Area (PRAMA) is limited by the Assured Water Supply regulations. The 1999 declaration that the PRAMA was out of safe yield resulted in the implementation of more stringent Assured Water Supply requirements, particularly more stringent limitations on the volume of groundwater that could be utilized by new subdivisions.

Because City of Prescott is a designated provider, it was evaluated differently. The method used to determine the manner in which local groundwater could be developed and utilized within the Prescott WPA was guided by the City of Prescott's Modified Designation of Assured Water Supply issued December 30, 2009 - Decision and Order No. 86-401501.0001 (Modified Designation). It was determined that there is existing well capacity to meet the Prescott WPA 2050 water supply deficit, therefore drafting cost estimates for new wells the was determined to be unnecessary for the Prescott WPA.

For Chino Valley, Dewey-Humboldt and Prescott Valley WPAs, currently platted subdivisions were queried in order to determine the maximum groundwater allowance allowed under currently issued Certificates of Assured Water Supply. The maximum groundwater allowance volume associated with currently undeveloped subdivisions lots was assumed to be met by new non-exempt, municipal wells. Any volume of groundwater in excess of the maximum groundwater allowance, or the 2050 water supply deficit must be met by exempt wells or by an alternative water supply.

Environmental Issues

Primary environmental issues of concern with development of groundwater to meet the 2050 deficit include potential impacts to surface water supplies where there is a groundwater-surface water connection. Anticipated issues include eventual declines and loss of stream and spring flows, changes in stream flow magnitude, duration and flood events, and the impact to groundwater availability. Activities affecting hydrology of the system also affect the biologic dynamics of the riparian and spring systems. Detrimental effects of loss of flow (and other hydrologic parameters) anticipated on native vegetation and plant communities, native wildlife habitat and species productivity, and the potential loss of native aquatic species. Habitat degradation due to changes in water availability may also lead to the establishment of unwanted exotic and non-native invasive plants and animal species. Other potential issues may arise if groundwater pumping were to affect groundwater levels and surface water flows including problems associated with land subsidence, and increasing issues in water quality including concentration of contaminants. Refer to Appendix XX for additional information and maps showing specific water-dependent natural resources known to occur within each WPA.

Legal and Institutional Issues

Requirements for groundwater development within a WPA that is inside of the PRAMA would have to meet Assured and Adequate Water Supply rules and may require right of way permissions and approval by the ACC. WIFA funding may be available. Depending on the outcome of the general adjudication of surface water rights, certain well locations could be subject to adjudication requirements. New groundwater development would be subject to NOI requirements, statutory limits on groundwater transportation, and well spacing requirements. Potable water deliveries would be subject to potable water facilities, SDWA and Water Treatment regulations. Depending on new well locations, groundwater development may be subject to Federal Reserved Rights for Indian Tribes.

Public Perception

New groundwater pumping could increase groundwater overdraft, potentially impact existing wells and surface water supplies, and subject to reliability concerns.

Cost

Alt #	Description of Alternative	Volume (AF/yr)	Costs				
			Field Cost ($)	Ammortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
1	Local GW Development Inside AMA –Urban Wells	1648	$1,080,713	$51,400		$31.19	$0.10
1	Local GW Development Inside AMA – Rural Wells	19623	$1,570,685,813	$74,687,700		$3,806.13	$11.68
1	**TOTAL - Local GW Development inside AMA (urban & rural wells)**	**21,271**	**$1,571,766,526**	**$74,739,100**		**$3,837.32**	**$11.78**

*This alternative comprises of both rural and urban volumes and costs added together.

Evaluation

Acceptability

Effectiveness

Efficiency

Completeness

Findings

Water Supply Alternative Evaluation
Alt. #2 Regional Groundwater Development
Big Chino Pipelines (PRAMA & Verde Valley)

Description

This alternative proposes two versions that rely on development of groundwater supplies from the Big Chino Sub-basin for transportation via pipeline to either specific WPAs within the PRAMA or to specific WPAs within the Verde Valley. This alternative is considered to be regional groundwater development because it requires development of groundwater supply from the Big Chino Water Ranch, within the study area.

The WPAs considered in the PRAMA version of this alternative are: City of Prescott, Prescott Valley and Town of Chino Valley. The water supply deficits for Prescott and Prescott Valley WPAs were limited by provisions within the City of Prescott's Modified Designation of Assured Water Supply which are 4,365 AF/yr for City of Prescott and 3,703 AF/yr for Prescott Valley. The water supply deficit of 4,400 AF/yr for the Town of Chino Valley to be met by this alternative was determined by the Town of Chino Valley.

The WPAs considered in the Verde Valley version of this alternative are: Clarkdale, Cottonwood, Sedona, Big Park CDP, Lake Montezuma CDP and Ctn-Verde Village CDP. This alternative meets the total 2050 water supply deficit of 12,382 AF/yr for these WPAs. Rural WPAs that are primarily served from private, domestic wells were not included within this alternative.

Environmental Issues

Primary environmental issues of concern with development of groundwater supplies from the Big Chino Sub-basin to meet the 2050 deficit include potential impacts to surface water supplies where there is a groundwater-surface water connection. Anticipated issues include eventual declines and loss of stream and spring flows, changes in stream flow magnitude, duration and flood events, and the impact to groundwater availability. Activities affecting hydrology of the system also affect the biologic dynamics of the riparian and spring systems. Detrimental effects of loss of flow (and other hydrologic parameters) anticipated on native vegetation and plant communities, native wildlife habitat and species productivity, and the potential loss of native aquatic species. Habitat degradation due to changes in water availability may also lead to the establishment of unwanted exotic and non-native invasive plants and animal species. Other potential issues may arise if groundwater pumping were to affect groundwater levels and surface water flows including problems associated with land subsidence, and increasing issues in water quality including concentration of contaminants.

This alternative also considers a mitigation framework for the maintenance of baseflow, which in the event the withdrawal of water from the Big Chino Sub-Basin is negatively affecting the flow of water in the Upper Verde River, mitigation of impacts will be considered (refer to An Agreement in Principle among the City of Prescott, the Town of Prescott Valley, and the Salt River Valley Water Users' Association and the Salt River Project Agricultural Improvement and Power District and Comprehensive Agreement No. 1).

Benefits may be anticipated to the basin where water is transported; sustain groundwater contribution to streams, helping reach safe-yield and providing alternative to local groundwater pumping.

Refer to Appendix XX for additional information and maps showing specific water-dependent natural resources known to occur within each WPA.

Legal and Institutional Issues

Would have to meet requirements of floodplain ordinances, grading permits and right of ways. WIFA funding may be available. Requirements under the State Historic Preservation Act and Arizona Native

Plant Laws would apply. Depending on the outcome of the general adjudication of surface water rights, certain well locations could be subject to adjudication requirements. Assured and Adequate Water Supply, Transportation of Groundwater, NOI and well spacing rules would apply. Potable water deliveries would be subject to Potable Water Facilities, SDWA and Water Treatment regulations. If Federal lands are crossed or if Federal funding is used, all NEPA requirements must be satisfied. Depending on new well locations, groundwater development may be subject to Federal Reserved Rights for Indian Tribes. Pipeline alignments would be subject to Native American Graves Protection and Repatriation Act. Groundwater pumping may require coordination and contractual agreements with the Salt River Project.

Public Perception

New groundwater pumping could cause groundwater overdraft and potentially impact existing wells and surface water supplies. High infrastructure costs for long-distance conveyance of water with potential for denial of voter approval for financing and construction. Concern over the potential for a high risk on investment returns for water infrastructure. Perception that current water supplies are adequate and that there is no need for additional water supplies. Perception that augmenting current supplies will result in increased population.

Cost

Alt #	Description of Alternative	Volume (AF/yr)	Costs				
			Field Cost ($)	Ammortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
2	Pipeline from Big Chino to PRAMA	12,468	121,892,305	5,796,100	1,868,805	615	1.89
2	Pipeline from Big Chino to Verde Valley	12,382	311,005,854	14,788,600	2,643,426	1,408	4.32

Evaluation

Acceptability

Effectiveness

Efficiency

Completeness

Findings

Water Supply Alternative Evaluation
Alt. #3 Regional Groundwater Development
Outside Study Area (Bill Williams & Big Sandy)

Description

This alternative proposes two options that rely on the development of groundwater supplies from either the Bill Williams Sub-basin or the Big Sandy Sub-basin for transportation via pipeline to the WPAs. This alternative is considered regional groundwater development because it is development of groundwater from one localized area outside of the study area. In the Big Sandy version of the alternative, the groundwater is developed near Wikieup, Arizona and in the Bill Williams version the groundwater is developed at Burro Creek.

The WPAs considered in this alternative are those that show a 2050 water supply deficit with the exception of Jerome and rural WPAs that are primarily served from private, domestic wells. The following WPAs were not included within this alternative: Jerome, Verde CCD, Prescott CCD, Mingus Mountain CCD, Humboldt CCD and Ashfork CCD.

Environmental Issues

The importation of water supplies to meet the 2050 deficit is anticipated to provide overall environmental benefit to the study area, and specifically to each basin where water in imported. Augmenting water supplies may help sustain groundwater contributions to streams, provides an alternative to local groundwater pumping, and protects vegetation, wildlife and aquatic species. There may be an impact to water quality due to greater mineral content from outside sources, but the environmental concerns would be minimal because it is assumed that imported water will be treated. This environmental review only considered environmental issues within the study area. Further environmental review would be required outside the study area to address impacts from removing groundwater from the Bill Williams and Big Sandy Sub-basins.

Legal and Institutional Issues

Would have to meet requirements of floodplain ordinances, grading permits and right of ways. WIFA funding may be available. May require approval by the ACC. Requirements under the State Historic Preservation Act and Arizona Native Plant Laws would apply. Depending on the outcome of the general adjudication of surface water rights, certain well locations could be subject to adjudication requirements. Assured and Adequate Water Supply, Transportation of Groundwater, Water Exchanges, NOI and well spacing rules would apply. Potable water deliveries would be subject to Potable Water Facilities, SDWA and Water Treatment regulations. If Federal lands are crossed or if Federal funding is used, all NEPA requirements must be satisfied. Depending on new well locations, groundwater development may be subject to Federal Reserved Rights for Indian Tribes. Pipeline alignments would be subject to Native American Graves Protection and Repatriation Act.

Public Perception

New groundwater pumping could cause groundwater overdraft and potentially impact existing wells and surface water supplies. High infrastructure costs for long-distance conveyance of water with potential for denial of voter approval for financing and construction. Concern over the potential for a high risk on investment returns for water infrastructure. Perception that current water supplies are adequate and that there is no need for additional water supplies. Perception that augmenting current supplies will result in increased population.

Cost

Alt #	Description of Alternative	Volume (AF/yr)	Costs				
			Field Cost ($)	Ammortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
3	Regional GW Outside Study Area-Big Sandy	42,379	987,537,108	46,958,400	11,595,880	1,382	2.24
3	Regional GW Outside Study Area-Bill Williams	42,379	910,985,979	43,318,300	11,124,148	1,285	3.94

Evaluation

Acceptability

Effectiveness

Efficiency

Completeness

Findings

Water Supply Alternative Evaluation
Alt. #4 Conversion of Existing Septic Systems - Urban

Description

This alternative considers conversion of urban residential septic systems to sewer connections. For the purposes of this study, "Urban" refers to a WPA that is serviced by a water provider, sewer provider, or is within the boundary of a Certificates of Convenience and Necessity (CC&N). A CC&N defines an area where an entity holds exclusive rights to supply water or wastewater services within a specified geographic area.

This analysis estimated the number of residential properties in urban areas that use on-site septic systems. Under this alternative, residential septic systems would be converted to connections with sewer conveyance infrastructure. This would involve extending sewer conveyance infrastructure into areas where residences are currently on septic systems. For this option, eleven WPA's are considered urban; Camp Verde, Chino Valley, Clarkdale, Cottonwood, Jerome, Prescott, Prescott Valley, Sedona, Big Park, Lake Montezuma and Paulden.

Environmental Issues

The conversion of existing septic systems to sewer may benefit environmental resources if the increasing availability of treated effluent lessens the need to pump water to meet the 2050 deficit. The assumption is that the treated effluent would be either reused or recharged and not discharged into a stream. The location of recharge would dictate the level of effect if any on stream water quality. Treated effluent is typically better quality than septic tank leachate, so local water quality could also be improved from baseline due to removal of septic systems. Recharge could augment groundwater and stream flow. Impact to vegetation and wildlife could be minimal and possibly positive if it reduced groundwater level decline and if recharge facilities are located to optimize augmentation of stream flow and riparian groundwater levels. Environmental issues to consider are concerns with water quality and biologic impacts from emerging contaminants on aquatic species, and in very low concentrations. Sewering septic tanks should improve treatment levels and hence result in lower ECs in the effluent, but the end use may be changing.

Legal and Institutional Issues

Septic tank owners would comply with local hook-up and septic tank abandonment requirements. If new wastewater treatment facility (WWTF) infrastructure crosses natural drainages, local regulations including a Flood Plain Ordinance and Grading Permit may be required. New infrastructure may require right of way permissions. Changes to existing or construction of new WWTF's would require obtaining permission through the appropriate Regional Water Quality Management Planning (208) authority. Changes to existing WWTF's or construction of new WWTF's would require modification or acquisition of new ADEQ permits including: APP, AZPDES, Reclaimed Water Conveyance, and Reclaimed Water Quality Standards. WIFA could be used for financing. . If no Federal lands are crossed and there is no Federal interest, than NEPA will not apply. However, if Federal funding is used, all NEPA requirements must be satisfied.

Public Perception

Perception of indirect and direct potable reuse. Cost and perception of conversion from private to public system. Water quality issues to upgrade water to standards. Cost to construct conveyance infrastructure and expand or construct new WWTF's.

Cost

Alt #	Description of Alternative	Volume (AF/yr)	Costs				
			Field Cost ($)	Ammortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
4	Conversion of Existing Systems – Urban	3,367	237,629,700	11,116,300	18,702,100	9,002	27.63

Evaluation
Acceptability (yes)
Effectiveness (yes)
Efficiency (yes)
Completeness (yes)

Findings
Viable: There are no fatal flaws in the legal & institutional. However there may be some public perception issues in regards to reuse and conversion costs. It is a reliable source of water supply that is local. Although it doesn't meet the entire deficit demand, it can complement other projects. During the environmental analysis, there were a lot of positives and there could be benefits to water quality.

Water Supply Alternative Evaluation
Alt. #5 Conversion of Existing Septic Systems - Rural

Description

This alternative involves conversion of residential septic systems to sewer service to increase the availability of effluent for reuse, in rural areas. This assessment considers rural areas to be outside of a water provider service area, a sewer service area or a CC&N. Rural areas tend to have larger lots and lower household density than urban areas. The WPA's are assessed individually.
Rural wastewater volumes were calculated using the number of rural parcels (2007 Yavapai County Geographic Information System), population (US Census 2000), and an average wastewater production of 69 gallons per person per day (Table 12). Only residential parcels are considered for conversion of septic systems to a sewer system. This process yielded a rural population estimate by planning area. For this option, thirteen WPA's are considered having rural population; Ashfork, Cornville, Cottonwood, Humboldt, Lake Montezuma, Mingus Mount, Paulden, Prescott CD, Prescott Valley, Prescott, Verde Cottonwood-Verde Village and Williamson.

Environmental Issues

The conversion of existing septic systems to sewer may benefit environmental resources if the increasing availability of treated effluent lessens the need to pump water to meet the 2050 deficit. The assumption is that the treated effluent would be either reused or recharged and not discharged into a stream. The location of recharge would dictate the level of effect if any on stream water quality. Treated effluent is typically better quality than septic tank leachate, so local water quality could also be improved from baseline due to removal of septic systems. Recharge could augment groundwater and stream flow. Impact to vegetation and wildlife could be minimal and possibly positive if it reduced groundwater level decline and if recharge facilities are located to optimize augmentation of stream flow and riparian groundwater levels. Possible negative impacts to water quality and fish/aquatic species. Environmental issues to consider are concerns with water quality and biologic impacts from emerging contaminants on aquatic species, and in very low concentrations. Sewering septic tanks should improve treatment levels and hence result in lower ECs in the effluent, but the end use may be changing.

Legal and Institutional Issues

Septic tank owners would comply with local hook-up and septic tank abandonment requirements. If new wastewater treatment facility (WWTF) infrastructure crosses natural drainages, local regulations including a Flood Plain Ordinance and Grading Permit may be required. New infrastructure may require right of way permissions. Changes to existing or construction of new WWTF's would require obtaining permission through the appropriate Regional Water Quality Management Planning (208) authority. Changes to existing WWTF's or construction of new WWTF's would require modification or acquisition of new ADEQ permits including: APP, AZPDES, Reclaimed Water Conveyance, and Reclaimed Water Quality Standards. WIFA could be used for financing. If no Federal lands are crossed and there is no Federal interest, than NEPA will not apply. However, if Federal funding is used, all NEPA requirements must be satisfied.

Public Perception

Negative perception of indirect and direct potable reuse. Cost and perception of conversion from private to public system. Water quality issues to upgrade water to standards.

Cost

Alt #	Description of Alternative	Volume (AF/yr)	Costs				
			Field Cost ($)	Ammortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
5	Conversion of Existing Systems – Rural	2,766	200,201,200	9,519,800	16,016,096	9232	28.33

Evaluation
Acceptability (yes)
Effectiveness (no)
Efficiency (no)
Completeness (no)

Findings
Not Viable: due to extreme cost associated with necessary infrastructure. Because of rural areas being spread out across a long distance, there isn't sufficient existing infrastructure and is a "no" for the completeness criteria.

Water Supply Alternative Evaluation
Alt. #6 New Effluent from New Population

Description

This alternative focuses on new wastewater volumes as a result of new population in each of the twenty WPA's from 2006 to 2050 and identifies the potential volume of water that would be available. The new population was determined during the Phase I - Demand Analysis conducted for this Study. The new population was multiplied by an average wastewater production of 69 gallons per day per person to estimate the new wastewater volume available in 2050.

The volume of effluent generated from the new wastewater is presented as a range of high and conservative volumes. The high estimate assumes that all new wastewater is captured in a sewer system for treatment, reuse and/or recharge. The conservative estimate takes into account the percentage of population in the region served by WWTF's. In 2002, the NACOG Section 208 Plan estimated that 45% of the population in Yavapai County was served by WWTF's. The conservative estimate uses the percent of the population that is served by a WWTF which may vary for each WPA based on projected land use and wastewater management plans.

In this analysis, infrastructure requirements for each alternative are based on the status of the WWTF's. When average daily flow into a WWTF reaches 80 percent of its rated capacity, it was determined that a WWTF would require expansion. Based on this criteria, the WWTF's are categorized into three groups within each WPA.

Group A – Existing WWTF can accommodate additional wastewater capacity. Expansion of sewer conveyance infrastructure is required.

Group B – Existing WWTF requires expansion to accommodate additional wastewater capacity Expansion of sewer conveyance infrastructure is required.

Group C – Construction of new WWTF and sewer conveyance infrastructure is required.

Under Alternative 6, all WPA's were considered.

Environmental Issues

The development and use of new effluent may benefit environmental resources if the increasing availability of treated effluent lessens the need to pump water to meet the 2050 deficit. The assumption is that the treated effluent would be either reused or recharged and not discharged into a stream. The location of recharge would dictate the level of effect if any on stream water quality. Treated effluent is typically better quality than septic tank leachate, so local water quality could also be improved from baseline due to removal of septic systems. Recharge could augment groundwater and stream flow. Impact to vegetation and wildlife could be minimal and possibly positive if it reduced groundwater level decline and if recharge facilities are located to optimize augmentation of stream flow and riparian groundwater levels. It may offset some development of other water resources. Benefits anticipated from the offset of stream impacts from development of other uses. Likewise recharge benefits to groundwater could also benefit biologic and watershed conditions. Environmental issues to consider are concerns with water quality and biologic impacts from emerging contaminants on aquatic species, and in very low concentrations.

Legal and Institutional Issues

If new wastewater treatment facility (WWTF) infrastructure crosses natural drainages, local regulations including a Flood Plain Ordinance and Grading Permit may be required. New infrastructure may require right of way permissions. Changes to existing or construction of new WWTF's would require obtaining permission through the appropriate Regional Water Quality Management Planning (208) authority. Changes to existing WWTF's or construction of new WWTF's would require modification or acquisition

of new ADEQ permits including: APP, AZPDES, Reclaimed Water Conveyance, and Reclaimed Water Quality Standards. WIFA could be used for financing. If Federal lands are crossed, there is a Federal interest or if Federal funding is used, all NEPA requirements must be satisfied.

Public Perception

Perception of indirect and direct potable reuse. Perception of the need for public WWTF systems versus private septic systems. Cost to construct conveyance infrastructure and expand or construct new WWTF's. Water quality issues to upgrade water to standards.

Cost

Alt #	Description of Alternative	Volume (AF/yr)	Costs				
			Field Cost ($)	Ammortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
6	New Effluent from New Population – High Volume	30,400	963,737,200	45,826,600	77,098,900	2,515	7.72
6	New Effluent from New Population – Conservative Volume	18,781	834,343,700	39,673,900	66,747,400	3,056	9.38

Evaluation

Acceptability

Effectiveness

Efficiency

Completeness

Findings

Water Supply Alternative Evaluation
Alt. #7 Capture and Store Unappropriated Verde River

Description

This alternative proposes as a source of supply the capture of unappropriated water from the Verde River watershed during a spill condition. This volume of floodwater is an intermittent source that is only available when all senior downstream water rights are being satisfied and storage capacity is being exceeded at Salt River Project's (SRP) reservoirs. There are a number of versions of this alternative but all include either increasing or creating additional reservoir storage. The increased reservoir storage would result in the ability to store water within the system that would normally be lost during the occasional spill condition. Water supply credits would accrue in the new space and designated for the WPA participants, and then debited when the water is used upstream.

In both Alternatives 7.1 and 7.2, the proposed reservoir volume increases are based on the reservoir yield potential concept: 10,000 AF\yr., 25,000 AF/yr., and 45,000 AF/yr. Versions 7.1 and 7.2 of this alternative require modifications to existing SRP dams in addition to construction of upstream catchments and transmission facilities. Infrastructure requirements for these versions include: increasing dam height, dam spillway modification, dam inlet/outlet modification, access improvements and relocation/reconstruction of ancillary facilities associated with dams, construction of reservoir for off-stream storage, water treatment plant, pump station and waterline. In this evaluation, the catchment locations and transmission facilities are conceptualized and estimated based on the various increased dam heights and water volumes captured. Conceptualized transmission lines are based on eight miles of pipeline; addition transmission lines to WPAs are not estimated.

Version 7.3 of this alternative is intake and catchment of water at Sullivan Lake, located about 1.5 miles south of Paulden. The catchment facility size and location was based on the surrounding topography, existing infrastructure, and proposed water treatment plant. This version assumed a two million gallon per day packaged water treatment plant that yielded the 2,240 AF/yr.

Version 7.4 of this alternative is catchment of water near Page Springs on the Oak Creek drainage area. The catchment facility size and location was based on the surrounding topography, existing infrastructure, and proposed water treatment plant. This version assumed a two million gallon per day packaged water treatment plant that yielded the 2,240 AF/yr.

The WPAs considered in versions 7.1 and 7.2 of this alternative are those that show a 2050 water supply deficit, except for Jerome. The WPAs considered in version 7.3 of this alternative are Dewey-Humboldt and Prescott. The WPAs considered in version 7.4 are Clarkdale and Cottonwood.

Environmental Issues

Primary environmental issues of concern from the development of on-stream or off-stream reservoirs to capture and store unappropriated Verde water are based on the overarching alteration of the natural hydrologic regime, impacting both upstream and downstream habitats, affecting the natural flow regime including floodflows, which are needed for a multitude of biologic parameters including native vegetation regeneration and aquatic species life cycles. Recruitment and survival of riparian vegetation is linked to high flows and removal of a portion of those flows could have a negative impact. Also it would be anticipated that where impacts to riparian and aquatic vegetation exist, there would also be anticipated impacts to species of wildlife that nest, forage, and otherwise utilize that habitat for all or portions of their life cycles. Impacts to ESA species or designated/proposed critical habitat could require increased regulatory compliance. In addition, storage/reservoir conditions may favor not-native species establishment and/or expansion. High flows are an important part of the streamflow regime and do much geomorphological work, which contributes to maintaining riparian and aquatic conditions in many ways. For instance, high flows and maintenance of riffle conditions are an important function in many aquatic

species reproductive cycles. Removal of a portion of the high flow regime could impact ecological response in ways that would require considerable study to fully delineate.

There may be localized benefit due to increased bank storage, groundwater storage, and/or reduced pumping requirements.

Legal and Institutional Issues

Would have to meet requirements of floodplain ordinances, grading permits and right of ways. WIFA funding may be available. May require approval by the ACC. Requirements under the State Historic Preservation Act and Arizona Native Plant Laws would apply. Assured and Adequate Water Supply, Colorado River Water Transfers, Supervision of Dams, Reservoirs and Projects, Surface Water Appropriation and Regulation, and Water Exchanges rules would apply. Would have to meet Arizona Pollutant Discharge Elimination System requirements. Potable water deliveries would be subject to Potable Water facilities, SDWA and Water Treatment regulations. Would have to comply with the Boulder Canyon Project Act. If Federal lands are crossed or if Federal funding is used, all NEPA requirements must be satisfied. Any new appropriation for surface water would be subject to existing Federal Reserved Rights for Indian Tribes that have been settled in the Gila River General Stream Adjudication. Pipeline alignments would be subject to Native American Graves Protection and Repatriation Act. This alternative will require coordination with Salt River Project as the operator of Bartlett and Horseshoe Reservoirs and consultation with the federal government regarding Safety of Dams requirements.

Public Perception

Feasibility of dam modification. Legal availability of appropriated and unappropriated surface water. Reliability of spilled surface water supplies. Physical availability for water storage. Increased seepage, increased evaporation losses, land ownership, liability, modified operation of expanded reservoirs. Complexity of water accounting, water rights, and exchanges. Unquantified tribal rights or claims. Pending surface water adjudication. Negative perception of building and/or expanding surface water reservoirs and potential denial of voter approval for financing and construction of proposed water development projects.

Cost

Alt #	Description of Alternative	Volume (AF/yr)	Costs[1]				
			Field Cost ($)	Ammortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
7.1	Capture & Store Unappropriated Verde River–Bartlett Dam & Conceptualized Upstream Catchment A	10,000	166,981,000	7,940,100	1,923,800	986	3.03
7.1	Capture & Store Unappropriated Verde River–Bartlett Dam & Conceptualized Upstream Catchment B	25,000	345,877,000	16,446,800	4,888,000	853	2.62
7.1	Capture & Store Unappropriated Verde River–Bartlett Dam & Conceptualized	45,000	570,108,000	27,109,200	8,378,350	789	2.42

[1] The cost for alternatives 7.1 and 7.2 may be additive to the costs in 7.3 and 7.4. In order for water credits to be available during non-spill events, the water must be first be captured downstream and "banked" during a spill event, Water could then be stored in the upstream reservoirs and used as needed regardless of a real time spill condition.

	Upstream Catchment C						
7.2	Capture & Store Unappropriated Verde River–Horseshoe Dam & Conceptualized Upstream Catchment A	10,000	157,956,000	7,511,000	1,923,000	943	2.90
7.2	Capture & Store Unappropriated Verde River–Horseshoe Dam & Conceptualized Upstream Catchment B	25,000	335,785,000	15,966,900	4,887,995	834	2.56
7.2	Capture & Store Unappropriated Verde River–Horseshoe Dam & Conceptualized Upstream Catchment C	45,000	559,746,000	26,616,500	8,378,350	778	2.39
7.3	Sullivan Dam	2,240	48,229,000	2,293,300	480,640	1,238	3.80
7.4	Page Springs	2,240	44,664,000	2,123,800	488,040	1,166	3.58

Evaluation

Acceptability

Effectiveness

Efficiency

Completeness

Findings

Water Supply Alternative Evaluation
Alt. #8 Rainwater Harvesting-Aquifer Storage

Description

This alternative evaluates a variety of rainwater harvesting methods to capture rainwater that would normally be lost to evaporation and transpiration. The methods evaluated in this alternative are considered large-scale, or macro-rainwater harvesting methods, that capture storm water and re-direct a portion of the rainwater to recharge facilities. It assumes that the water gathered via rainwater harvesting efforts is water that would not be considered appropriable as surface water. Under current state law there is no provision that would recognize this distinction. For each alternative, the rainwater that is harvested is gathered at numerous smaller locations (lots) and then transmitted to another location for recharge and recovery. There were two general categories of rainwater harvesting considered in this alternative. The first is harvesting from developed areas such as existing residential and commercial properties. The second is harvesting from undeveloped areas that have land surfaces modified via compaction to increase runoff from storm events.

In this alternative, there were 10 water harvesting scenarios developed for specific lots that differ by lot location, lot size, the amount of development on the lot (pervious versus impervious versus pervious made impervious land surfaces), existing infrastructure and proposed infrastructure improvements. For each scenario, the horizontal land surface, nature of the land surface, and rainfall records were used to estimate the annual volume of rainwater that could be harvested based on a collective 12 lot sample wherein the lots were physically linked through lateral and collector infrastructure improvements. There was no attempt to evaluate impacts to downstream water right holders.

The WPAs evaluated in this alternative are Prescott Valley, Chino Valley, Prescott and Prescott CCD. However, this alternative is applicable to all WPAs.

Environmental Issues

Developed Areas

The collection of rainwater from developed areas may provide some benefit to the environment if direct uses of groundwater and surface water can be offset or alleviated. Although overall effect to the environment is considered minimal, water quality may still be a concern, whether water is collected in cisterns or recharged underground.

Undeveloped Areas

Although some benefit to the study area would be derived if direct use of groundwater is offset with additional supplies, the environmental issues associated with land surface and/or vegetation treatment for the capture of water that would otherwise evapotranspire in the water cycle is not clear, and could be significant. Land surface disturbance has the potential to impact vegetation and wildlife species and their habitats. There are also indirect affects to consider including changes to micro-climate affecting soil, vegetation attributes, disturbed trophic-level interactions, and life cycle elements needed for species viability. Much additional study is needed to determine how redirecting water from the natural water cycle might directly or indirectly affect species, communities, and ecosystem function. In addition, disturbed land surfaces may cause non-native species proliferation which then impacts native plants and wildlife.

Legal and Institutional Issues

Would have to meet requirements of floodplain ordinances, grading permits and right of ways. WIFA funding may be available. Requirements under the State Historic Preservation Act and Arizona Native Plant Laws would apply. May be subject to Regional Water Quality Management Planning (208) authority requirements. Depending on the outcome of the general adjudication of surface water rights, could be subject to adjudication requirements. Assured and Adequate Water Supply; Groundwater Use Authority inside AMA; NOI; Supervision of Dams, Reservoirs and Projects; Surface Water Appropriation and Regulations; Underground Water Storage, Savings, and Replenishment Act; and Well Spacing Rules

could apply. Would have to meet Arizona Pollutant Discharge Elimination System, Aquifer Protection Permit, and Aquifer Water Quality Standard requirements. If Federal lands are crossed or if Federal funding is used, all NEPA requirements must be satisfied. May be subject to Federal Reserved Rights for Indian Tribes and Native American Graves Protection and Repatriation Act. Macro-rainfall harvesting would require change in state surface water law.

Public Perception

Legal availability of appropriated and unappropriated surface water. Complexity of water accounting, water rights, and exchanges. Unquantified tribal rights or claims. Pending surface water adjudication. Negative perception and potential denial of voter approval for financing and construction of proposed water development projects. Enhanced benefit to aquifer that is accountable. Quantifiable benefits. High risk of potential return on investment.

Cost

Alt #	Description of Alternative	Volume (AF/yr)	Costs				
			Field Cost ($)	Ammortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
8	Rainwater Harvesting – Aquifer Storage Scenario 1	18	374,555	17,800	17,416	4,389	13.47
8	Rainwater Harvesting – Aquifer Storage Scenario 2	21	537,127	25,600	17,695	4,805	14.74
8	Rainwater Harvesting – Aquifer Storage Scenario 3	21	522,611	24,800	17,620	3,691	11.33
8	Rainwater Harvesting – Aquifer Storage Scenario 4	22	538,440	25,600	17,620	3,161	9.70
8	Rainwater Harvesting – Aquifer Storage Scenario 5	16	503,899	23,900	17,009	4,328	13.28
8	Rainwater Harvesting – Aquifer Storage Scenario 6	13	707,801	33,700	16,463	8,370	25.69
8	Rainwater Harvesting – Aquifer Storage Scenario 7	11	536,367	25,500	16,389	6,796	20.77
8	Rainwater Harvesting – Aquifer Storage Scenario 8	36	1,366,057	65,000	18,241	5,449	16.72
8	Rainwater Harvesting – Aquifer Storage Scenario 9	48	732,563	34,900	19,408	1,746	5.36
8	Rainwater Harvesting – Aquifer Storage Scenario 10	35	1,369,999	65,100	18,241	5,571	17.10

Evaluation

Acceptability

Effectiveness

Efficiency

Completeness

Findings

Water Supply Alternative Evaluation
Alts. 10 & 11- Surface Water in Alamo Lake and Colorado River water via Alamo Lake, Diamond Creek, Lake Mead, Lake Havasu, Lake Mohave and Lake Powell

Description

This alternative proposes use of surface water obtained from outside of the study area in the volume of 42,379 AF/yr. Alternative 10 proposes delivery of water from Alamo Lake via pipeline. The variations of Alternative 11 propose delivery of water from the Colorado River via pipelines from several different locations: Alamo Lake, Diamond Creek, Lake Mead, Lake Havasu, Lake Mohave and Lake Powell. The WPAs considered in this alternative are those that show a 2050 water supply deficit with the exception of Jerome and rural WPAs that are primarily served from private domestic wells. The following WPAs were not included within this alternative: Jerome, Verde CCD, Prescott CCD, Mingus Mountain CCD, Humboldt CCD and Ashfork CCD.

Environmental Issues

The importation of water supplies to meet the 2050 deficit is anticipated to provide overall environmental benefit to the study area, and specifically to each basin where water in imported. Augmenting water supplies may help sustain groundwater contributions to streams, provides an alternative to local groundwater pumping, and protects vegetation, wildlife and aquatic species. There may be an impact to water quality but the environmental concerns would be minimal because it is assumed that imported water will be treated. This environmental review only considered environmental issues within the study area. Further environmental review would be required outside the study area to address impacts from removing and piping surface water supplies from Alamo Lake, Diamond Creek, Lake Mead, Lake Havasu, Lake Mohave and Lake Powell.

Legal and Institutional Issues

Would have to meet requirements of floodplain ordinances, grading permits and right of ways. May be subject to Regional Water Quality Management Planning (208) authority requirements. Requirements under the State Historic Preservation Act and Arizona Native Plant Laws would apply. Assured and Adequate Water Supply, Colorado River Water Transfers, and Water Exchanges rules could apply. Would have to meet Arizona Pollutant Discharge Elimination System requirements. Potable water deliveries would be subject to Potable Water Facilities, SDWA and Water Treatment regulations. Boulder Canyon Project Act could apply. If Federal lands are crossed or if Federal funding is used, all NEPA requirements must be satisfied. May be subject to Federal Reserved Rights for Indian Tribes, Native American Graves Protection and Repatriation Act and Tribal rights-of-way.

Public Perception

Legal availability of appropriated and unappropriated surface water. Complexity of water accounting, water rights, and exchanges. Unquantified tribal rights or claims. Pending surface water adjudication. Surface water impacts. Surface water quality. Negative perception and potential denial of voter approval for financing and construction of proposed water development projects. Quantifiable benefits. High risk of potential return on investment. Perception of adequate current water supplies and the need for additional water supplies. Perception that augmenting current supplies will result in increased population.

Cost

Alt #	Description of Alternative	Volume (AF/yr)	Costs				
			Field Cost ($)	Ammortized Annual Cost ($)	Annual O&M Cost ($)	Annual Cost per AF ($/AF)	Annual Cost per Thousand ($/Kgal)
10	Alamo Lake	42,379	895,515,610	42,582,700	11,744,870	1,282	3.93
11	Colorado River via Alamo Lake	42,379	895,515,610	42,582,700	11,744,870	1,282	3.93
11	Colorado River via Diamond Creek	42,379	1,028,225,962	48,893,200	12,243,356	1,443	4.43
11	Colorado River via Lake Mead	42,379	1,447,553,494	68,832,600	14,700,056	1,971	6.05
11	Colorado River via Lake Havasu	42,379	1,397,988,786	66,475,800	13,966,410	1,898	5.83
11	Colorado River via Lake Mohave	42,379	1,273,716,646	60,566,500	14,709,294	1,776	5.45
11	Colorado River via Lake Powell	42,379	1,161,614,426	55,235,900	12,722,029	1,605	4.92

Evaluation

Acceptability
Effectiveness
Efficiency
Completeness

Findings

Central Yavapai Highlands Water Resources Study
Water Supply Alternatives
Evaluation Process

Study Purpose
The intent of this study is to identify water resources and water management strategies that include a range of alternatives designed to meet future water supply needs of communities in the Central Yavapai Highlands, Arizona.

Alternative Evaluation
Based on the information generated in the analysis phase, the study partners, in accordance with the Federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&Gs), will evaluate the viability of each alternative. Originally established as guidance for conducting studies in 1983, the "four tests of viability" have traditionally been applied as a screening tool to identify alternatives to screen options for fatal flaws.

A fatal flaw is defined as; "Any problem, lack, or conflict (real or perceived) that will destroy a solution or process. A negative effect that cannot be offset by any degree of benefits from other factors."

For an alternative to be viable, it will require that it passes all four tests of viability. Each test is answered with" yes" or "no" and with a brief explanation of why.

These four tests include the following:

Acceptability
The workability and viability of the alternative with respect to acceptance by state and local entities and the public, and compatibility with existing laws, regulations, and public policies. *(Refer to the Legal & Institutional and Public Perception documents)*

Effectiveness
The extent to which an alternative plan solves the specified problems and achieves the specified opportunities as stated in the Study purpose and need. *(How reliable is the supply/system?)*

Efficiency
The extent to which an alternative plan is a cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment. *(Is it worth the money and effort? Use the Cost/Volume Table and Environmental Analysis document)*

Completeness
The extent to which the alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. This may require linking the plan to other public or private plans if the other plans are crucial to realizing the objective. Each alternative is analyzed to assess whether it would respond to the Study purpose and objectives as a stand-alone project, without further investments or implementation of other plans not assumed to already be in place. *(Could it stand alone or is it dependent on another project or infrastructure?)*

Central Yavapai Highlands Water Resources Management Study
Environmental Considerations related to Water Supply Alternatives

This document contains a brief description followed by an environmental-issues table for each alternative under consideration for meeting future unmet water demands in the CYHWRMS study area. The table contains hydrologic, biologic, and watershed categories. The effect on these categories is classified as positive (+), negative (-), or neutral (0). A notes column provides some explanation of the rationale for effect.

This environmental considerations analysis will be assessing environmental issues and impacts within the study area only. Water development outside the study area would require additional environmental assessment relative to impacts to those areas where water is derived from, including ground water and/or surface water sources.

Alternative 1
Local Groundwater Development (within each WPA)

This alternative proposes the continued use and development of groundwater supplies within each of the water planning areas to meet all of their future municipal water demand.

For municipal demand, each Water Planning Area (WPA) was analyzed to determine what percentage is provided by a water provider or by private domestic wells. It is presumed that groundwater in rural areas is generally accessed by private domestic wells (exempt wells). Urban areas are generally served by water providers of varying sizes with non-exempt wells. The proportion of non-exempt wells and exempt wells reflect an approximation of rural and urban populations in each planning area. It is assumed that the present pattern for rural or urban areas will be similar in future growth.

Local groundwater development in the Prescott AMA will be more limited than in the rest of the study area. State law prohibits future subdivision growth based on local groundwater development, although growth will likely continue on a limited number of subdivision lots that were platted prior to the 1999 Groundwater Mining Declaration and on lot-splits supplied by exempt wells.

Alternative 1. Local Groundwater Development (within each WPA)

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	**0/-**	Diminished flow reduces mixing and oxygen levels which affects fish and aquatic species. Possible site specific consideration to quality parameters,

		including temperature.
Impact to Streamflow	-	Eventual reduction of base flow where there is a GW-SW connection
Impact to Groundwater Availability	-	Lowers water table, reduces amount of recoverable groundwater in areas of pumping
Biologic		
Impact to Vegetation	-	Eventual reduction of riparian habitat, and may include other vegetative communities (phreatophytes).
Impact to Wildlife (Riparian-Obligate)	-	Habitat loss to riparian species
Impact to Fish/Aquatic Species	-	Habitat loss to aquatic species from changes in base-flow, stream flow magnitude, duration and flooding events
Watershed		
Impact to Watersheds	**0**	Potential increase in ephemeral & intermittent stream segments. Land subsidence (minimal)

Alternative 2
Regional Groundwater Development within the Study Area – Big Chino Sub-basin Pipelines to Prescott AMA and Verde Valley

This alternative considers regional groundwater development for the Prescott AMA, specifically the Prescott Valley, Chino Valley and Prescott WPAs from the Big Chino Sub-basin. A second alternative considers regional groundwater development for the Verde Valley, specifically the Clarkdale, Cottonwood, Sedona, Big Park, Lake Montezuma and Cottonwood-Verde Village WPAs from the Big Chino Sub-basin.

The Prescott AMA alternative provides water to the planning area based on Arizona legislation ARS Sec. 45-555. The total volume of water described in ARS Sec. 45-555(E) allows a city or town in the Prescott AMA to withdraw and transport 8,068 AF/YR from the Big Chino sub-basin. Additionally, Chino Valley has requested that 4,400 AF/YR be included in this alternative. Therefore, for the purposes of groundwater development for the Prescott AMA, 12,468 AF/YR of groundwater was used for this alternative. Since Prescott has purchased a 4,500-acre property 18 miles northwest of Paulden (The Big Chino Water Ranch) for purposes of locating a well field, it is assumed that the well field would be located at the Water Ranch.

The second alternative for the Verde Valley was considered since the alternatives needed to address the future water supply needs of all the WPAs and not only for the ones that applied for legislative authority. Therefore, for the purposes of groundwater development for the Verde Valley, 12,382 AF/YR of groundwater was used for this alternative. It is also assumed that the well field would be located at the Big Chino Water Ranch.

Alternative 2. Regional Groundwater Development within the Study Area

Environmental Issues (+) or (-) Affect, or Minimal (0)	Assumes Mitigation* for Maintaining Base flow	Assumes NO Mitigation and Pumping Impacts Stream	Notes
Hydrologic			
Impact to Water Quality	**0/-**	**-**	Diminished flow reduces mixing and oxygen levels which affects fish and aquatic species. In lieu mitigation water may be of lower quality than GW supported springs.
Impact to Streamflow	**0**	**-**	Eventual reduction of base flow where there is a GW-SW connection
Impact to Groundwater Availability	**-**	**-**	Within the sub-basin where pumping occurs, and down-gradient sub-basin if GW underflow exists.
Biologic			

Impact to Vegetation	**0**	**-**	Reductions in GW may affect SW flows, and eventual reduction of riparian habitat, and may include other vegetative communities (phreatophytes).
Impact to Wildlife (Riparian-Obligate)	**0**	**-**	Negative effects with loss of riparian vegetation
Impact to Fish/Aquatic Species	**0/-**	**-**	Habitat loss to aquatic species from changes in base-flow, stream flow magnitude, duration and flooding events Also depends if mitigation impacts water quality. Mitigated water supplies may include water of lower quality than what is being lost (replaced).
Watershed			
Impact to Watersheds	**0**	**0**	Impact dependent on level/type of mitigation. Positive or negative effects are very difficult to discern at this level. Expect benefits to basin where water is transported; sustains groundwater contribution to streams, helps reach safe-yield, provides alternative to exempt wells.

* Mitigation is based on An Agreement in Principle among the City of Prescott, the Town of Prescott Valley, and the Salt River Valley Water Users' Association and the Salt River Project Agricultural Improvement and Power District. The agreement is titled: *Withdrawal and Use of Water from the Big Chino Sub-Basin and the Protection of Stream Flow in the Upper Verde River.*

The Communities agree that in the event the withdrawal of water from the Big Chino Sub-Basin is negatively affecting the minimum flow of water in the Upper Verde River, they will mitigate such impact proportionately to the extent of the effect of their combined withdrawals on the Upper Verde River as compared to the effect of the withdrawals by other water users in the Big Chino aquifer.

Alternative 3
Regional Groundwater Development outside the Study Area

The Bill Williams Sub-basin and Big Sandy Sub-basin alternatives deliver water to the planning areas from the two separate groundwater basins. A conceptualized well field is assumed to be placed in the river bed alluvium and the total 2050 water supply deficit of 42,379[1] AFY of water delivered through a transmission line that follows along major roadways.

Alternative 3. Regional Groundwater Development outside the Study Area - Impacts assessed to watershed within study area

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	**0/-**	Assume imported water will be treated but concerns with greater mineral content from outside sources.
Impact to Streamflow	**+**	This alternative assumes import of the total 2050 projected water supply deficit. Benefits anticipated from a decreased need to utilize water supplies from within Study Area.
Impact to Groundwater Availability	**+**	Same
Biologic		
Impact to Vegetation	**+**	Same
Impact to Wildlife (Riparian-Obligate)	**+**	Same
Impact to Fish/Aquatic Species	**+**	Same
Watershed		
Impact to Watersheds	**+**	Same

[1] Water Supply deficit as calculated in Phase 1 Demand Analysis; Status Quo Method.

Alternative 4.1
Conversion of Existing Septic Systems (Urban)

This alternative proposes converting existing septic systems to sewer service resulting in increased availability of effluent for reuse and/or recharge, specifically in urban areas. For the purposes of this discussion only, urban areas are those serviced by a water provider.

Two "uses" of the additional effluent will be considered. Direct use will consist of irrigation that replaces a particular volume of an existing water source. Indirect use will include recharge into the groundwater system.

Each WPA has treatment facilities that produce different classes or quality of effluent from Class B to Class A+. The assumption is that any expansion of treatment facilities (Groups A & B) will continue with the same Class of water. However, there is an alternative or option to upgrade the treatment facility to improve the effluent quality. Also, the construction of a new treatment facility (Group C) will be Class A+ water.

It is assumed that an existing facility does not need added capacity until it has reached 80% design capacity. There are 3 categories or scenarios:

Group A – existing wastewater treatment facility can accommodate additional capacity

Group B – existing wastewater treatment facility will need to build additional capacity

Group C – a new wastewater treatment facility is required

Alternative 4.1. Conversion of Existing Septic Systems to Sewer System (Urban)

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	+	The assumption is that the treated effluent would either be reused or recharged; not discharged into a stream, so the location of recharge would dictate the level of effect if any on stream water quality. Treated effluent is typically better quality than septic tank leachate, so local water quality could also be improved from baseline due to removal of septic systems. Concerns with water quality and biologic impacts from emerging contaminants; many studies have shown a detrimental impact of ECs on fish, in very low concentrations. Sewering septic tanks should improve treatment levels and hence result in lower ECs in the effluent, BUT the end use may be changing (discharge points, depth to groundwater).

Impact to Streamflow	+	Reuse replaces part of the GW demand, which reduces capture of base flow. If treated water is recharged, additional GW is available to support base flow; recharge can be located to optimize this effect.
Impact to Groundwater Availability	+	Reuse replaces part of the GW demand, recharge augments GW availability.
Biologic		
Impact to Vegetation	0/+	Minimal, but could be positive if decreased GW demand due to reuse results in reduced GW level decline and if recharge facilities are located to optimize augmentation of streamflow and riparian groundwater levels.
Impact to Wildlife (Riparian-Obligate)	0/+	Same as above
Impact to Fish/Aquatic Species	+/-	The assumption is that the treated effluent would either be reused or recharged; not discharged into a stream, so the location of recharge would dictate the level of effect if any on stream water quality. Local water quality could be improved from baseline due to removal of septic systems. Fish/aquatic species could benefit from increased reuse (decreased GW demand=decreased capture) and streamflow augmentation from appropriately located and designed recharge facilities. Possible negative impact to water quality and fish/aquatic species depending on level of wastewater treatment and where effluent is recharged.
Watershed		
Impact to Watersheds	0	

Alternative 4.2
Conversion of Existing Septic Systems (Rural)

This alternative proposes converting existing septic systems to sewer service specifically in rural areas. For the purposes of this discussion, rural areas are those outside of a water provider service area and sewer service area.

The new or additional available effluent will only be of value if it reduces demand for another water supply or provides a new water supply. Two "uses" of the additional available effluent will be considered. Direct use will consist of irrigation that replaces a particular volume of an existing water source. Indirect use will include recharge into the groundwater system. The type of treatment and resulting cost will depend on the desired use. However, for this alternative, the cost estimate will be based on a facility that produces Class A+ effluent.

Alternative 4.2. Conversion of Existing Systems (Rural)

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	+	Eliminates poorly treated discharge from septic systems. Low density systems typically not quality concern although localized conditions may preexist (i.e. high groundwater, near aquatic resources). Concerns with water quality and biologic impacts from emerging contaminants; many studies have shown a detrimental impact of ECs on fish, in very low concentrations. Sewering septic tanks should improve treatment levels and hence result in lower ECs in the effluent, BUT the end use may be changing (discharge points, depth to groundwater).
Impact to Streamflow	0/+	Minimal due to low density. Reuse replaces part of GW demand, which reduces capture of base flow. If treated water is recharged, additional GW is available to support base flow; recharge can be located to optimize this effect.
Impact to Groundwater Availability	0/+	Minimal due to low density. However, large numbers of conversions and targeted recharge could have positive effects on groundwater.
Biologic		
Impact to Vegetation	0/+	Minimal due to low density. But could be positive if decreased GW demand due to reuse results in reduced GW level decline and if recharge facilities are located to optimize augmentation of

		streamflow and riparian GW levels.
Impact to Wildlife (Riparian-Obligate)	**0/+**	Same as above
Impact to Fish/Aquatic Species	**+/-**	The assumption is that the treated effluent would either be reused or recharged; not discharged into a stream, so location of recharge would dictate the level of effect if any on stream water quality. Local water quality could be improved from baseline due to removal of septic systems. Fish/aquatic species could benefit from increased reuse (decreased GW demand=decreased capture) and streamflow augmentation from appropriately located and designed recharge facilities. Possible negative impact to water quality and fish/aquatic species depending on level of wastewater treatment and where effluent is recharged.
Watershed		
Impact to Watersheds	**0**	

Alternative 5
Existing Unused Effluent and/or Capacity

Although most facilities in the study area do use effluent for some purpose, there are facilities where some or all the effluent is unused. For the purposes of this discussion unused effluent is defined as effluent that is passively disposed of. Effluent that is evaporated or discharged into a wash is considered unused. This alternative proposes utilizing effluent that is presently unused. Five WPAs currently have unused effluent: Cottonwood, Camp Verde, Clarkdale, Jerome and Sedona.

However, formal agreements to provide effluent to an area or body of water are interpreted as utilized. Big Park WPA is the only one instance of effluent being utilized because of a formal agreement. Big Park Domestic Wastewater Improvement District has an agreement with the Forest Service to discharge a particular volume of effluent down a tributary of Jack's Canyon Wash.

Two "uses" of the additional effluent will be considered. Direct use will consist of irrigation that replaces a particular volume of an existing water source. Indirect use will include recharge into the groundwater system. The type of treatment and resulting cost will depend on the desired use. For this alternative the cost estimate will be based on a facility that produces Class B with an option to upgrade to Class A+.

Alternative 5. Existing Unused Effluent and/or Capacity

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	**0/-**	Water quantity issues more of issue when removing effluent that currently supports perennial or aquatic habitats. However, concerns with water quality and biologic impacts from emerging contaminants; many studies have shown a detrimental impact of ECs on fish, in very low concentrations. Water quality is also a concern when treating for human uses. Assume that reuse/recharge of unused effluent may require a higher level of treatment.
Impact to Streamflow	**-**	Streams dependent upon effluent discharge to support flow/aquatic/riparian habitats may be impacted where use of effluent will instead be used to meet projected demands.
Impact to Groundwater Availability	**+**	Positive influence on water table, due to reduction in pumping demands - if this offsets future GW development

Biologic		
Impact to Vegetation	-	negative from potential loss of effluent currently discharged into drainage; positive where future pumping demands are reduced
Impact to Wildlife (Riparian-Obligate)	-	negative from loss of effluent currently discharged into drainage; positive where future pumping demands are reduced
Impact to Fish/Aquatic Species	-	negative from loss of effluent currently discharged into drainage; positive where future pumping demands are reduced
Watershed		
Impact to Watersheds	-	Impacts to stream habitats from reuse of effluent may negatively impact overall health and function of watersheds.

Alternative 6
New Effluent from New Population

This alternative estimates the volume of new effluent generated from new population in 2050. New population is the difference between the population in 2006 and 2050.

The volume of effluent generated from the new wastewater is presented as a range of possible values. The high estimate assumes that all new wastewater is captured in a sewer system for treatment, reuse and/or recharge. A more realistic volume takes into account the percentage of population in the region served by wastewater treatment facilities (WWTFs). In 2002 the Northern Arizona Council of Governments (NACOG) Section 208 Plan estimated that 45% of the population in Yavapai County was served by WWTFs. That percentage (45%) is utilized in this study for the conservative estimate. The two exceptions are Cottonwood at 60% and Prescott Valley at 100%.

Two "uses" of the additional effluent will be considered. Direct use will consist of irrigation that replaces a particular volume of an existing water source. Indirect use will include recharge into the groundwater supply. The amount of treatment and resulting cost will depend on the desired use.

Each Water Planning Area has treatment facilities that produce different classes or quality of effluent from Class B to Class A+. The assumption is that any expansion of treatment facilities (Groups A & B) will continue with the same Class of water. However, there is an alternative or option to upgrade the treatment facility to improve the effluent quality. Also, the construction of a new treatment facility (Group C) will be Class A+ water.

It is assumed that an existing facility does not need added capacity until it has reached 80% design capacity. There are 3 categories or scenarios:
Group A – existing wastewater treatment facility can accommodate additional capacity
Group B – existing wastewater treatment facility will need to build additional capacity
Group C – a new wastewater treatment facility is required

Alternative 6. New Effluent from New Population

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	**0/-**	Direct use of new effluent supplies, when considered solely is not anticipated to negatively impact environmental resources. Assume that reuse/recharge of unused effluent may require a higher level of treatment. Concerns with water quality from emerging contaminants, whether treating for human uses or

		using as mitigated/alternate sources for the environment.
Impact to Streamflow	+	Offsets some development of other water resources
Impact to Groundwater Availability	+	Could have benefit to groundwater availability because pumping could be reduced from new uses/volumes of effluent available. Impact to GW would be (+) if effluent is recharged.
Biologic		
Impact to Vegetation	+	Benefits anticipated from the offset of stream impacts from development of other uses. Likewise recharge benefits to groundwater could also benefit biologic and watershed conditions.
Impact to Wildlife (Riparian-Obligate)	+	Benefits anticipated from the offset of stream impacts from development of other uses. Likewise recharge benefits to groundwater could also benefit biologic and watershed conditions.
Impact to Fish/Aquatic Species	+	Benefits anticipated from the offset of stream impacts from development of other uses. Likewise recharge benefits to groundwater could also benefit biologic and watershed conditions.
Watershed		
Impact to Watersheds	+	Benefits anticipated from the offset of stream impacts from development of other uses. Likewise recharge benefits to groundwater could also benefit biologic and watershed conditions.

Alternative 7
Capture and Store Unappropriated Verde (or Tributary) Flood Water

This alternative proposes capturing unappropriated floodwater from the Verde River drainage area that is occasionally available when all downstream senior water rights are being satisfied and storage is being exceeded at SRP's reservoirs.

Four options to capture unappropriated floodwater were identified for evaluation increasing the height of Bartlett Dam, increasing the height of Horseshoe Dam, in-stream storage and off-stream storage. The options of increasing the height of the dams would require in-stream or off-stream storage in strategic locations upstream of the dams to capture and store water for distribution to the areas where it is needed.

Alternative 7. Capture and Store Verde (or Tributary) Flood Water

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	**0/-**	Addition of storage reservoirs (in-stream or off-stream) may impact water temperature, turbidity, siltation, and downstream effects.
Impact to Streamflow	**-**	The hydrologic regime would be altered from natural conditions by capturing and storing a portion of high flows, which removes that water from the stream. If its mainstem storage, negative impact would be larger, but tributary storage would also have negative impact.
Impact to Groundwater Availability	**0/+**	Localized benefit due to increased bank storage, and/or reduced pumping requirements. GW availability may improve due to infiltration of stored water.
Biologic		
Impact to Vegetation	**-**	Within area of conservation storage, vegetation will be impacted. Although some vegetation may be inundated by the storage, edges will develop a riparian zone that may offset some impacts to areas of inundation. However, creation of edge habitat surrounding a reservoir (vs. native stream system) may increase conditions for establishment of non-native vegetation. Recruitment and survival of riparian vegetation is linked to high flows; removal of a portion of those flows could have a negative impact.

Impact to Wildlife (Riparian-Obligate)	-	Removal of a portion of the high flows would negatively impact recruitment and survival of riparian vegetation and hence would impact the species that nest, forage, and otherwise utilize that habitat for all or portions of their life cycles. Impacts to ESA species or designated/proposed critical habitat could require increased regulatory compliance.
Impact to Fish/Aquatic Species	-	Storage/reservoir conditions may favor non-native species expansion. High flows are an important part of the streamflow regime and do much geomorphological work, which contributes to maintaining riparian and aquatic conditions in many ways. High flows and maintenance of riffle conditions are an important function in many aquatic species reproductive cycle. Removal of a portion of the high flow regime could impact ecological response in ways that would require considerable study to fully delineate.
Watershed		
Impact to Watersheds	**-/0**	Dependent upon placement of capture reservoirs within watershed, downstream impacts of hydrologic and biologic function could be anticipated. Overall watershed function may be altered from the upstream placement of reservoirs.

Alternative 8 Storm Water –Macro Water Harvesting

The general water harvesting concept represented by this alternative involves capturing precipitation before it enters surface water channels and recharging it into the regional aquifer or utilizing it locally.

This water harvesting alternative includes the concept of capturing water that would otherwise evaporate. The term "Macro-Rainwater Harvesting" refers to rainwater harvesting on a larger scale. In this alternative, we consider two general categories of macro-rainwater water harvesting activities:

8.1 Rainwater harvested from developed areas
8.2 Rainwater harvested from undeveloped areas

8.1 Rainwater Harvested from Developed Areas

The concept of this category is to take water captured from developed areas and convey it to optimal recharge areas or to be used for on-site irrigation. Harvested water in residential and commercial areas would originate from impermeable surfaces such as rooftops, driveways, parking lots, sidewalks and roads. Precipitation could be captured by using surface or sub-surface methods. Any one particular developed property may be a relatively small area but the accumulation of many developed properties could be relatively large in area.

One example that has been quantified is the potential water captured from roof-tops during average rainfall events and storing it in cisterns or barrels and using it in close proximity to where it was captured. It was done for all building roof-tops, buildings 50,000 sq. ft or more, 100,000 sq. ft or more and residential buildings.

Alternative 8.1. Rainwater Harvested from Developed Areas

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	**0/-**	The quality of water in cisterns is likely to vary significantly and there could be health issues. Community cisterns may fair better, but water quality may still be an issue. Overall affect to environmental resources may be minimal, considering outside/landscape uses.
Impact to Streamflow	**0/+**	Depends on quantity of urban water capture/use. Anticipate that less water pumped from aquifer, benefiting streamflow. Runoff & recharge transpiration could be affected, and should be evaluated in further review.

Impact to Groundwater Availability	+	Anticipated benefit from reduced need to utilize water supplies (GW/SW) for landscape/outside purposes.
Biologic		
Impact to Vegetation	+	Less water pumped
Impact to Wildlife (Riparian-Obligate)	+	Less water pumped
Impact to Fish/Aquatic Species	+	Less water pumped
Watershed		
Impact to Watersheds	+	Less water pumped

8.2. Rainwater Harvested from Undeveloped Areas

Macro-rainwater harvesting from undeveloped areas include concepts such as subsurface capture, land surface treatment and vegetation treatment. All of the above concepts are based on the premise that ultimately, these flows, if not harvested, would be subject to evaporation and/or evapotranspiration.

The general concept behind subsurface capture is to collect water from shallow saturated soils via underground systems prior to evaporation caused by capillary action in finer soils. Capillary action and subsequent evaporation of saturated soils can take place within 1-1.5 meters of surface soils.

Land surface treatment involves concepts such as compaction of land, re-grading of land, or material application to lands to create conditions of increased runoff from storm events.

Vegetation treatment as envisioned in this alternative is mostly vegetation management and includes concepts such as forest thinning, fire utilization, juniper removal, etc. It is intended to reduce ET and create conditions where some of the water recharges the aquifer through natural processes.

8.2. Rainwater Harvested from Undeveloped Areas

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	+/-	Concentrated constituents could be captured and treated to avoid surface water or GW contamination. Impact may be negative since treatment is uncertain and could differ from place to place.

Impact to Streamflow	**+/-**	Under above definition, use of captured water could reduce pumping and/or surface water diversion. However, it's unlikely that there are areas where sheet flow makes zero contribution to vegetation, surface water or infiltration. For example, except for the component of rainfall that lands directly in gullies, the rainwater that gets into gullies gets there via sheet flow.
Impact to Groundwater Availability	**+/-**	Same as above - increase water table
Biologic		
Impact to Vegetation	**-**	May cause non-native proliferation in disturbed areas.
Impact to Wildlife (Riparian-Obligate)	**-**	More evidence required to understand direct or indirect impacts to riparian-obligate wildlife species.
Impact to Fish/Aquatic Species	**-**	More evidence required to understand direct or indirect impacts to Fish/Aquatic wildlife species.
Watershed		
Impact to Watersheds	**-**	Changing micro-climate affecting soil, vegetation and attributes of landscape, can impact plants and animals through disturbed trophic-level interactions.

Alternative 9 Conservation

This alternative proposes to improve water efficiency which is the simplest, most effective way of conserving water. Conservation programs such as high efficiency toilets, xeriscaping, hot water recirulation, waterless urinals, rainwater harvesting, public ordinances for new development and public education are just some of the programs that can be implemented.

Conservation measures were built in to the Phase I Demand Analysis portion of the Appraisal Report by providing the opportunity for each of the individual WPAs to reduce their GPCD rate in 2050. However, there were no common guidelines for the reduction and the lowering of the GPCD rates were done inconsistently. It is difficult to give an overall average of how much additional future water this alternative could conserve since the WPAs' reduction of their 2050 GPCD rates were more drastic in some than others.

Alternative 9. Conservation

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	+	Less water pumped
Impact to Streamflow	+	Less water pumped
Impact to Groundwater Availability	+	Less water pumped
Biologic		
Impact to Vegetation	+	Less water pumped
Impact to Wildlife (Riparian-Obligate)	+	Less water pumped
Impact to Fish/Aquatic Species	+	Less water pumped
Watershed		
Impact to Watersheds	+	Less water pumped

Alternative 10 & 11 Surface Water Outside the Study Area
Alamo Lake & Colorado River via Alamo Lake, Diamond Creek, Lake Mead, Lake Havasu, Lake Mohave, Lake Powell

Both of these alternatives propose delivering the total 2050 water supply deficit of 42,379[2] AFY of surface water from outside the study area.
The alternatives are as follows:

Alternative 10 (Alamo Lake Pipeline Alignment) delivers water through a transmission line that follows along major roadways to the planning areas from Alamo Lake.

Alternative 11 (Colorado River Pipeline Alignments) deliver water through transmission lines that follow along major roadways to the planning areas from the Colorado River via Alamo Lake, Lake Havasu, Lake Mead, Lake Mohave, Diamond Creek, and Lake Powell.

The alternative from Colorado River via Alamo Lake will be similar to the Alamo lake alternative but with a water exchange component. It consists of acquiring a Colorado River water entitlement withdrawn as an exchange from Alamo Lake. The infrastructure and alignment would be the same as the Alamo Lake alternative.

Alternative 10. Surface Water Outside the Study Area; Alamo Lake - Issues assessed WITHIN study area from importation from Alamo Lake

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	0	Assumes lake water will be treated to potable standards
Impact to Streamflow	+	Use less GW
Impact to Groundwater Availability	+	Use less GW
Biologic		
Impact to Vegetation	+	Proportional to volume imported
Impact to Wildlife (Riparian-Obligate)	+	Proportional to volume imported
Impact to Fish/Aquatic Species	+	Proportional to volume imported
Watershed		
Impact to Watersheds	+	Proportional to volume imported

[2] Water Supply deficit as calculated in Phase 1 Demand Analysis; Status Quo Method.

Alternative 11. Surface Water Outside the Study Area; Colorado River via Alamo Lake, Lake Havasu, Lake Mead, Lake Mohave, Diamond Creek, and Lake Powell - Issues assessed from WITHIN study area from importation of water from Colorado River

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	**0/-**	Assume imported water will be treated but concerns with greater mineral content
Impact to Streamflow	**+**	Use less GW
Impact to Groundwater Availability	**+**	Use less GW
Biologic		
Impact to Vegetation	**+**	Proportional to volume imported
Impact to Wildlife (Riparian-Obligate)	**+**	Proportional to volume imported
Impact to Fish/Aquatic Species	**+**	Proportional to volume imported
Watershed		Proportional to volume imported
Impact to Watersheds	**+**	Proportional to volume imported

Alternative 12
Weather Modification

This alternative proposes to look at weather modification by cloud seeding for producing additional water. The process introduces particles such as silver iodide compounds into moist air as it moves up to higher elevation. The moisture in the air cools and condenses around the particles forming orographic clouds and then falls as snow or rain. Modeling studies have indicated moderate potential for precipitation and stream flow enhancement by wintertime cloud seeding over the Mogollon Rim with increases in yield varying from 11.1 to 23.6 percent.

Alternative 12. Weather Modification

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	**0/-**	Could increase turbidity during flood event. Maybe rainfall constituent concerns with this alternative. Similar to concerns about emerging contaminants.
Impact to Streamflow	**0/+**	If designed and implemented properly, could increase stream flow up to 10-15 %
Impact to Groundwater Availability	**0/+**	Potential to increase recharge - timing is very important
Biologic		
Impact to Vegetation	**+**	Increasing precipitation into study area could benefit hydrologic, biologic and watershed resources. However additional definition would be required to determine how augmentation efforts would be focused; temporally and spatially.
Impact to Wildlife (Riparian-Obligate)	**+**	Increasing precipitation into study area could benefit hydrologic, biologic and watershed resources. However additional definition would be required to determine how augmentation efforts would be focused; temporally and spatially.
Impact to Fish/Aquatic Species	**+**	Increasing precipitation into study area could benefit hydrologic, biologic and watershed resources. However additional definition would be required to determine how augmentation efforts would be focused; temporally and spatially.
Watershed		
Impact to Watersheds	**+**	Increasing precipitation into study area could benefit hydrologic, biologic and watershed resources. However additional definition would be required to determine how augmentation efforts would be focused; temporally & spatially.

Alternative 13
Watershed Management

This alternative proposes to increase water yield by manipulating vegetative coverage specifically in watersheds with chaparral shrublands, ponderosa and conifer forests. Results for water yield are best in areas that receive more than 19 inches of annual precipitation or more. However, clearing vegetation for augmenting water supplies may be short lived due to quick re-growth, maintenance costs, water quality degradation, flooding and concerns over environmental impacts.

Alternative 13. Watershed Management

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	-	Alternative description states that "*Removing trees for water yield can cause degraded water quality*…". Also chaparral studies show that following treatments there was an initial flush of both sediment and nutrients that lasted for a year or two.
Impact to Streamflow	+	It is estimated that runoff may increase from watershed and vegetation treatment. NAU has estimated a range of runoff increases; from 7 to 21% in first treatment areas. This estimate is based on Beaver Creek studies when basal area of ponderosa pine forest was reduced by 30-100%. The range estimated is intended to reflect the low and high end of a range of potentially expected values. As such, the low end is adjusted downward for diminishing effects over time, with no increased water yield after 6 years for a given treatment. The high end reflects the absolute possible high, the first year after treatment. There is anticipated to be diminishing returns over time after initial treatment. As part of the Four Forest Restoration Initiative a paired watershed study is planned to test water yield effects over time from various treatment intensities as well as effects of followup treatments.
Impact to Groundwater Availability	+	Groundwater recharge should increase with better upland watershed vegetation management
Biologic		

Impact to Vegetation	+	Improvements due to increased water availability and more natural hydrologic regime than in over forested watershed
Impact to Wildlife (Riparian-Obligate)	+	
Impact to Fish/Aquatic Species	+	
Watershed		
Impact to Watersheds	+	Overall improved watershed condition from thinning/burning, reduced risk of catastrophic wildfire

Water-Dependent Natural Resource Index for the Central Yavapai Highlands Water Resources Management Study

This table depicts major water-dependent natural resources within Water Planning Areas in the Central Yavapai Highlands Water Resources Management Study Area. It is not meant to be a comprehensive assessment of *all* important water-dependent natural resources, and some potentially important features are not represented here. Rather, this information is meant to be used as a starting point for identifying important water-dependent natural resources in each Water Planning Area.

	Streams, Springs, Groundwater					Aquatic Fish & Wildlife			Federal/State Agency Designations				Social, Economic	
	Perennial Water	Major Springs	Waters in Federal/State Conservation Lands	GW Supports SW Flow In/Out WPA*	Stream Environmental Resources Augmented by Effluent	ESA Riparian/Aquatic Species Observed	Other Sensitive Native Riparian/Aquatic Species Observed	ESA Critical Habitat Designated	Federal Wild and Scenic Proposed/Designated	Instream Flow Certificate	ADEQ Outstanding Arizona Water	Audubon Important Bird Area	Water Based Recreation Opportunity
Camp Verde	■	■		■		■	■	■		■			■
Dewey Humboldt	■			■			■	■					■
Clarkdale	■	■	■	■		■	■	■				■	■
Cottonwood			■	■	2	■	■	■				■	■
Jerome		1		■	■								
Prescott Valley				■	3		■						
Chino Valley		■		■		■	■	■					
Prescott	■			■		■	■					■	■
Sedona	■			■		■	■	■			■	■	■
Paulden CDP	■	■	■	■		■	■	■					■
Big Park CDP				■	■		■	■					
Cornville CDP	■	■	■	■		■	■	■		■	■	■	■
Lake Montezuma CDP	■			■		■	■	■					■
Ctn-Verde Village CDP	■		■	■		■	■	■					■
Williamson CDP				■			■						
Verde CCD	■	■	■	■	■	■	■	■	■	■	■	■	■
Prescott CCD	■		■	■		■	■	■	■			■	■
Mingus Mtn CCD	■	■	■	■	■	■	■	■	■	■		■	■
Humboldt CCD	■		■	■	■	■	■	■	■	■			■
Ashfork CCD				■									

1. Jerome water supply fed by small springs < 10 GPM
2. Cottonwood discharges treated effluent into Del Monte Wash
3. Prescott Valley's managed recharge project. Primary purpose is for longterm storage credits. Does not contribute to an Effluent Dependent Stream Reach

* See Tab 2: GW-SW Annotations

Other Literature Used to Identify Resources per Water Planning

Perennial Stream Reaches were identified per Anning, D.W., Parker, J.T.C. (2009). Predictive models of the hydrological regime of unregulated streams in Arizona (USGS OFR 2009-1269). Reston, VA: U.S. Geological Survey. Available from http://pubs.usgs.gov/of/2009/1269

Basin	Sub-Basins	Current GW/SW Connection?
Agua Fria	None	YES
Prescott	Little Chino	YES
	Upper Agua Fria	YES
Verde River	Big Chino	YES
	Verde Canyon	YES
	Verde Valley	YES

From: Brown DE, Carmony NB, Turner RM. 1981. Drainage map of Arizona showing perennial streams

Anning, D.W. and Konieczki, A.D. 2005. Classification of hydrogeologic areas and hydrogeologic flow sy

Water Planning Area	Perennial Flow	Current GW/SW Connection?
Camp Verde	YES	YES
Dewey Humboldt	YES	YES
Clarkdale	YES	YES
Cottonwood	YES	YES
Jerome		YES
Prescott Valley		YES
Chino Valley		YES
Prescott	YES	YES
Sedona	YES	YES
Paulden CDP	YES	YES
Big Park CDP		YES
Cornville CDP	YES	YES
Lake Montezuma CDP	YES	YES
Ctn-Verde Village CDP	YES	YES
Williamson CDP		YES
Verde CCD	YES	YES
Prescott CCD	YES	YES
Mingus Mtn CCD	YES	YES
Humboldt CCD	YES	YES
Ashfork CCD		YES

*Brown DE, Carmony NB, Turner RM. 1981. Drainage map of Arizona showing perennial streams and some impor

*Anning, D.W. and Konieczki, A.D. 2005. Classification of hydrogeologic areas and hydrogeologic flow systems in t

Water Planning Area	Perennial Flow	Current GW/SW Connection?
Camp Verde	YES	YES
Dewey Humboldt	YES	YES
Clarkdale	YES	YES
Cottonwood	YES	YES
Jerome		YES
Prescott Valley		YES
Chino Valley		YES
Prescott	YES	YES
Sedona	YES	YES
Paulden CDP	YES	YES
Big Park CDP		YES
Cornville CDP	YES	YES
Lake Montezuma CDP	YES	YES
Ctn-Verde Village CDP	YES	YES
Williamson CDP		YES
Verde CCD	YES	YES
Prescott CCD	YES	YES
Mingus Mtn CCD	YES	YES
Humboldt CCD	YES	YES
Ashfork CCD		YES

Description of GW/SW Connection
Agua Fria basin contains perennial reach on Horseshoe Ranch and other locations; BLM National Monument
Little Chino subbasin contains Del Rio Spring and GW underflow / connection to Upper Verde River
Upper Agua Fria subbasin contains a perennial reach of Agua Fria River adjacent to Young Farm
Big Chino subbasin contains perennial reaches of the Verde River and Williamson Valley wash
Verde Canyon contains perennial reaches of the Verde River and tributaries (East Verde River, Fossil Creek; Deadman Creek, Lime Creek, and others)
Verde Valley subbasin contains perennial reaches of the Verde River and tributaries (Sycamore Creek; Oak Creek; Beaver Creek; West Clear Creek

; and some important wetlands. Arizona Game and Fish Department, Phoenix.
ystems in the Basin and Range Physiographic Province, Southwestern United States. USGS Professional Paper 1702. 37 pp.

Description of GW/SW Connection
Groundwater moves from areas of recharge to areas of discharge. Where the land surface intersects the water table (or potentiometric surface), groundwater discharges to streams, springs, and wetlands. The CYHWRMS water planning areas are mostly in the Verde River watershed (Dewey-Humbolt WPAs is in the Agua Fria watershed; Prescott Valley WPA spans the Verde-Agua Fria watershed divide). The Verde River is perennial throughout its length and the Agua Fria River includes perennial reaches. Groundwater beneath the CYHWRMS WPAs is moving towards points of discharge in the Verde and Agua Fria watershed (see Figures 9 and 17 of Pool et al 2011; and USGS/ADWR groundwater level contour maps). Thus, groundwater beneath the WPAs supports discharge to the Verde and Agua Fria rivers, and a groundwater-surface water connection exists.

tant wetlands. Arizona Game and Fish Department, Phoenix.
:he Basin and Range Physiographic Province, Southwestern United States. USGS Professional Paper 1702. 37 pp.

Description of GW/SW Connection
33 Miles of perennial flow in planning area - Verede River, Beaver Creek, West Clear Creek
4 miles of perennial flow in planning area - Agua Fria River
7 miles of perennial flow in planning area - Verde River, Bitter Creek and tributary
11 miles of perennial flow in planning area - Verde River
Jerome water supply comes from springs along Allen Springs Road (in the Mingus Mountain CCD)
0 miles of perennial flow in planning area. Groundwater moves to the Verde or Agua Fria Rivers, both of which have perennial reaches.
1 mile of perennial flow in planning area - Verde River
3 miles of perennial flow in planning area - Granite Creek
8 miles of perennial flow in planning area - Oak Creek
3 miles of perennial flow in planning area - Verde River, Granite Creek
0 miles of perennial flow in planning area. Groundwater moves to Oak Creek, which is perennial.
20 miles of perennial flow in planning area - Oak Creek, Spring Creek.
7 miles of perennial flow in planning area - Wet Beaver Creek
2 miles of perennial flow in planning area - Verde River
0 miles of perennial flow in planning area. Groundwater moves to Little Chino and Williamson valleys, both of which contain perennial river reaches.
40 miles of perennial flow in planning area - Verde River, Oak Creek, Wet Beaver Creek, Dry Beaver Creek, Sycamore Creek, West Clear Creek, Soda Springs.
28 miles of perennial flow in planning area - Verde River, Hassayampa River, Mint Wash, Walnut Creek (N. Fork), Williamson Valley Wash
23 miles of perennial flow in planning area- Verde River, Black Canyon Creek
Planning area is comprised of two small, disjunct pieces with 0 miles of perennial flow. Beneath the eastern portion, groundwater moves to the Verde River; beneath the western portion, to the Agua Fria.
0 miles of perennial flow in planning area. Groundwater moves to the Upper Verde River.

INTRODUCTION AND PURPOSE

The intent of the Central Yavapai Highlands Water Resource Management Study is to identify water resources and water management strategies that include a range of alternatives designed to meet future water supply needs of communities in the Central Yavapai Highlands, Arizona. The study will provide a summary of needs, objectives, constraints and opportunities. As such, a component of the study is to identify potential environmental issues to be considered under each of the proposed water development alternatives.

These documents, datasets, maps, and supporting information form the basis of the environmental issues tables identified per alternative. They may also be used by each WPA to inform land and water-based management decisions, especially relating to potential issues associated with the environment and natural resources within a WPA.

These data represent the best available data in 2012, and although as comprehensive as possible, may not represent ALL necessary information about natural resources to inform management decisions.

Note on Mapping Efforts: To maintain clarity at the given scale and preserve the purpose of the maps, symbols representing certain features were slightly exaggerated. These features include critical habitat for fish and other species constrained to river and stream courses, surface water filings instream, riparian habitat and effluent dependent stream systems. Amplification of features is an accepted part of the cartographic process, and enhancement of the symbols was not meant to exaggerate their meaning, but only to improve legibility and accomodate the associated symbology.

Contents of this spreadsheet (organized by Water Planning Area):

- ADWR Major Springs (>10 gpm)
- ADEQ Arizona Outstanding Waters
- Effluent Dependent Stream Systems
- ADWR Certificated Instream Flow Rights
- Critical Habitats
- Arizona Audubon Important Bird Areas
- Sensitive Species
- National Forest Lands
- Federally Protected Lands and Waters
- State Conservation Lands
- Waters within Federal and State Conservation Lands

Spring Counts for Water Planning Areas

"Major" springs (>10 gpm) are represented in this table (as ID'd by ADWR), with additions noted by the Town of Jerome. Spring data were compiled by ADWR using multiple sources, and as referenced by the Water Resource Development Commission, Natural Resources Report.

Water Planning Area	**Count Springs**
Ashfork	0
Big Park	0
Camp Verde	6
Clarkdale	1
Cornville	4
Cottonwood	0
Humboldt	0
Jerome (added to dataset)	1+
Lake Montezuma	0
Mingus Mountain	7
Paulden	2
Prescott CCD	0
Prescott Valley	0
Prescott	0
Sedona	0
Town of Chino Valley	1
Town of Dewey-Humboldt	0
Verde	11
Verde Village	0
Williamson Valley	0
Spring Count Total	**32**

Spring datasets were compiled by ADWR (2008), and include sources from USGS, state universities, USFS, NPS, and BLM. A detailed description of the methods used to compile information on springs is provided in the Arizona Water Atlas, Volume 1 (ADWR, 2010).

Arizona Department of Water Resources. (2008). ADWR_FinalSpringsTblAtlas_2008 [Data file]. Phoenix, AZ: Unpublished.

Arizona Department of Water Resources. (2010a). Arizona Water Atlas, Executive Summary (Vol. 1). Phoenix, AZ: Author. Available from http://www.azwater.gov/adwr/statewideplanning/wateratlas

ADEQ Outstanding Arizona Waters in Water Planning Areas

Outstanding Arizona Waters were formerly known as "unique waters", and are classified by ADEQ. An Outstanding Arizona Water means a surface water that is classified as an outstanding state resource water by the Director or ADEQ under R18-11-112.

Water Planning Area	**Outstanding Arizona Water**
Cornville WPA	Oak Creek
Sedona WPA	Oak Creek
Verde WPA	Oak Creek

Arizona Administrative Code (A.A.C). (2008), Title 18, Chapter 11, Article 1, §Section R18-11-112. Outstanding Arizona Waters, amended 31 January 2009.

Arizona Department of Environmental Quality. (2009). Outstanding Arizona Waters (2008) [Data file]. Phoenix, AZ: Author. Available from http://agic.az.gov/portal/main.do

Water Planning Area Effluent-Dependent Streams

Effluent-dependent streams are characterized as streams or stream reaches that are naturally ephemeral (or have become so over time), but now have surface flow in response to the discharge of treated wastewaer. A compilation of two datasets, along with WPA input, were used to identify and illustrate streams supported by effluent-discharge.

Water Planning Area	Stream
Ashfork	None Detected
Big Park	Jacks Canyon
Camp Verde	None Detected
Clarkdale	None Detected
Cornville	None Detected
Cottonwood	Del Monte Wash
Humboldt	unnamed reach (added per community input)
Jerome	Bitter Creek
Lake Montezuma	None Detected
Mingus Mountain	Bitter Creek
Mingus Mountain	2 unnamed reaches (added per community input)
Paulden	None Detected
Prescott CCD	None Detected
Prescott	None Detected
Sedona	None Detected
Town of Chino Valley	None Detected
Town of Dewey-Humboldt	None Detected
Verde	Jacks Canyon
Verde Village	None Detected
Williamson Valley	None Detected
Prescott Valley WPA	None Detected

Arizona Department of Water Resources. (2009-2010). Arizona Water Atlas (Vols. 2-8). Phoenix, AZ: Author. Available from http://www.azwater.gov/azdwr/statewideplanning/wateratlas

Non-point Education for Municipal Officials - NEMO. (2009). [Information regarding Effluent Dependent Stream reaches in Arizona] [Data file]. Tucson, AZ: University of Arizona. Unpublished.

Water Planning Areas Certificated Instream Flow Rights

An instream flow water right is a non-diversionary appropriation of surface water for recreation and wildlife use. An application to appropriate public water for instream flow purposes must be submitted to the Arizona Department of Water Resources, which makes the determination of whether to approve or reject the application. If a permit is approved, the Department issues a Certificate of Water Right. All permits and certificates are for specific uses at specific places. ADWR maintains a database that tracks the status of instream flow applications.

Water Planning Area	Certificated ISF's	Count of Certificated ISF's
Ashfork	None Detected	0
Big Park	None Detected	0
Camp Verde	Verde River	1
Clarkdale	None Detected	0
Cornville	Spring Creek	2
Cottonwood	None Detected	0
Humboldt	Verde River	1
Jerome	None Detected	0
Lake Montezuma	None Detected	0
Mingus Mountain	Sycamore Creek	1
Paulden	None Detected	0
Prescott CCD	None Detected	0
Prescott Valley	None Detected	0
Prescott	None Detected	0
Sedona	None Detected	0
Town of Chino Valley	None Detected	0
Town of Dewey-Humboldt	None Detected	0
Verde	Sycamore Creek	1
Verde	Verde River	1
Verde	Walker Creek	1
Verde	West Clear Creek	1
Verde	Wet Beaver Creek	2
Verde Village	None Detected	0
Williamson Valley	None Detected	0
Water Planning Areas Instream Totals		**11**

Arizona Department of Water Resources. (2010b). Instream Flow Applications (06/27/1976 to 06/15/2010) [Data file]. Available from the Arizona Department of Water Resource's Surface Water Rights Database

Instream Streams totals derived from ADWR_filingInstream where status = 'certifcated'

Critical Habitats found in Water Planning Areas

The Endangered Species Act of 1973 allows the U.S. Fish and Wildlife Service to designate specific areas as protected "critical habitat" zones. The provision of the law in Section 4 of the Act that establishes critical habitat is a regulatory link between habitat protection and recovery goals, requiring the identification and protection of all lands, water and air necessary to recover endangered species. Critical habitats are areas considered essential for the conservation of a listed species. The Critical Habitats listed by WPA were derived from Geospatial data provided by the U.S. FWS and identified through GIS analysis.

Water Planning Area	**Critical Habitat for:**
Ashfork	None Detected
Big Park	Gila Chub, Southwillow Flycatcher
Camp Verde	Southwillow Flycatcher, Gila Chub, Spikedace, Loach Minnow
Clarkdale	Razorback Sucker, Spikedace, Loach Minnow
Cornville	Gila Chub, Spikedace, Loach Minnow
Cottonwood	Southwestern Willow Flycatcher, Razorback Sucker, Spikedace, Loach Minnow
Humboldt	Southwestern Willow Flycatcher, Razorback Sucker, Spikedace
Jerome	None Detected
Lake Montezuma	Spikedace, Loach Minnow
Mingus Mountain	Razorback Sucker, Spikedace, Loach Minnow
Paulden	Spikedace, Loach Minnow
Prescott CCD	Gila Chub, Spikedace, Mexican Spotted Owl
Prescott Valley	None Detected
Prescott	None Detected
Sedona	Spikedace, Loach Minnow
Town of Chino Valley	Spikedace, Loach Minnow
Town of Dewey-Humboldt	Southwestern Willow Flycatcher, Razorback Sucker
Verde	Southwestern Willow Flycatcher, Razorback Sucker, Spikedace, Loach Minnow
Verde Village	Razorback Sucker, Southwestern Willow Flycatcher, Spikedace, Loach Minnow
Williamson Valley	None Detected

U.S. Fish and Wildlife Service. (2011, 2012). [information regarding Threatened and Endangered Species final Critical Habitat designation in Arizona] [Data file]. Albuquerque, NM: Author. Available from

Important Bird Areas found in Water Planning Areas

The Important Bird Area Porgram (IBA) is a global effort to identify and conserve areas that are vital to birds and other biodiversity. Audubon chapters work with landowners, public agencies, community groups, and other non-profit organizations to identify areas of conservation value. IBAs are sites that provide essential habitat for one or more species of bird. IBAs may be a few acres or thousands of acres, but usually they are discrete sites that stand out from the surrounding landscape.

Water Planning Area	**IBAs**
Cornville	Lower Oak Creek IBA
Clarkdale	Tuzigoot IBA
Mingus Mountain	Tuzigoot IBA
Paulden	Upper Verde river State Wildlife Area IBA
Prescott CCD	Upper Verde river State Wildlife Area IBA
Prescott	Watson and Willow Lakes IBA
Verde	Lower Oak Creek IBA

Tuzigoot IBA http://iba.audubon.org/iba/viewSiteProfile.do?siteId=2290&navSite=state

Watson and Willow Lake Ecosystem IBA
http://iba.audubon.org/iba/viewSiteProfile.do?siteId=952&navSite=state
Lower Oak Creek IBA http://iba.audubon.org/iba/viewSiteProfile.do?siteId=1236&navSite=state
Upper Verde River State Wildlife IBA
http://iba.audubon.org/iba/viewSiteProfile.do?siteId=3444&navSite=state

Descriptions of IBAs in Arizona can be found on the Audubon website

Riparian-Obligate, Aquatic and Marshland Species Observed and Documented in Water Planning

Arizona's Heritage Data management System (HDMS), housed in the Arizona Game and Fish Department, is part of an international network of natural heritage programs and conservation data centers operating an all 50 American States, Canada, Latin America and the Caribbean. The HDMS collects and manages detailed local information on plants, animals, and ecosystems and is the leading source of information about rare and endangered species in the State of Arizona.

HDMS data are compiled from many sources and carefully documented. Information included in the HDMS comes from published and unpublished reports, data collected by cooperating agencies, museum and herbarioum collections, the scientific and academic communities, and many other sources.

HDMS tracks species that are federally listed as threatened or endangered under the Endangered Species Act of 1973, or are candidate species for listing under ESA. HDMS also tracks some species that have been identified as sensitive species by other agencies, notably the Bureau of land management and the U.S. Forest Service.

Species summaries per WPA were generated using the HDMS Geographic Information System dataset, and provided by AZGFD. The database was queried to PROVIDE A SUBSET OF INFORMATION RELATING ONLY TO AQUATIC, MARSHLAND, AND RIPARIAN SPECIES. The data subset was then filtered by WPA to identify which species have been observed and documented within each WPA. Not all species have been systematically surveyed throughout the state, meaning that some species may not be accounted for in all basins. This list is meant to provide WPA's a GENERAL understanding of what species have been documented and recorded in their planning areas, for planning purposes only. Any additional questions related to species occurrence should be posed to AZGFD or USFWS.

Note: No species observed/recorded in Jerome or Ash Fork Planning Areas.

WATER PLANNING AREA	COMMON NAME	TAXON	USESA (Status Definitions** defined below)
Big Park WPA	Arizona Toad	AMPHIBIAN	SC
Camp Verde WPA	Arizona Toad	AMPHIBIAN	SC
Camp Verde WPA	Bald Eagle - Sonoran Desert area Population	BIRD	LT,DPS
Camp Verde WPA	Bald Eagle - Winter Population	BIRD	SAT
Camp Verde WPA	Belted Kingfisher	BIRD	
Camp Verde WPA	Bigelow Onion	PLANT	
Camp Verde WPA	Common Black-Hawk	BIRD	
Camp Verde WPA	Desert Sucker	FISH	SC
Camp Verde WPA	Gila Longfin Dace	FISH	SC
Camp Verde WPA	Gila Topminnow	FISH	LE

Camp Verde WPA	Great Blue Heron	BIRD	
Camp Verde WPA	Lowland Leopard Frog	AMPHIBIAN	SC
Camp Verde WPA	Maricopa Tiger Beetle	INVERTEBRATE	SC
Camp Verde WPA	Mogollon Rim Treefrog	AMPHIBIAN	
Camp Verde WPA	Northern Mexican Gartersnake	REPTILE	C
Camp Verde WPA	Roundtail Chub	FISH	C
Camp Verde WPA	Sonora Sucker	FISH	SC
Camp Verde WPA	Southwestern Willow Flycatcher	BIRD	LE
Camp Verde WPA	Speckled Dace	FISH	SC
Camp Verde WPA	Spikedace	FISH	LT
Camp Verde WPA	Yellow-billed Cuckoo (Western U.S. DPS)	BIRD	PS:C
Clarkdale WPA	Bald Eagle - Winter Population	BIRD	SAT
Clarkdale WPA	Desert Sucker	FISH	SC
Clarkdale WPA	Gila Longfin Dace	FISH	SC
Clarkdale WPA	Lowland Leopard Frog	AMPHIBIAN	SC
Clarkdale WPA	Maricopa Tiger Beetle	INVERTEBRATE	SC
Clarkdale WPA	Northern Mexican Gartersnake	REPTILE	C
Clarkdale WPA	Roundtail Chub	FISH	C
Clarkdale WPA	Sonora Sucker	FISH	SC
Clarkdale WPA	Southwestern Willow Flycatcher	BIRD	LE
Clarkdale WPA	Yellow-billed Cuckoo (Western U.S. DPS)	BIRD	PS:C
Cornville WPA	Arizona Toad	AMPHIBIAN	SC
Cornville WPA	Bald Eagle - Winter Population	BIRD	SAT
Cornville WPA	Balmorhea Saddle-case Caddisfly	INVERTEBRATE	SC
Cornville WPA	Common Black-Hawk	BIRD	
Cornville WPA	Desert Sucker	FISH	SC
Cornville WPA	Gila Chub	FISH	LE
Cornville WPA	Gila Longfin Dace	FISH	SC
Cornville WPA	Lowland Leopard Frog	AMPHIBIAN	SC
Cornville WPA	Northern Mexican Gartersnake	REPTILE	C
Cornville WPA	Page Spring Micro Caddisfly	INVERTEBRATE	SC
Cornville WPA	Page Springsnail	INVERTEBRATE	C
Cornville WPA	Roundtail Chub	FISH	C
Cornville WPA	Sonora Sucker	FISH	SC
Cornville WPA	Speckled Dace	FISH	SC
Cornville WPA	Yellow-billed Cuckoo (Western U.S. DPS)	BIRD	PS:C
Cottonwood WPA	Bald Eagle - Winter Population	BIRD	SAT
Cottonwood WPA	Common Black-Hawk	BIRD	
Cottonwood WPA	Desert Sucker	FISH	SC
Cottonwood WPA	Northern Mexican Gartersnake	REPTILE	C
Cottonwood WPA	Roundtail Chub	FISH	C
Cottonwood WPA	Sonora Sucker	FISH	SC
Cottonwood WPA	Southwestern Willow Flycatcher	BIRD	LE
Cottonwood WPA	Yellow-billed Cuckoo (Western U.S. DPS)	BIRD	PS:C
Humboldt	Bald Eagle - Sonoran Desert area Population	BIRD	LT,DPS
Humboldt	Bald Eagle - Winter Population	BIRD	SAT
Humboldt	Desert Sucker	FISH	SC

Humboldt	Gila Topminnow	FISH	LE
Humboldt	Great Blue Heron	BIRD	
Humboldt	Lowland Leopard Frog	AMPHIBIAN	SC
Humboldt	Roundtail Chub	FISH	C
Humboldt	Sonora Sucker	FISH	SC
Humboldt	Yellow-billed Cuckoo (Western U.S. DPS)	BIRD	PS:C
Lake Montezuma WPA	Cameron Water-parsley	PLANT	SC
Lake Montezuma WPA	Common Black-Hawk	BIRD	
Lake Montezuma WPA	Desert Sucker	FISH	SC
Lake Montezuma WPA	Gila Longfin Dace	FISH	SC
Lake Montezuma WPA	Roundtail Chub	FISH	C
Lake Montezuma WPA	Sonora Sucker	FISH	SC
Lake Montezuma WPA	Speckled Dace	FISH	SC
Lake Montezuma WPA	Yellow-billed Cuckoo (Western U.S. DPS)	BIRD	PS:C
Mingus Mountain	American Peregrine Falcon	BIRD	SC
Mingus Mountain	Arizona Toad	AMPHIBIAN	SC
Mingus Mountain	Bald Eagle - Sonoran Desert area Population	BIRD	LT,DPS
Mingus Mountain	Bald Eagle - Winter Population	BIRD	SAT
Mingus Mountain	Common Black-Hawk	BIRD	
Mingus Mountain	Desert Sucker	FISH	SC
Mingus Mountain	Eastwood Alum Root	PLANT	
Mingus Mountain	Gila Longfin Dace	FISH	SC
Mingus Mountain	Lowland Leopard Frog	AMPHIBIAN	SC
Mingus Mountain	Maricopa Tiger Beetle	INVERTEBRATE	SC
Mingus Mountain	Mogollon Vole	MAMMAL	PS
Mingus Mountain	Narrow-headed Gartersnake	REPTILE	SC
Mingus Mountain	Northern Mexican Gartersnake	REPTILE	C
Mingus Mountain	Razorback Sucker	FISH	LE
Mingus Mountain	Roundtail Chub	FISH	C
Mingus Mountain	Sonora Sucker	FISH	SC
Mingus Mountain	Southwestern Willow Flycatcher	BIRD	LE
Mingus Mountain	Speckled Dace	FISH	SC
Mingus Mountain	Spikedace	FISH	LT
Mingus Mountain	Western Red Bat	MAMMAL	
Mingus Mountain	Yellow-billed Cuckoo (Western U.S. DPS)	BIRD	PS:C
Paulden WPA	Bald Eagle - Sonoran Desert area Population	BIRD	LT,DPS
Paulden WPA	Bald Eagle - Winter Population	BIRD	SAT
Paulden WPA	Desert Sucker	FISH	SC
Paulden WPA	Gila Longfin Dace	FISH	SC
Paulden WPA	Great Blue Heron	BIRD	
Paulden WPA	Razorback Sucker	FISH	LE
Paulden WPA	Sonora Sucker	FISH	SC
Paulden WPA	Yellow-billed Cuckoo (Western U.S. DPS)	BIRD	PS:C
Prescott CCD	American Peregrine Falcon	BIRD	SC
Prescott CCD	Bald Eagle - Sonoran Desert area Population	BIRD	LT,DPS
Prescott CCD	Bald Eagle - Winter Population	BIRD	SAT
Prescott CCD	Belted Kingfisher	BIRD	

Prescott CCD	Common Black-Hawk	BIRD	
Prescott CCD	Crested Coralroot	PLANT	
Prescott CCD	Desert Sucker	FISH	SC
Prescott CCD	Eastwood Alum Root	PLANT	
Prescott CCD	Gila Chub	FISH	LE
Prescott CCD	Great Blue Heron	BIRD	
Prescott CCD	Hualapai Mexican Vole	MAMMAL	LE
Prescott CCD	Lowland Leopard Frog	AMPHIBIAN	SC
Prescott CCD	Maricopa Tiger Beetle	INVERTEBRATE	SC
Prescott CCD	Narrow-headed Gartersnake	REPTILE	SC
Prescott CCD	Razorback Sucker	FISH	LE
Prescott CCD	Roundtail Chub	FISH	C
Prescott CCD	Sonora Sucker	FISH	SC
Prescott CCD	Speckled Dace	FISH	SC
Prescott CCD	Spikedace	FISH	LT
Prescott CCD	Yellow-billed Cuckoo (Western U.S. DPS)	BIRD	PS:C
Prescott CCD	Arizona Toad	AMPHIBIAN	SC
Prescott CCD	Gila Longfin Dace	FISH	SC
Prescott CCD	Mexican Spotted Owl	BIRD	LT
Prescott Valley WPA	Arizona Toad	AMPHIBIAN	SC
Prescott WPA	Arizona Toad	AMPHIBIAN	SC
Prescott WPA	Bald Eagle - Winter Population	BIRD	SAT
Prescott WPA	Belted Kingfisher	BIRD	
Prescott WPA	Maricopa Tiger Beetle	INVERTEBRATE	SC
Prescott WPA	Northern Mexican Gartersnake	REPTILE	C
Prescott WPA	Wood Duck	BIRD	
Prescott WPA	Yellow-billed Cuckoo (Western U.S. DPS)	BIRD	PS:C
Sedona WPA	American Peregrine Falcon	BIRD	SC
Sedona WPA	Arizona Toad	AMPHIBIAN	SC
Sedona WPA	Bald Eagle - Winter Population	BIRD	SAT
Sedona WPA	Bigelow Onion	PLANT	
Sedona WPA	Common Black-Hawk	BIRD	
Sedona WPA	Lowland Leopard Frog	AMPHIBIAN	SC
Sedona WPA	Narrow-headed Gartersnake	REPTILE	SC
Sedona WPA	Roundtail Chub	FISH	C
Sedona WPA	Yellow-billed Cuckoo (Western U.S. DPS)	BIRD	PS:C
Town of Chino Valley WPA	Bald Eagle - Sonoran Desert area Population	BIRD	LT,DPS
Town of Chino Valley WPA	Bald Eagle - Winter Population	BIRD	SAT
Town of Chino Valley WPA	Great Blue Heron	BIRD	
Town of Chino Valley WPA	Yellow-billed Cuckoo (Western U.S. DPS)	BIRD	PS:C
Town of Dewey-Humbolt WPA	Arizona Toad	AMPHIBIAN	SC
Verde	American Peregrine Falcon	BIRD	SC
Verde	Bald Eagle - Sonoran Desert area Population	BIRD	LT,DPS
Verde	Bald Eagle - Winter Population	BIRD	SAT
Verde	Balmorhea Saddle-case Caddisfly	INVERTEBRATE	SC
Verde	Bigelow Onion	PLANT	
Verde	Cameron Water-parsley	PLANT	SC

Verde	Colorado Pikeminnow	FISH	LE,XN
Verde	Common Black-Hawk	BIRD	
Verde	Desert Sucker	FISH	SC
Verde	Gila Chub	FISH	LE
Verde	Gila Longfin Dace	FISH	SC
Verde	Gila Topminnow	FISH	LE
Verde	Lowland Leopard Frog	AMPHIBIAN	SC
Verde	Mexican Spotted Owl	BIRD	LT
Verde	Mogollon Rim Treefrog	AMPHIBIAN	
Verde	Montezuma Well Springsnail	INVERTEBRATE	SC
Verde	Narrow-headed Gartersnake	REPTILE	SC
Verde	Northern Mexican Gartersnake	REPTILE	C
Verde	Page Spring Micro Caddisfly	INVERTEBRATE	SC
Verde	Page Springsnail	INVERTEBRATE	C
Verde	Razorback Sucker	FISH	LE
Verde	Roundtail Chub	FISH	C
Verde	Sonora Sucker	FISH	SC
Verde	Southwestern Willow Flycatcher	BIRD	LE
Verde	Speckled Dace	FISH	SC
Verde	Spikedace	FISH	LT
Verde	Western Red Bat	MAMMAL	
Verde	Yellow-billed Cuckoo (Western U.S. DPS)	BIRD	PS:C
Verde	Arizona Toad	AMPHIBIAN	SC
Verde Village WPA	Bald Eagle - Winter Population	BIRD	SAT
Verde Village WPA	Desert Sucker	FISH	SC
Verde Village WPA	Lowland Leopard Frog	AMPHIBIAN	SC
Verde Village WPA	Roundtail Chub	FISH	C
Verde Village WPA	Yellow-billed Cuckoo (Western U.S. DPS)	BIRD	PS:C
Williamson Valley WPA	Arizona Toad	AMPHIBIAN	SC
Williamson Valley WPA	Great Blue Heron	BIRD	

Arizona Game and Fish Department. (2011a). Arizona's Natural Heritage Program: Heritage Data Management System (HDMS) [Data file]. Retrieved from

Status Definitions

http://www.azgfd.gov/w_c/edits/hdms_status_definitions.shtml

Federal U.S. Status

FWS

BGA Bald and Golden Eagle Protection Act(http://www.fws.gov/migratorybirds/baldeagle.htm)

Prohibits take of bald and golden eagles without prior USFWS permit.

ESA Endangered Species Act (1973 as amended)

US Department of Interior, Fish and Wildlife Service

Listed

LE	Listed Endangered: imminent jeopardy of extinction.
LT	Listed Threatened: imminent jeopardy of becoming Endangered.
PS	Partial Status: listed Endangered or Threatened, but not in entire range.
XN	Experimental Nonessential population.
PDL	Proposed for delisting.
No Status	Certain populations of this taxon do not have designated status (check with state or regional USFWS office for details about which populations have designated status).
SAT	Listed Threatened due to Similarity of Appearance. This happens when a member of a non-listed population is found within the geographic area of a Distinct Population Segment for a listed species (e.g., a wintering bald eagle within the DPS for listed

Proposed for Listing

PE	Proposed Endangered
PT	Proposed Threatened

Candidate (Notice of Review: 2008)

C	Candidate. Species for which USFWS has sufficient information on biological vulnerability and threats to support proposals to list as Endangered or Threatened under ESA. However, proposed rules have not yet been issued because such actions are precluded at present by other listing activity.
SC	Species of Concern. The terms "Species of Concern" or "Species at Risk" should be considered as terms-of-art that describe the entire realm of taxa whose conservation status may be of concern to the US Fish and Wildlife Service, but neither term has official status (currently all former C2 species).

Critical Habitat (check with state or regional USFWS office for location details)

Y	Yes: Critical Habitat has been designated.
P	Proposed: Critical Habitat has been proposed.

[\N No Status: Certain populations of this taxon do not have designated status (check with state or regional USFWS office for details about which populations have designated status)].

DPS	Distinct Population Segment: a portion of a species' or subspecies' population or range. The DPS is generally described geographically. A DPS can apply to a Candidate or Listed or Proposed Species.
10(j)	10(j) Recovery Area: under section 10(j), a population of a listed species reestablished outside its current range, but within its probably historic range may be designated as "experimental" at the discretion of the Secretary of the Interior. The 10(j) recovery area is the geographic boundary established under Final Rule and may be larger than the actual occupied area or "primary recovery zone."
10(a)(1)(A)	An experimental population currently managed under a 10(a)(1)(A) permit from the U.S. Fish and Wildlife Service. A 10(a)(1)(A) permit can be issued under the authority of section 10(a)(1)(A) of the Endangered Species Act "for scientific purposes or to enhance the propagation or survival of the affected species including, but not limited to, acts necessary for the establishment and maintenance of experimental populations." The 10(a)(1)(A) recovery area is a geographic boundary and may be larger than the actual occupied area.

USFS US Forest Service (1999 Animals, 1999 Plants: corrected 2000)

US Department of Agriculture, Forest Service, Region 3

S	Sensitive: those taxa occurring on National Forests in Arizona which are considered sensitive by the Regional Forester.

State Status

SPROT:

Plants - NPL Arizona Native Plant Law (2008)

Arizona Department of Agriculture

HS	Highly Safeguarded: no collection allowed.
SR	Salvage Restricted: collection only with permit.
ER	Export Restricted: transport out of State prohibited.
SA	Salvage Assessed: permits required to remove live trees.
HR	Harvest Restricted: permits required to remove plant by-products.

Wildlife - WSCA Wildlife of Special Concern in Arizona (in prep)

Arizona Game and Fish Department

WSC	Wildlife of Special Concern in Arizona. Species whose occurrence in Arizona is or may be in jeopardy, or with known or perceived threats or population declines, as described by the Arizona Game and Fish Department's listing of Wildlife of Special Concern in Arizona (WSCA, in prep). Species indicated on printouts as WSC are currently the same as those in Threatened Native Wildlife in Arizona (1988).

National Forest Lands Inside WPAs

Water Planning Area	Forest Lands
Ashfork	Prescott National Forest
Big Park WPA	Coconino National Forest
Camp Verde WPA	Coconino National Forest
Camp Verde WPA	Prescott National Forest
Clarkdale WPA	Coconino National Forest
Clarkdale WPA	Prescott National Forest
Cornville WPA	Coconino National Forest
Cottonwood WPA	Coconino National Forest
Cottonwood WPA	Prescott National Forest
Humboldt	Coconino National Forest
Humboldt	Prescott National Forest
Jerome WPA	Prescott National Forest
Lake Montezuma WPA	Coconino National Forest
Mingus Mountain	Coconino National Forest
Mingus Mountain	Prescott National Forest
Paulden WPA	Prescott National Forest
Prescott CCD	Prescott National Forest
Prescott Valley WPA	Prescott National Forest
Prescott WPA	Prescott National Forest
Sedona WPA	Coconino National Forest
Town of Dewey-Humboldt WPA	Prescott National Forest
Verde	Coconino National Forest
Verde	Prescott National Forest
Verde Village WPA	Coconino National Forest
Verde Village WPA	Prescott National Forest
Williamson Valley WPA	Prescott National Forest

Arizona Land Resources Information System. (1990). Wilderness Areas [Data file]. Phoenix, AZ: Arizona State Land Department. Available from http://www.land.state.az.us/alris/layers.html

Federal Conservation Lands Inside WPAs

Federal Conservation Lands include Forest Service designated Wilderness, and proposed and designated Wild and Scenic River.

Water Planning Area	Federal Conservation Lands
Humboldt	Cedar Bench Wilderness
Humboldt	Verde River Wild and Scenic Designated River
Humboldt	Verde Scenic River Area Wild and Scenic Designated River
Mingus Mountain	Sycamore Canyon Wilderness
Mingus Mountain	Woodchute Wilderness
Mingus Mountain	Proposed Upper Verde River Wild and Scenic River
Prescott CCD	Proposed Upper Verde River Wild and Scenic River
Prescott CCD	Apache Creek Wilderness
Prescott CCD	Granite Mountain Wilderness
Prescott CCD	Juniper Mesa Wilderness
Prescott CCD	Woodchute Wilderness
Sedona WPA	Munds Mountain Wilderness
Sedona WPA	Red Rock-Secret Mountain Wilderness
Verde	Munds Mountain Wilderness
Verde	Red Rock-Secret Mountain Wilderness
Verde	Sycamore Canyon Wilderness
Verde	Verde River Wild and Scenic Designated River
Verde	Verde Scenic River Area Wild and Scenic Designated River
Verde	Proposed Upper Verde River Wild and Scenic River
Williamson Valley WPA	Granite Mountain Wilderness

Arizona Land Resources Information System. (1990). Wilderness Areas [Data file]. Phoenix, AZ: Arizona State Land Department. Available from http://www.land.state.az.us/alris/layers.html

U.S. Forest Service. (2004). Special Designation Areas on Forest Service Lands in Arizona [Data file]. Salt Lake City, UT: USDA Forest Service, Geospatial Service and Technology Center (GSTC).

U.S. Forest Service. (2007). Wild_and_Scenic_Rivers [Data file]. Phoenix, AZ: USDA Forest Service, Tonto

U.S. Forest Service. (2012). Proposed Wild and Scenic Rivers [Data file]. Prescott NF, AZ: USDA Forest

State Conservation Lands Inside WPAs

State Conservation Lands include lands managed by the Arizona Game and Fish Department and Arizona State Parks for the purpose of natural resource and wildlife conservation, as well as historic and cultural resources.

Water Planning Area	State Conservation Lands
Camp Verde WPA	Fort Verde State Historic Park
Camp Verde WPA	Verde River Greenway State Natural Area
Clarkdale WPA	Verde River Greenway State Natural Area
Cornville WPA	Page Springs Hatchery
Cottonwood WPA	Dead Horse Ranch State Park
Cottonwood WPA	Verde River Greenway State Natural Area
Jerome WPA	Jerome State Historic Park
Mingus Mountain	Dead Horse Ranch State Park
Mingus Mountain	Verde River Greenway State Natural Area
Paulden WPA	Upper Verde WA (Granite Cr)
Paulden WPA	Upper Verde WA (Sullivan Lake)
Prescott CCD	Upper Verde WA (Granite Cr)
Prescott CCD	Upper Verde WA (Campbell Place)
Prescott CCD	Upper Verde WA (Tract 39)
Verde	Page Springs Hatchery
Verde	Dead Horse Ranch State Park
Verde	Red Rock State Park
Verde Village WPA	Verde River Greenway State Natural Area

Arizona Game and Fish Department. (2011c). Lands owned or managed by the Arizona Game and Fish Commission [Data file]. Phoenix, AZ: Unpublished.

Arizona Game and Fish Department. (2011d). Properties owned by the Arizona Game and Fish Department [Data file]. Phoenix, AZ: Unpublished.

Arizona State Parks. (2010). Arizona State Parks [Data file]. Phoenix, AZ: Author.

Waters Within Federal and State Conservation Lands Inside WPAs

These data represent perennial stream reaches and springs located within federal and state conservation lands. These waters represent a subset of waters that have additional conservation values due to their inclusion on lands with specific conservation and protection measures.

Water Planning Area	Federal Conservation Lands Inside WPAs
	Cedar Bench Wilderness NWA
Humboldt, Verde	Verde River WSR
Humboldt, Verde	Verde Scenic River Area NWSR
Verde, Mingus Mountain	Sycamore Canyon Wilderness NWA
	Woodchute Wilderness NWA
Prescott CCD, Mingus Mountain, Verde	Proposed Upper Verde River NWSR
	Apache Creek Wilderness NWA
	Granite Mountain Wilderness NWA
	Juniper Mesa Wilderness NWA
	Munds Mountain Wilderness NWA
Verde	Red Rock-Secret Mountain Wilderness NWA
	State Conservation Lands Inside WPAs
	Fort Verde State Historic Park
	Jerome State Historic Park
Clarkdale, Verde Village, Cottonwood	Verde River Greenway State Natural Area
	Upper Verde WA (Granite Cr)
	Upper Verde WA (Sullivan Lake)
	Upper Verde WA (Granite Cr)
	Upper Verde WA (Campbell Place)
	Upper Verde WA (Tract 39)
	Page Springs Hatchery
Cottonwood	Dead Horse Ranch State Park
Verde	Red Rock State Park
Cornville	AGFD Deeded Lands
Verde	AGFD Deeded Lands
Prescott	AGFD Deeded Lands

Anning, D.W., Parker, J.T.C. (2009). Predictive models of the hydrological regime of unregulated streams in Arizona (USGS OFR 2009-1269). Reston, VA: U.S. Geological Survey. Available from http://pubs.usgs.gov/of/2009/1269

Spring datasets were compiled by ADWR (2008), and include sources from USGS, state universities, USFS, NPS, and BLM. A detailed description of the methods used to compile information on springs is provided in the Arizona Water Atlas, Volume 1 (ADWR, 2010).

Arizona Department of Water Resources. (2008). ADWR_FinalSpringsTblAtlas_2008 [Data file]. Phoenix, AZ: Unpublished.
Arizona Department of Water Resources. (2010a). Arizona Water Atlas, Executive Summary (Vol. 1). Phoenix, AZ: Author. Available from http://www.azwater.gov/adwr/statewideplanning/wateratlas

Water Planning Area	Perennial Waters	Major Springs	Outstanding Az Water
Humboldt, Verde	Verde River		
Humboldt, Verde	Verde River		
Verde, Mingus Mountain	Sycamore Creek	Parson, Spider John, Summers	
Prescott CCD, Mingus Mountain, Verde	Verde River		
Verde	Oak Creek		Oak Creek
Clarkdale, Verde Village, Cottonwood	Verde River		
Cottonwood	Verde River		
Verde	Oak Creek		
Cornville	Spring Creek	Spring Creek	
Verde	Verde River	Page Area #1, Lolo-Mai	
Prescott	Granite Creek	Big Chino	

Central Yavapai Highlands Water Resources Management Study

List of Potential Impacts to Water-Dependent Natural Resources based on Proposed Water Development Alternatives

Note: Impacts may be positive or negative, or minimal/non-applicable depending on alternative.

Hydrologic

Three main hydrologic issues were identified as the main drivers of impacts to the environment from particular water development alternatives.

1. Impact to Water Quality
    a. Increased Contaminants
    b. Emerging Contaminants
    c. Temperature
    d. Channel and/or Floodplain Sedimentation/Turbidity
    e. Algal Blooms

2. Impact to Streamflow
    a. Timing, Magnitude, Duration and Frequency
    b. Flood Flow
    c. Baseflow
    d. Water Evaporation
    e. Vegetation Evapotranspiration
    f. Spring Discharge

3. Impact to Depth to Groundwater

Biological

Based on potential impacts to hydrologic conditions of groundwater and surface water systems from proposed water development alternatives, the following three environmental / biologic impacts may be anticipated.

1. Impact to Vegetation
    a. Riparian vegetation establishment/maintenance
    b. Wetland vegetation establishment/maintenance
    c. Non-native vegetation establishment

2. Impact to Riparian-obligate Species
    a. Habitat Quality (loss, degradation, conversion)
    b. Habitat Size/Distribution
    c. Habitat integrity (e.g. fragmentation)
    d. Trophic Interactions (food web impacts or food availability)
    e. Species viability in the affected area

3. Impact to Fish/Aquatic species

a. Habitat Quality (loss, degradation, conversion)
b. Habitat quantity
c. Stream system fragmentation
d. Non-native species introduction/increases
e. Introduction of disease, pathogens, parasites
f. Food availability
g. Viability in the affected area

Landscape

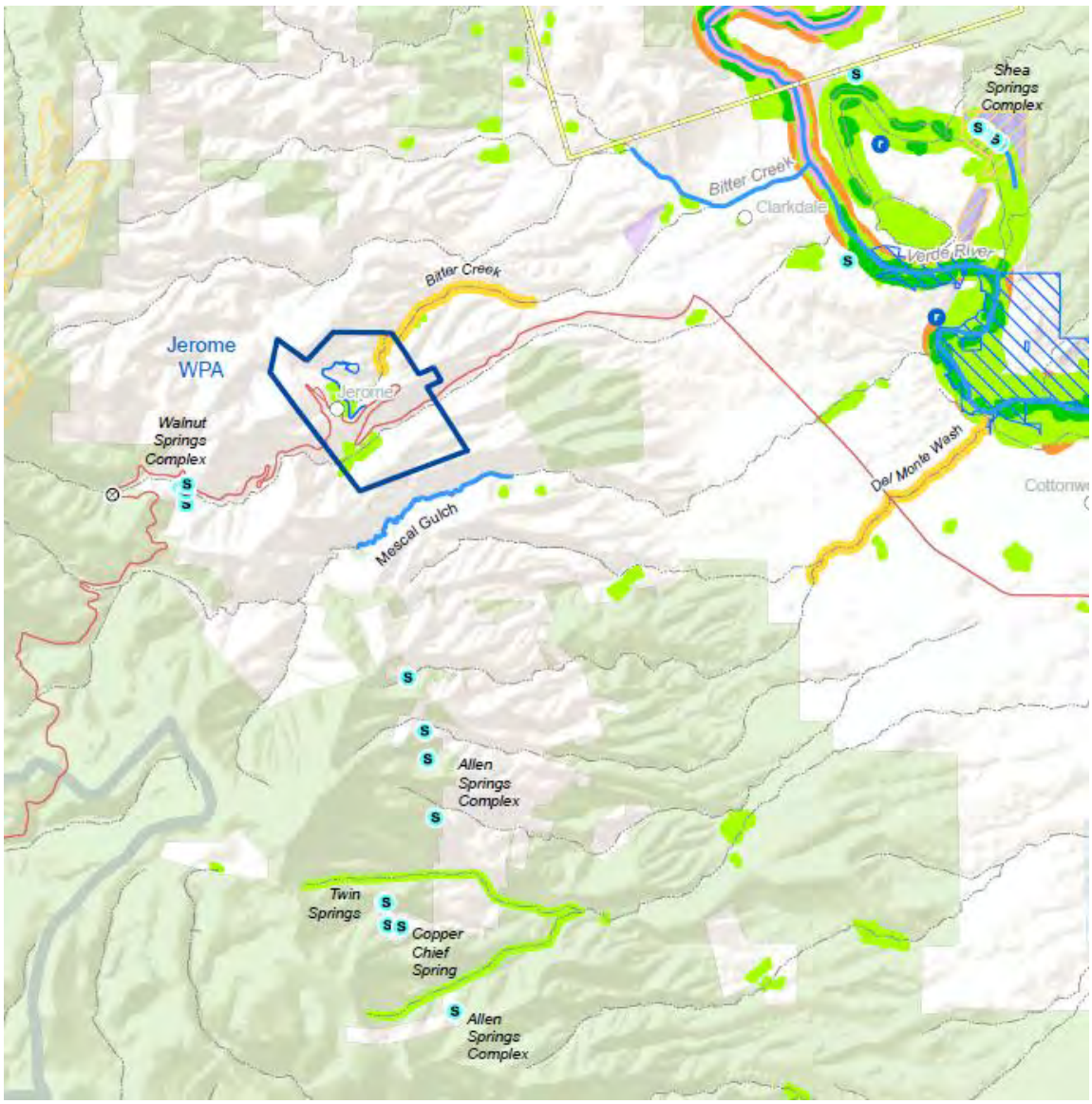
In addition to hydrologic and biologic categories of impacts, there may be broader watershed impacts to consider based on proposed water development alternatives.

1. Impact to Watersheds
    a. Ephemeral and Intermittent Channels (Stream morphology)
    b. Forest and Rangeland Health
    c. Soil Impacts (salinity, erosion, infiltration/runoff)
    d. Land Subsidence
    e. Micro-Climate

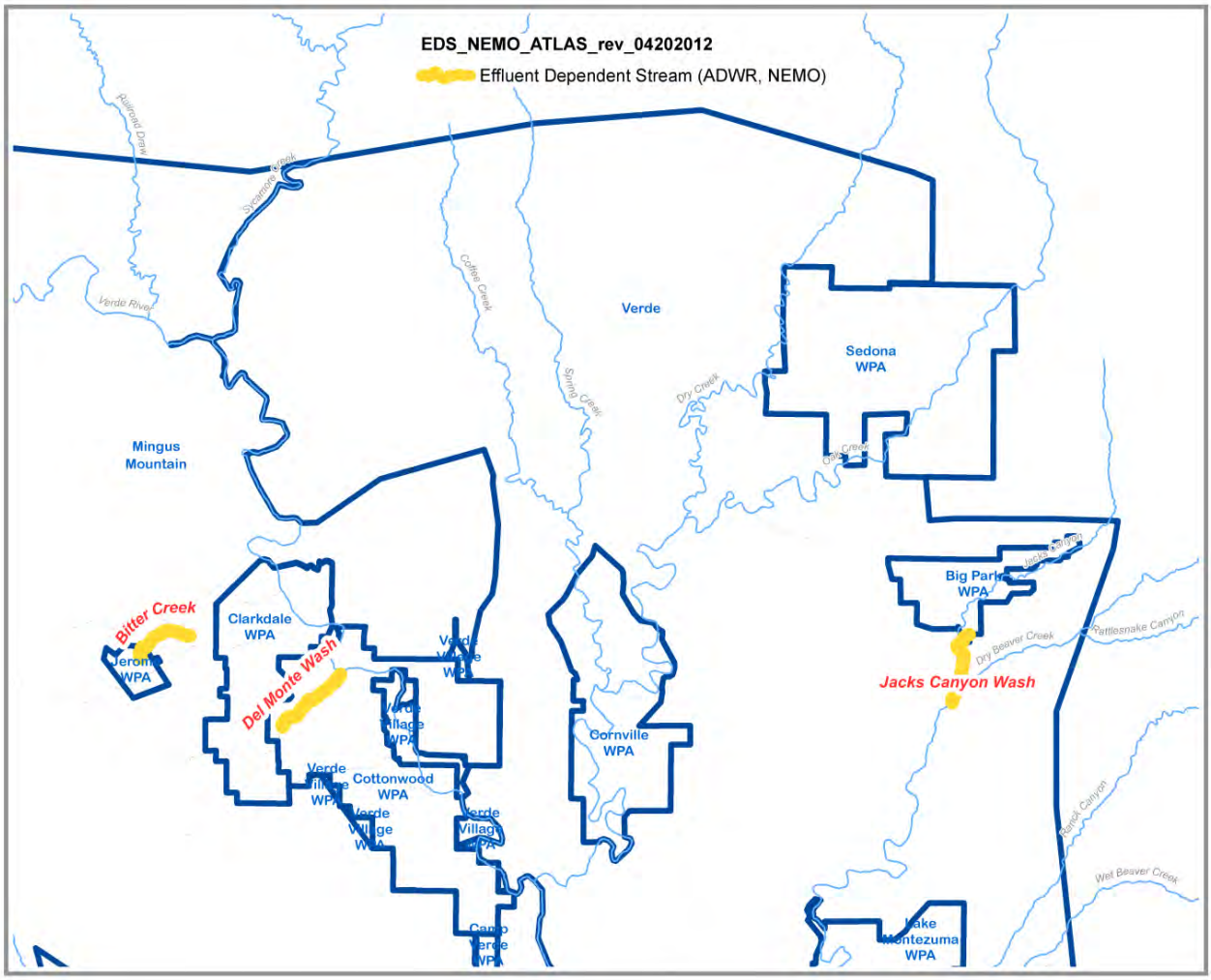
CYHWRMS Mapping Project Anomalies
May 2 ,2012 - L. Bredimus

The majority of the methods and resources used in creating the maps and queries for CYHWRMS are identical to those used by the WRDC Environmental Committee. There are a few anomalies, and they are illustrated below.

Spring complexes shown here were identified and labeled based on input from Jane Moore of the Town of Jerome. (Source: ADWR Major Springs)

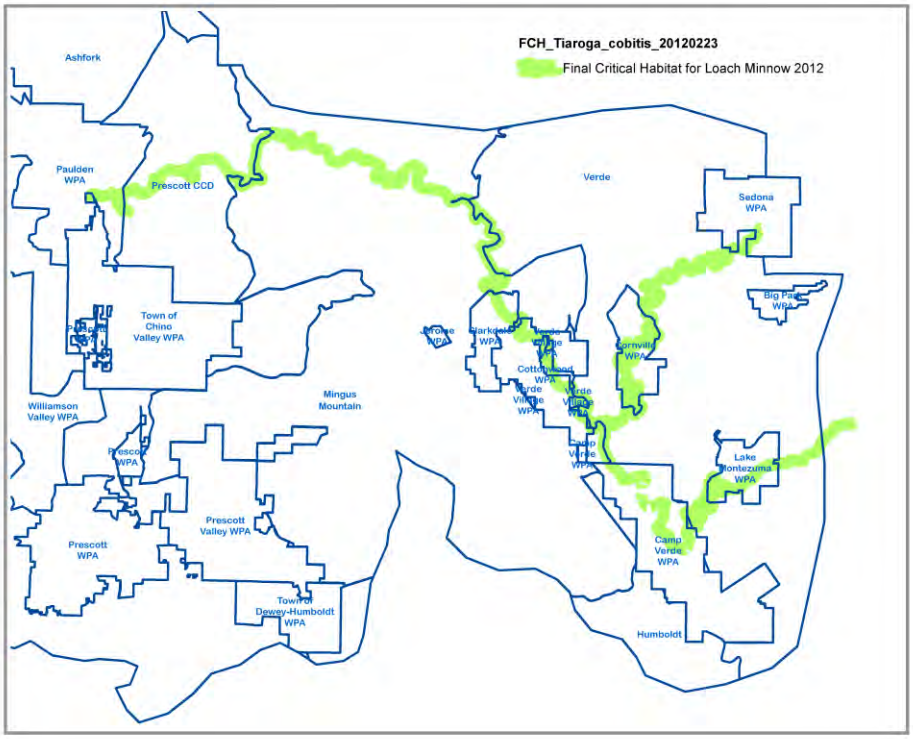


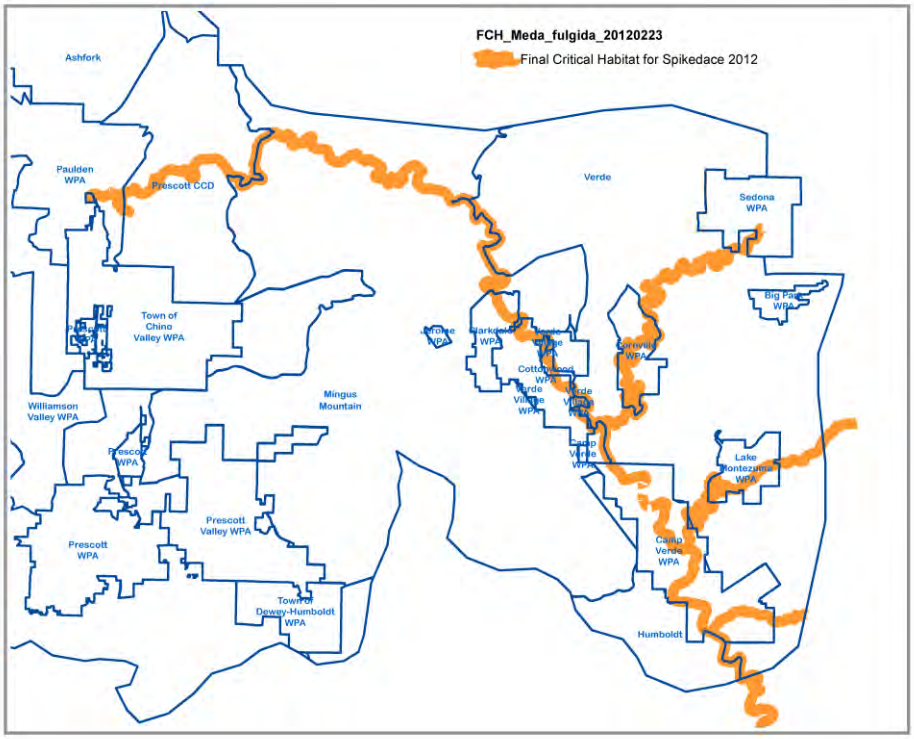
Three **effluent dependent streams** were included based on input from community members: Bitter Creek, Del Monte Wash, Jack's Canyon. (Source: EDS NEMO Atlas)



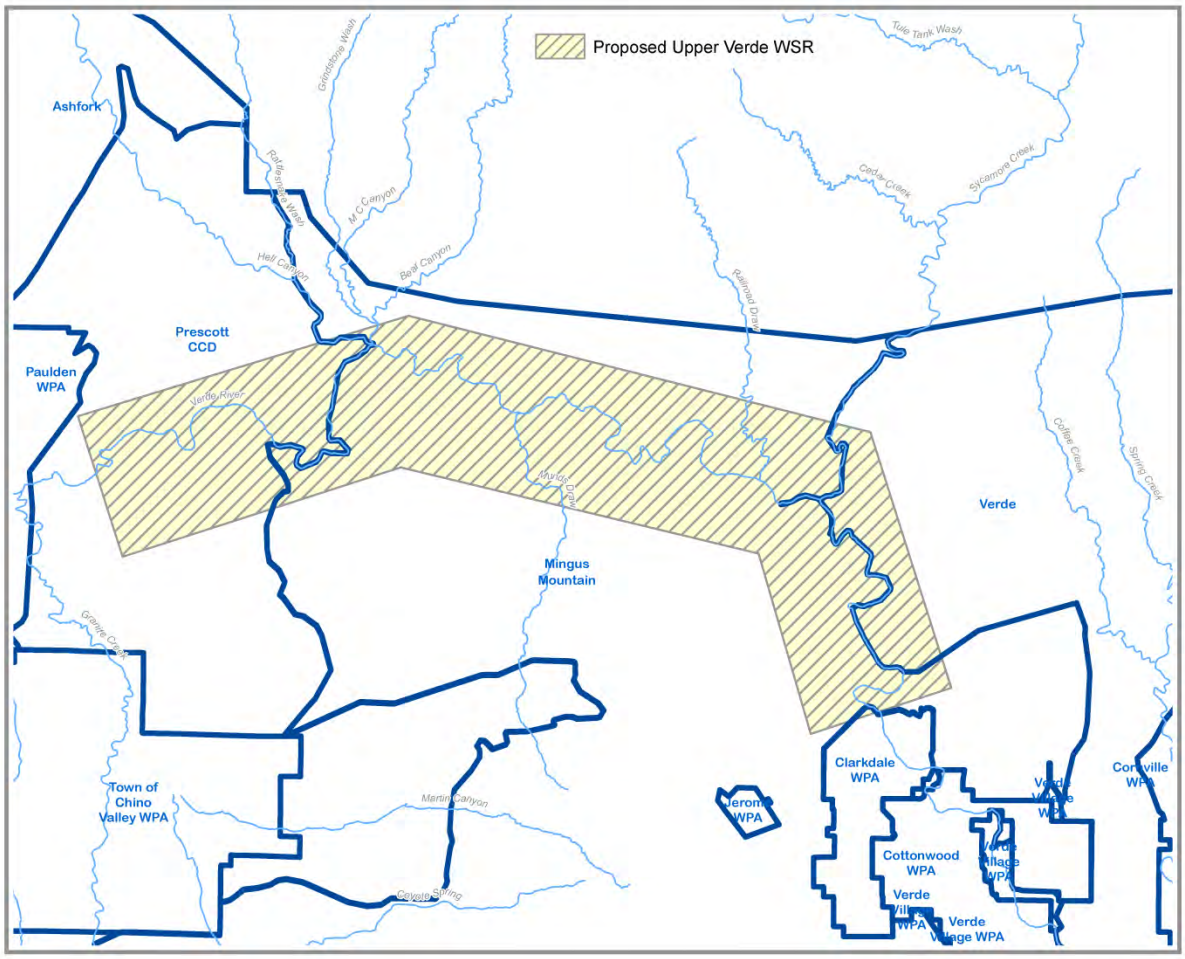
Based on comments from John Munderloh, any reaches of the Agua Fria River appearing in the original EDS NEMO Atlas of effluent dependent streams were removed from the maps and queries. He also commented that there are no discharges from Prescott Valley's WWTP, so that feature was also removed.

New data was available for **Final Critical Habitat** of two fish species, loach minnow and spikedace. (Source: USFWS)





New data was available for the **proposed WSR reaches of the Upper Verde River**. The boundary shown is very generalized, exaggerated for legibility. (Source: Prescott National Forest)



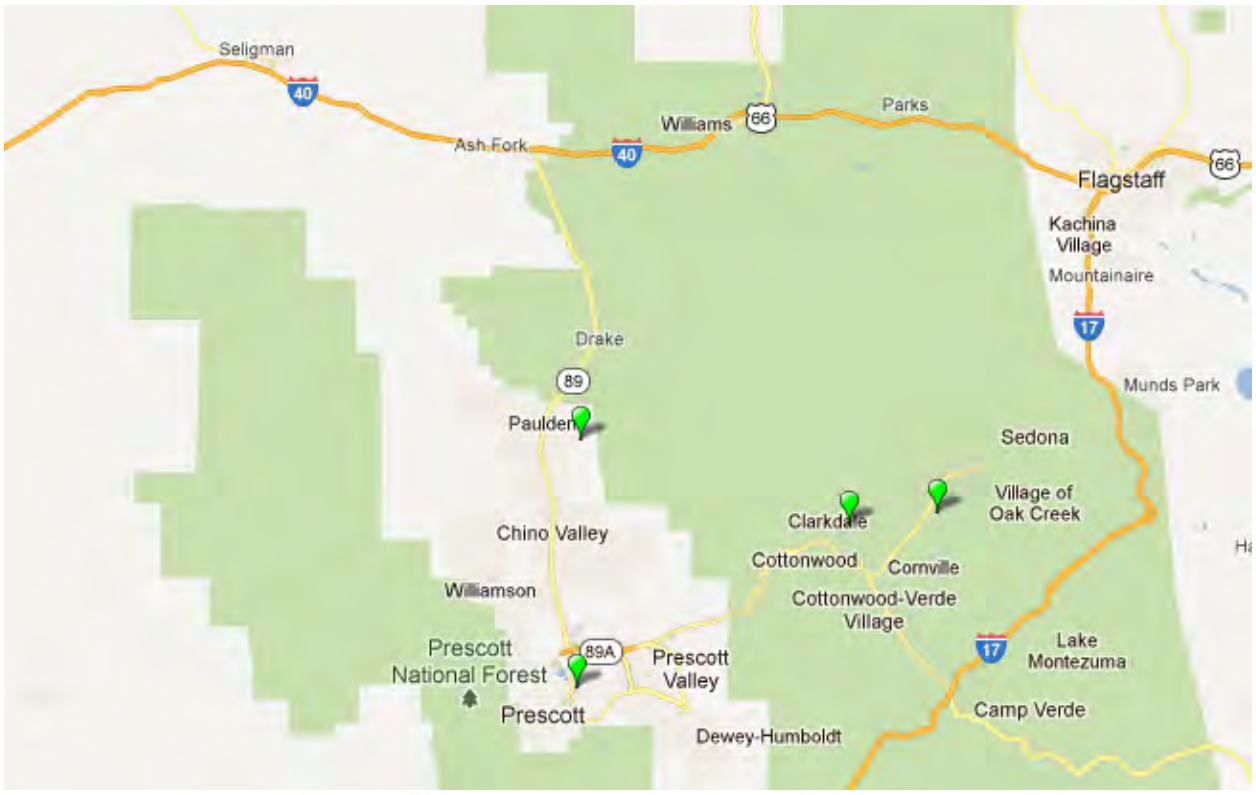
Audubon IBA's (Important Bird Areas) were mapped based on a written description found on this website: http://web4.audubon.org/bird/iba/ - no GIS data was available.

Lower Oak Creek (river corridor, extending upslope to approximately the rim level on either side of the river extending from Red Rock State Park to just south of Page Springs Fish Hatchery)

Tuzigoot (consists of three distinct and inter-related water-based systems: 1) a 2-mile stretch of the Verde River riparian corridor, 2) Peck?s Lake and associated riparian and upland habitats, and 3) Tavasci marsh)

Upper Verde River State Wildlife Area (2145 acres located along the upper Verde River and lower Granite Creek)

Watson and Willow Lakes Ecosystem (Watson Lake east of Highway 89 and Willow Lake west of Highway 89. the immediate surrounding uplands, and 2 miles of Granite Creek flowing into Watson Lake)



Central Yavapai Highlands Water Resources Management Study
Legal and Institutional Considerations

This document outlines the legal and institutional considerations for the CYHWRMS water supply alternatives. The intent of this section is to identify potential legal requirements, including those of Federal agencies, State and local entities, and nongovernmental interests, that may need to be met to construct an alternative. Alternatives are not limited to those that could be implemented directly under current authorities of Federal agencies, State and local entities, and nongovernment interests. Alternatives may be in compliance with existing statutes, administrative regulations, and established common law; or may propose necessary changes in statutes, regulations, or common law to be implemented.

Potential legal requirements associated with an alternative may have known timeframes and costs, such as obtaining a permit, and can be taken into consideration when evaluating an alternative. Also listed in this section, are potential issues and public perceptions that may arise in association with a particular alternative. This assessment begins with an overview of potential legal and institutional considerations for each of the alternatives.

The *Legal and Institutional Considerations* table shows potential regulations and legal considerations that may be associated with an alternative. The table lists alternatives in the rows and potential legal and institutional considerations as column headers. Potential legal and institutional considerations that may be relevant to each alternative are indicated with an "X" in the table. Note, if a regulation or legal consideration is identified for an alternative, this does not definitively mean that this will be a requirement to construct the alternative. Further analysis of the legal and institutional considerations associated with an alternative would be conducted under a Feasibility Study.

Potential legal and institutional requirements are briefly described in the following text and are provided for use during the alternative evaluation process.

Following the legal and institutional descriptions, potential issues and public perceptions that could arise in association with the proposed alternatives are listed. Potential issues and public perception are qualitative, they do not involve permit costs, timelines, or known contractual requirements. They are listed to provide a general understanding of circumstances that could arise during implementation of an alternative. While it is not known how public perceptions and issues may affect construction of a potential alternative, it is important to understand that public response may support, delay or stop construction of a project.

Local, State, Federal and Tribal Legal Requirements and Nongovernmental Interests

Local

Flood Plain Ordinance
Flood Plain ordinances, established by local governing entities, require permits for proposed construction or development within a community, to determine whether the proposed construction or development is within flood-prone areas. Permits are required to ensure that proposed projects meet the community's floodplain management ordinance.

Grading Permit
Grading ordinances, established by local governing entities, set forth rules and regulations to control excavation, grading, and earthwork construction, including fills and embankments, and provides for approval of plans and inspections of grading construction. The purpose is to safeguard public welfare and property by

regulating grading on private property.

Planning and Zoning
This refers to plan of development for the unincorporated jurisdiction of Yavapai County, Arizona as provided in Title 11, Chapter 6 of the Arizona Revised Statutes. This provides the minimum requirements to govern the use of land to facilitate adequate provision of transportation, water, sewerage, schools, parks and other public requirements. These provisions govern whenever they are more stringent than any other statute, ordinance, legal covenant, agreement or contract.

Regional Water Quality Management Planning (208)
Regional Water Quality Management Planning (WQMP) is a requirement of Section 208 of the federal Clean Water Act to protect water quality. The 208 Program facilitates review of infrastructure projects to assure consistency with the certified regional water quality management plan of the designated planning agency. The Northern Arizona Council of Governments (NACOG) represents Yavapai and Coconino Counties, Tribes, and Cities and Towns in North Central Arizona.

Right of Way
Right-of-way ordinances, established by local governing entities, specify that there be no encroachment within a publicly maintained right of way, without a written permit from the local administrator of such ordinance. An encroachment includes any obstruction, temporary or permanent.

State

Arizona Corporation Commission
The following statute describes the Arizona Corporation Commission's requirements for allowing surcharges to water utility bills: ARS 40-370. Water utility surcharges are used to recover operating costs.

Arizona Native Plant Law
All land in the State of Arizona belongs to someone, whether it be a government agency or a private citizen. Plants cannot be removed from any lands without permission of the owner and a permit from the Arizona Department of Agriculture. Lessees of State or Federal land must obtain specific authorization from the landlord agency to remove protected native plants.

State Historic Preservation Act
Arizona Revised Statutes 41-841 through 41-847 prohibit excavation of historic or pre-historic sites on lands owned or controlled by the State of Arizona, except by permit from the Director of the Arizona State Museum.

Water Infrastructure Finance Authority
A.R.S. 49-1201 through 1268 provides the statutes covering the Water Infrastructure Finance Authority (WIFA). WIFA can adopt rules pursuant to Title 41, Chapter 6, governing the application for and awarding of wastewater treatment facility, drinking water facility, and nonpoint source project financial assistance under this article, the administration of the clean water revolving fund and the drinking water revolving fund, and the issuance of water quality bonds.

Arizona Department of Water Resources

Assured and Adequate Water Supply Programs
The Assured and Adequate Water Supply Programs were created to address the problem of limited groundwater supplies and apply when a subdivision is being developed. Consequently, applicability of the programs is driven by the Arizona Department of Real Estate definition of a subdivision. The Assured Water Supply Program is

applicable within the Prescott AMA and the Adequate Water Supply Program is applicable in all non-AMA areas of the study.

Both programs are based on a demonstration of a 100-year water supply that includes current and committed demand in addition to future demand. A.R.S. §45-576 through 580 and Arizona Administrative Code Rules R12-15-701 through R12-15-729 govern the Assured and Adequate Water Supply programs. In both programs, water included must be physically, legally and continuously available and of adequate quality. Water providers must demonstrate the financial capability to construct the water facilities necessary to make the water supply available. Additionally, in the Assured Water Supply Program, the water supplies utilized must be consistent with both the management plan and the management goal.

Inside AMAs, development of subdivisions can only occur if there is either a Certificate of Assured Water Supply issued for the subdivision or if the subdivision obtains water from a water provider that has a Designation of Assured Water Supply. Outside AMAs, subdivisions can be developed even if ADWR has determined that the water supply for the development is inadequate. However, counties and cities and towns can require mandatory adequacy by ordinance, A.R.S. §11-823(A) and A.R.S. §9-463.01(o), respectively. The Town of Clarkdale passed an ordinance in 2008 requiring mandatory adequacy for subdivisions developed within the town's boundaries.

Colorado River Water Transfers
The right or authorization to beneficially use Colorado River water is defined as an entitlement. Entitlements held by non-federal Arizona Colorado River water users are created either by decree or through a contract with the Secretary of the Interior under Section 5 of the Boulder Canyon Project Act. A contractual right is a permanent entitlement administered by the U.S. Bureau of Reclamation.

The Director of the ADWR is generally responsible for formulating plans and programs for the development, management, conservation and use of surface water and groundwater throughout the state (A.R.S. §45-105) and consistent with this responsibility, entities that contemplate the transfer of entitlements are required to cooperate, confer and obtain the advice of the Director (A.R.S. §45-107). Consequently, ADWR will review any proposed transfers by a non-federal Arizona contractor of a Colorado River entitlement for the purpose of determining the potential water management impacts caused by the redistribution of water. ADWR will make a recommendation to the Secretary regarding the appropriate redistribution of mainstream Colorado River water supplies consistent with the policies and laws of the state. The process for ADWR review is found in the ADWR substantive policy statement titled "Policy and Procedures for Transferring an Entitlement of Colorado River Water".

General Adjudication of Water Rights
A general stream adjudication is a judicial proceeding in which the nature, extent, and relative priority of surface water rights is determined. There are two general stream adjudications in Arizona, the Gila River System (Gila Adjudication) and Source and the Little Colorado River System and Source. The Gila Adjudication is pertinent to the planning area. A.R.S. §45-251 to 264 are the statutes that pertain to regulations governing the general adjudication of water rights.

Groundwater Use Authority Inside AMA
In the Prescott AMA, groundwater can only be withdrawn and put to beneficial use pursuant to a grandfathered groundwater right (see A.R.S. §45-461 through 483), a groundwater withdrawal permit (see A.R.S. §45-511 through 528) or a service area right (see A.R.S. §45-491 through 498).

Grandfathered groundwater rights were established based on groundwater uses existing at the time the AMA was designated, or in 1980. Although there is provision for late applications for certificates of grandfathered

rights, these rights are typically not pertinent to new groundwater uses within the AMA. However, there are two mechanisms by which grandfathered groundwater rights may be utilized for new non-irrigations uses. A.R.S. §45-469 authorizes the retirement of an irrigation grandfathered right for non-irrigation uses. A.A.C. Rules R12-15-723 through R12-15-727 provide for the extinguishment of certain grandfathered rights in exchange for extinguishment credits that may be utilized in applications under the Assured Water Supply Program.

Groundwater withdrawal permits within AMAs are authorized by A.R.S. §45-511 through 528. There are seven categories of groundwater withdrawal permits: dewatering permits; mineral extraction and metallurgical processing permits; general industrial use permits; poor quality groundwater permits; temporary permits; drainage water permits; and hydrologic testing permits. It is not anticipated that groundwater withdrawals authorized by these types of permits would result in significant water supplies to meet the future projected demands within the study area.

A.R.S. §45-491 through 498 are the statutes that pertain to groundwater rights and uses of groundwater within service areas inside AMAs. Service areas are legally defined geographic areas associated with cities, towns, private water companies and irrigation districts. These statutes authorize groundwater withdrawals for the benefit of landowners and residents within service areas in a volume necessary to meet the needs of those landowners and residents. Groundwater withdrawals pursuant to a service area right are subject to the conservation requirements of the AMA management plans.

Notice of Intent to Drill
A.R.S. §45-596 F.2. describes the requirement for a well site plan that shows the property and the location of any septic tank or sewer system located on the property or within one hundred feet of the proposed well site and is submitted with the notice of intention to drill proposed wells for domestic purposes on a parcel of land of five or fewer acres.

Supervision of Dams, Reservoirs, and Projects
A.R.S. § 1201 assigns the responsibility for supervision of the safety of specific dams to the ADWR. In general, these are referred to as jurisdictional dams that are by definition an artificial barrier for the impounding or diversion of water; such dams being either 25 feet or more in height or impounding more that 50 acre-feet of water. Certain smaller dams or barriers are exempt from ADWR regulation and the department does not exercise jurisdiction over federally owned dams. A.R.S. §45-1202 through 1223 and A.A.C. Rules R12-15-1201 through 1226 pertain to regulation of dam safety within the state. It is unlawful to construct, reconstruct, repair, operate, maintain, enlarge, remove or alter any jurisdictional dam except upon approval of the director.

Surface Water Appropriation and Regulation
A.R.S. §45-141 describes surface water as "waters of all sources, flowing in streams, canyons, ravines or other natural channels, or in definite underground channels, whether perennial or intermittent, flood, waste or surplus water, and of lakes, ponds and springs on the surface" and mandates that those waters belong to the public and are subject to appropriation and beneficial use.

A.R.S. §45-151 through 166 are the statutes that pertain to the appropriation of surface water, including the permitted uses of surface water and the priority of competing uses. A.R.S. 45-171 through176 describe an entity's rights to water and the process for severing a surface water right from its place of use and transferring it to a new location. A.R.S. §45-181 through 190 are the statutes that describe the water rights registration program and the process for asserting water rights claims by filing a statement of claim. These statements of claim assert the rights to water that was appropriated before June 12, 1919. A majority of the surface water rights in the study area assert pre-1919 water use.

Transportation of Groundwater
In general, transportation of groundwater between basins is prohibited; however, there are some exceptions. A.R.S. §45-541 through 45-547 are the statutes that pertain to regulations governing transportation of groundwater within the state. A.R.S. 45-551 through 45-559 are the statutes that pertain to regulations governing the transportation of groundwater to active management areas. Specifically, A.R.S. §45-555 prescribes the manner in which groundwater withdrawn in the Big Chino sub-basin may be transported to the Prescott AMA.

Underground Water Storage, Savings, and Replenishment Act
The Underground Water Storage, Savings, and Replenishment (UWS) program has five goals: (1) to promote the use of renewable supplies by allowing for flexible storage and recovery; (2) to provide for the efficient use of water through storage and recovery; (3) to reduce overdraft through water storage; (4) to accommodate seasonal demand through storage; and (5) to augment water supplies. The UWS program encourages the use of renewable water over the use of groundwater by restricting water that may be stored to accrue long-term storage credits to sources that cannot be used directly. A.R.S . §45-801.01 to 882.01 are the statutes that pertain to regulations governing storage facilities, water storage and recovery well permits, storage and recovery pursuant to Indian water rights settlements, accounting and annual reports.

Water Exchanges
A.R.S. §45-1001 to 1006, A.R.S. §45-1021 to 1022 and A.R.S. §45-1041 to 1063 authorize and regulate the exchange of any type of water for any type of water, establish classifications of exchanges, and give the Director authority over exchanges. Consequently, since the Water Exchange Act was passed, and amended, there has been greater certainty provided for entities participating in water exchanges.

Well Spacing Rules
A.A.C. Rule R12-15-1301 through 1308 (and A.R.S. §45-559) describe the well spacing requirements and define replacements wells in approximately the same location. These rules became effective in 2006 and were designed to prevent unreasonably increasing damage to surrounding land or other water users from a concentration of wells. The well spacing rules do not apply to the construction or use of the following types of wells: (1) wells drilled outside of AMAs, with two exceptions; (2) exempt wells within AMAs; (3) wells within AMAs withdrawing water pursuant to groundwater withdrawal permits other than general industrial use permits; and (4) wells that withdraw only surface water. In general, new wells will not be permitted if the withdrawals from the proposed well will exceed 10 feet of additional drawdown after the first five years of operation.

Arizona Department of Environmental Quality

Arizona Pollutant Discharge Elimination System (AZPDES)
A.R.S. R18-9-A901 describes ADEQ's Arizona Pollutant Discharge Elimination System (AZPDES) program pursuant to Section 402 of the Clean Water Act. The AZPDES program includes the regulation of waste water and storm water point source discharges and the industrial pretreatment program.

Aquifer Protection Permits
Unless otherwise exempted, a waste discharge that has the potential to degrade water quality in an aquifer must receive an APP from ADEQ certifying that specified measures have been or will be taken to prevent pollution of the aquifer.

Aquifer Water Quality Standards
Under Title 49, ADEQ has adopted rules (A.A.C.R18-11-401, et seq.) which set both numeric and narrative AWQSs as well as Health-Based Guidance Levels (HBGL). Numeric AWQSs are equivalent to the Federal

primary drinking water standards, while narrative standards may be set on a "case-by-case" basis utilizing HBGLs or other technical information to protect human health or current and future aquifer use.

BADCT for Sewage Treatment Facilities
A.A.C. Title 18, Ch. 9, Art. 2, Part B, R18-9-B201 through B206. In 2001, and revised by modifications in 2005, ADEQ adopted a Best Available Demonstrated Control Technology (BADCT) standard for sewage treatment plants under its APP program that requires tertiary treatment in all new or significantly expanding wastewater treatment plants. Under this standard, high quality denitrified, disinfected reclaimed water must be produced.

Potable Water Facilities
ADEQ is designated as the responsible agency for this State to take all actions necessary or appropriate to ensure that all potable water distributed or sold to the public through public water systems is free from unwholesome, poisonous, deleterious, or other foreign substances and filth or disease-causing substances or organisms. All such actions shall be taken at the direction of the director of the department. The statutes which address potable water systems can be found in A.R.S. Title 49 parts 353 through 360.

Reclaimed Water Conveyance
A.A.C. Title 18, Ch. 9, Art. 6, R18-9-601 through 603. These provisions consist of a basic set of technical criteria for the design and construction of reclaimed water distribution systems.

Reclaimed Water Quality Standards
A.A.C. Title 18, Ch. 11, Art. 3, R18-9-301 through 309 describes the five classes of reclaimed water quality based on protection of public health and groundwater quality (A+, A, B+, B, and C).

Safe Drinking Water Act
A.A.C. Title 18 Chapter 4 describes the ADEQ Safe Drinking Water regulations, standards, and requirements to ensure the safety of drinking water quality.

Water Treatment Regulations
Laws and regulations governing the quality of water delivered to domestic users include the Safe Drinking Water Act, the Surface Water Treatment Rule, the Enhanced Surface Water Treatment Rule, the Total Coliform Rule, the Disinfection/ Disinfectant By-Products Rule, the Lead and Copper Rule, and the future Long-Term 1 Enhanced Surface Water Treatment Filter Backwash Rule. A.R.S. 49-201 through 225 provides the statutes by which ADEQ governs water quality standards.

Federal

Boulder Canyon Project Act of December 21, 1928
The Boulder Canyon Project Act federalized the administration of Colorado River water rights by requiring a contract with the Secretary of the Interior to use Colorado River water under either Section 4 or Section 5 of the act. A contractual right, issued under the authority of the Boulder Canyon Project Act, is a permanent entitlement administered by the U.S. Bureau of Reclamation. The ADWR and the U.S. Bureau of Reclamation work conjunctively with respect to non-federal transfers of Colorado River entitlements within Arizona for a period of more than one year.

Clean Air Act of 1963, as Amended
This act requires that any Federal entity engaged in an activity that may result in the discharge of air pollutants must comply with all applicable air pollution control laws and regulations (Federal, State, or local).

Clean Water Act
The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. Federal activities affecting water supply alternatives being evaluated include compliance with Sections 401, 402, and 404 of the Clean Water Act.

National Pollutant Discharge Elimination System Permits
Pursuant to section 402 of the Clean Water Act, ADEQ administers the certification of NPDES permits for EPA. The NPDES Permit for Point Sources of Pollution, as defined by ADEQ, protects the waters of the State from pollutants discharged from a point source. The waters of the State include all perennial or intermittent streams, lakes, ponds, impounding reservoirs, marshes, watercourses, waterways, wells, aquifers, springs, irrigation systems, drainage systems, and other bodies or accumulations of surface, underground, natural, artificial, public, or private water situated wholly or partly in or bordering on the State.

A NPDES storm water permit may also be required for certain industrial and construction activities that discharge storm water. NPDES permits are usually required for effluent or industrial wastewater being disposed of by discharge to the waters of the State. However, when wastewater is proposed for a reuse application, such as recharge, the ADEQ wastewater reuse and APP rules are applied.

Prior to the issuance of either an NPDES or 404 permit (see below), the applicant must obtain a Section 401 certification. This declaration states that any discharge complies with all applicable effluent limitations and water quality standards.

Section 404 Clean Water Act Dredge and Fill Permits
Section 404 of the Clean Water Act requires that the United States Army Corps of Engineers, with the concurrence of EPA, issue or deny permits for activities that result in the discharge of dredged or fill material into the waters of the United States. For the purposes of this section, waters of the United States include most streams, stream channels, and wetlands in Arizona. The 404 permit also pertains to disturbance activities in wetlands and riparian areas. Intended to prevent the unlawful filling of wetlands, this section would apply to most channel modifications made for in-channel recharge projects. A 404 (b)1 analysis (alternative analysis) must be completed in order to determine the least environmentally damaging practicable alternative.

Endangered Species Act
The purposes of the Endangered Species Act are to provide a means for conserving the ecosystems upon which threatened and endangered species depend, and to provide a program for the conservation of these species. In addition, it is unlawful for anyone to take a federally-listed animal without a permit. “Take” is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Federal agencies are required to use their authorities to promote the conservation purposes of the ESA and to consult with the U.S. Fish and Wildlife Service to ensure that their activities (Federal actions authorized, funded, or carried out by the agency) do not jeopardize the continued existence of a listed species or adversely modify "critical" habitat for a listed species. If non-federal activities may result in the take of threatened or endangered fish or wildlife species, a landowner or other applicant can receive a permit to take the listed species, incidental to otherwise legal activities, by developing a habitat conservation plan that includes measures to minimize and mitigate impacts to the species.

Executive Order 11988, Floodplain Management, May 24, 1977
Executive Order 11988 requires avoiding or minimizing harm associated with the occupancy or modification of a flood plain.

Executive Order 11990, Protection of Wetlands, May 24, 1977
Executive Order 11990 provides for the protection of wetlands through avoidance or minimization of adverse impacts.

Fish and Wildlife Coordination Act of 1934, as Amended
This act requires coordination with Federal and State wildlife agencies (FWS and Arizona Game and Fish Department) for the purpose of mitigating project-caused losses to wildlife resources, and requires equal consideration and coordination of wildlife conservation with other water resources development programs.

National Historic Preservation Act of 1966, as Amended
Federal agencies are responsible for the identification, management, and nomination to the National Register of Historic Places cultural resources that would be affected by Federal actions. Consultation with the Advisory Council on Historic Preservation, the State Historic Preservation Officer and affected Indian tribes is required when a Federal action may affect cultural resources on, or eligible for inclusion in, the *National Register*.

NEPA Compliance
The National Environmental Policy Act (NEPA) is our basic national charter for protection of the environment. Compliance with NEPA requires participation of Federal, State, and local agencies, and concerned and affected public in the planning process. The act requires full disclosure about actions, alternatives, impacts, and possible mitigation for actions taken by Federal agencies. This act allows environmental concerns and impacts to be expressed and considered while an action is being planned.

Tribal

Federal Reserved Rights for Indian Tribes
The presence of unresolved federal reserved right claims for the Yavapai-Apache Nation adds a layer of uncertainty to long-term water planning for both the tribal and non-tribal communities. Since 2001, the standard that has been utilized to quantify Indian water rights in Arizona has been the homeland standard. This means that the volume of water reserved for the tribe is a volume of water sufficient to maintain the tribal homeland into the future. Additionally, the priority date of Indian reserved water rights is generally the date the reservation was created and not the actual date that water use began. The result is that Indian reserved water rights tend to be earlier priority than other water rights and potentially a larger volume of water than currently being utilized by the tribe.

Native American Graves Protection and Repatriation Act
Public Law 101-601; 25 U.S.C. 3001-3013 describes the treatment, repatriation, and disposition of Native American human remains, funerary objects, sacred objects, and objects of cultural patrimony, referred to collectively as cultural items, that demonstrate lineal descent or cultural affiliation. The statute also protects Native American burial sites and control of removal of cultural items, when such items are discovered on Federal or tribal lands.

Rights-of-Way
Rights-of-way over tribal lands are regulated and are similar to regulations for easements required for State and local highways; however the recourse to use eminent domain is generally not available, except in rare instances. The Energy Policy Act of 2005 contains provisions that authorize tribes to "grant a right of way over tribal land for a pipeline or an electric transmission or distribution line without approval by the Secretary" in certain circumstances.

Water Rights
The Yavapai-Prescott Indian Tribe shall have the right to beneficially use, on the Reservation, and to store and divert on or off the Reservation, up to one thousand (1,000) AFY, of the right to Granite Creek surface water established by CVID pursuant to Arizona law and to be confirmed in the Gila River Adjudication, or to permit the diversion, treatment and delivery by Prescott of a portion of this water to facilitate deliveries of absolute priority water by Prescott pursuant to Subparagraph 5.1 of the Water Service Agreement, as further described in paragraph 6.0 of the Yavapai-Prescott Indian Tribe Water Rights Settlement Agreement. The priority of the Yavapai-Prescott Indian Tribe's right to such Granite Creek water shall be the priority of that water as determined by the confirmation of CVID's right to Granite Creek water in the Gila River Adjudication. The Tribe shall be entitled each year to store, divert and use: (a) as its Minimum Annual Entitlement, fifty (50) percent of the flow, as measured at the State Highway 89 bridge across Granite Creek adjacent to the Reservation, until it has diverted five hundred and fifty (550) AFY; unless revised pursuant to conditions described in Paragraphs 4.0, 5.0 or 6.0 of the Yavapai-Prescott Indian Tribe Water Rights Settlement Agreement.

Other Interests

SRP Coordination and/or Contractual Requirements
SRP operates Bartlett and Horseshoe Reservoirs on the Verde River pursuant to several agreements with the federal government. Its primary responsibility in operating the reservoirs is towards fulfilling its obligations as a Reclamation Project. Those agreements, shareholder obligations, along with other contractual arrangements must be considered when discussing any modifications/expansions to facilities that could potentially impact those commitments. Many of these issues are mentioned below under "Flood Supply".

Potential Issues and Public Perceptions

Potential Issues

Groundwater Supply

- Assured Water Supply and conveyance of water from Big Chino
- Costs for long-distance conveyance of groundwater
- Groundwater pumping and overdraft within the PRAMA
- Declining water quality in deeper aquifers
- Impractical/unrealistic number of wells required to access all available groundwater in storage
- As groundwater levels decline, increased costs to deepen wells, to construct new wells and to pump wells
- Land subsidence and earth fissures
- Low well yields for many consolidated sedimentary rock and bedrock aquifers (Geology)
- Ownership of groundwater (inside AMAs, federal reserved groundwater rights)
- Well permitting, well spacing and impact rules, pumping exclusions near some Tribal lands
- Final decision and order related to delineation of subflow and the resulting reduction in the ability to develop new wells
- Statutory limits on groundwater transportation

Effluent Supply

- Cost for conversion
- Facilitating indirect and direct potable reuse
- Costs to upgrade wastewater treatment facilities to meet water quality standards

- Cost for conveyance infrastructure
- Cost to recharge treated effluent

Flood Supply

- Cost benefit (available spill times and volume)
- Dam modification feasibility (geology, etc.)
- Legal availability
- Reliability of flood flow supplies
- Effects of climate change on flood flow supplies
- Evaporative and seepage losses due to increased reservoir surface area
- Liability and downstream risks of expanded reservoirs
- Susceptibility to flooding and destruction of storage/dams on Upper Verde
- Surface water quality
- Water accounting
- Water rights & exchanges
- Modification to operation of dams and administration of water account
- Impact on property value
- Would require coordination with SRP who operate the impacted reservoirs

Storm Water Supply

- Enhanced benefit to aquifer that is accountable
- High infrastructure cost for long-distance conveyance of water
- Ownership of captured water
- Surface water quality
- Impact on property value
- Surface water regulations

Conservation

- Reimbursement or rebate costs and customer costs
- "Hardening of demand" in times of shortage, reduces flexibility, especially during drought
- Inability to quantify water savings
- Increased solids in wastewater streams
- Reduced availability of reclaimed water
- Disposal of replaced water features (toilets)

Surface Water Supply

- Cost prohibitive long-distance transport of water to places of use
- Physical availability and water storage
- Surface water quality
- Tribal rights or claims
- Water rights and exchanges
- Impact on property value

Other Water Supply

- Ownership of water
- Quantifiable benefits
- Indian Settlement Obligations
- Liability (potential flooding, etc.)

Public Perceptions

Groundwater Supply

- Potential impact on private wells
- Groundwater/surface water impacts (Verde River, springs, etc.)
- Negative public perception and potential denial of voter approval for financing and construction of proposed water development, conveyance, and infrastructure projects
- Reliability concerns
- New groundwater pumping could increase groundwater overdraft

Effluent Supply

- Public education to increase awareness of the value and safety of effluent
- Public perception of direct reuse of treated effluent for potable use
- Conversion from private to public water systems

Flood Supply

- Negative public perception and potential denial of voter approval for financing and construction of proposed water development, transport, and infrastructure projects

Storm Water Supply

- Negative public perception and potential denial of voter approval for financing and construction of proposed water development, transport, and infrastructure projects

Conservation

- Unintended consequences in conserving water such as drop in water pressure, less profit, etc.

Surface Water Supply

- Negative public perception and potential denial of voter approval for financing and construction of proposed water development, transport, and infrastructure projects

Other Water Supply

- High risk of potential return on investment
- Negative public perception and potential denial of voter approval for financing and construction of proposed water development, transport, and infrastructure projects

Table ___. Legal and Institutional Considerations.
Shows potential regulations and legal considerations that may be associated with an alternative, however, it is not indicative of a definitive requirement to construct an alternative.

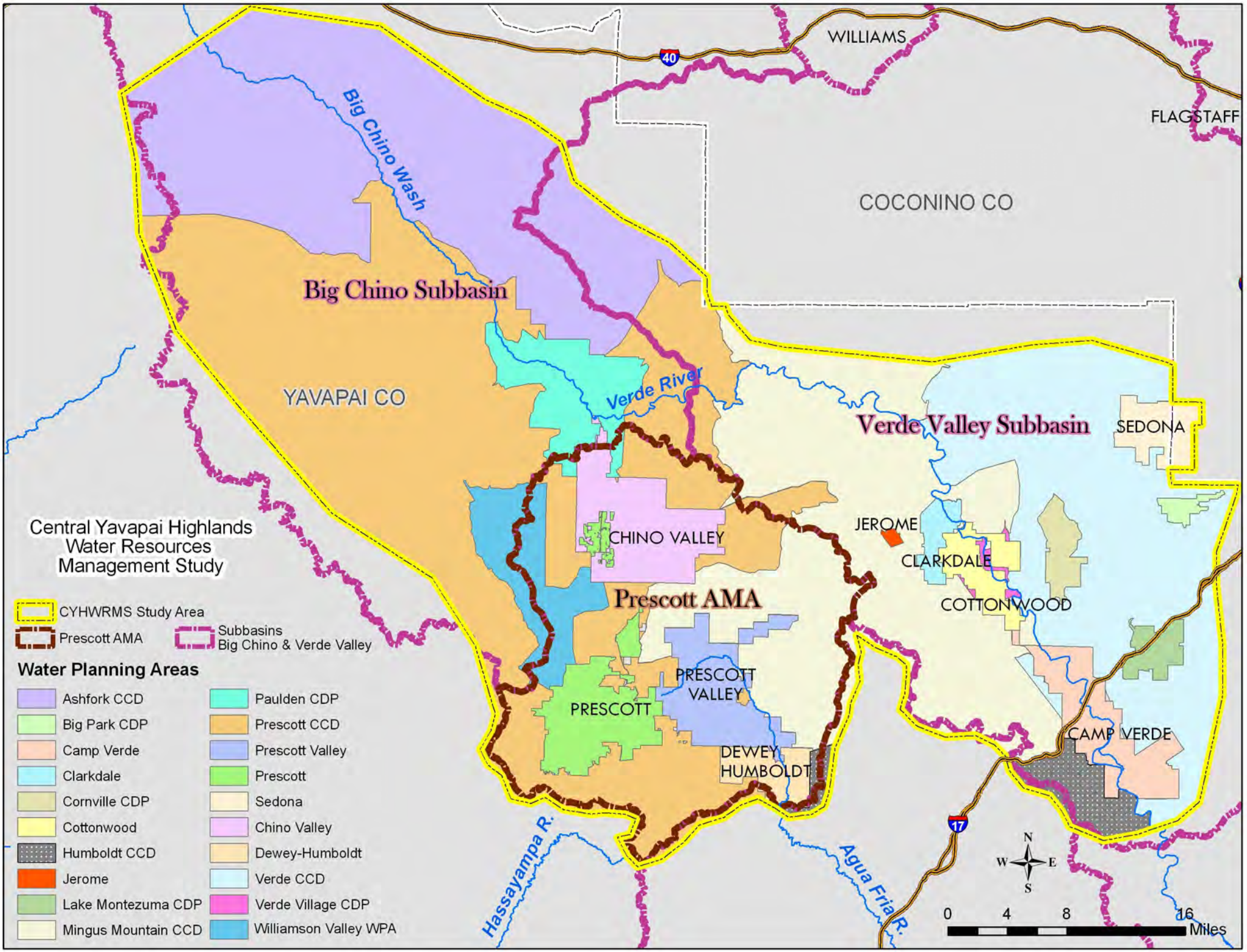
	Local Regulations								Other State Agencies				Arizona Department of Water Resouces											Arizona Department of Environmental Quality									Federal									Tribal		Other Interests
Alternative	Flood Plain Ordinance	Grading Permit	Planning and Zoning	Regional Water Quality Management Planning (208)	Right of Way	Arizona Corporation Commission	Arizona Native Plant Law	State Historic Preservation Act	Water Infrastructure Finance Authority	Assured and Adequate Water Supply	Program (Use not Supply)	Colorado River Water Transfers	General Adjudication of Water Rights	Groundwater Use Authority inside AMA	Notice of Intent to Drill	Supervision of Dams, Reservoirs, and Projects (Non-federal dams)	Surface Water Appropriation and Regulation (impound & Use)	Transportation of Groundwater (between basins)	Underground Water Storage, Savings, and Replenishment Act	Water Exchanges	Well Spacing Rules	Arizona Pollutant Discharge Elimination System (AZPDES)	Aquifer Protection Permit	Aquifer Water Quality Standards	BADCT for Sewage Treatment Facilities	Potable Water Facilities	Reclaimed Water Conveyance	Reclaimed Water Quality Standards	Safe Drinking Water Act	Water Treatment Regulations	Boulder Canyon Project Act of December 21, 1928	Clean Air Act of 1963, as Amended	Clean Water Act	Endangered Species Act	Executive Order 11988, Floodplain Management, May 24, 1977	Executive Order 11990, Protection of Wetlands, May 24, 1977	Fish and Wildlife Coordination Act of 1934, as Amended	National Historic Preservation Act of 1966, as Amended	NEPA Compliance	Federal Reserved Rights for Indian Tribes	Native American Graves Protection and Repatriation Act	Rights-of-Way	Water Rights	SRP Coordination and/or Contractual Requirements	
1. Local Groundwater Development within the WPA (inside & outside AMA)					X	X			X	X		X	X	X						X					X			X	X											X					
2. Regional Groundwater Development - Big Chino Pipelines (Prescott AMA & Verde Valley)	X	X	X		X		X	X	X	X		X		X			X			X					X			X	X		X	X	X			X	X	X	X	X				X	
3. Regional Groundwater Development Outside Study Area (Bill Williams & Big Sandy Sub-basins)	X	X	X		X	X	X	X	X	X				X			X		X	X					X			X	X		X	X	X	X	X	X	X	X	X	X					
4. Conversion of Existing Systems - Urban	X	X	X	X	X				X	X											X	X	X	X		X	X																		
5. Conversion of Existing Systems - Rural	X	X	X	X	X				X	X											X	X	X	X		X	X																		
6. New Effluent from New Population	X	X	X	X	X				X	X											X	X	X	X		X	X																		
7. Capture and Store Unappropriated Verde River or Tributary Water	X	X			X	X	X	X	X	X	X	X			X	X			X		X				X			X	X	X	X	X	X	X	X	X	X	X	X	X			X
8. Rainwater Harvesting - Aquifer Storage	X	X	X	X	X		X	X	X	X		X	X	X	X	X		X		X	X	X	X								X	X	X	X	X	X	X	X		X		X	
10. Alamo Lake	X	X		X	X	X	X	X		X											X				X			X	X		X	X	X	X	X	X	X	X		X			
11. Colorado River via (a)Alamo Lake, (b)Diamond Creek, (c)Lake Mead, (d)Lake Havasu, (e)Lake Mohave & (f)Lake Powell	X	X		X	X	X	X	X		X	X								X		X				X			X	X	X	X	X	X	X	X	X	X	X	X	X	X		

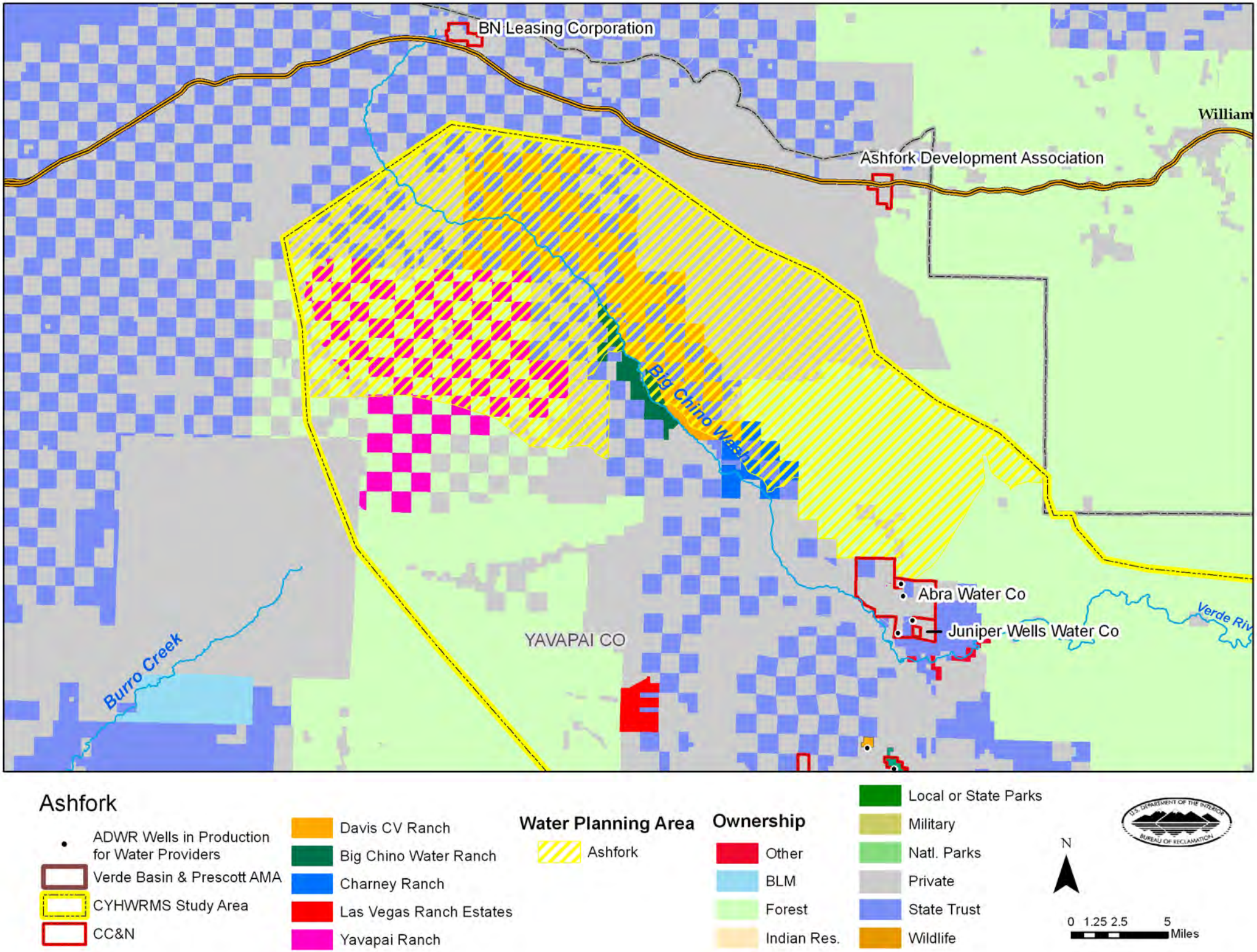
Central Yavapai Highlands Water Resource Management Study (CYHWRMS)

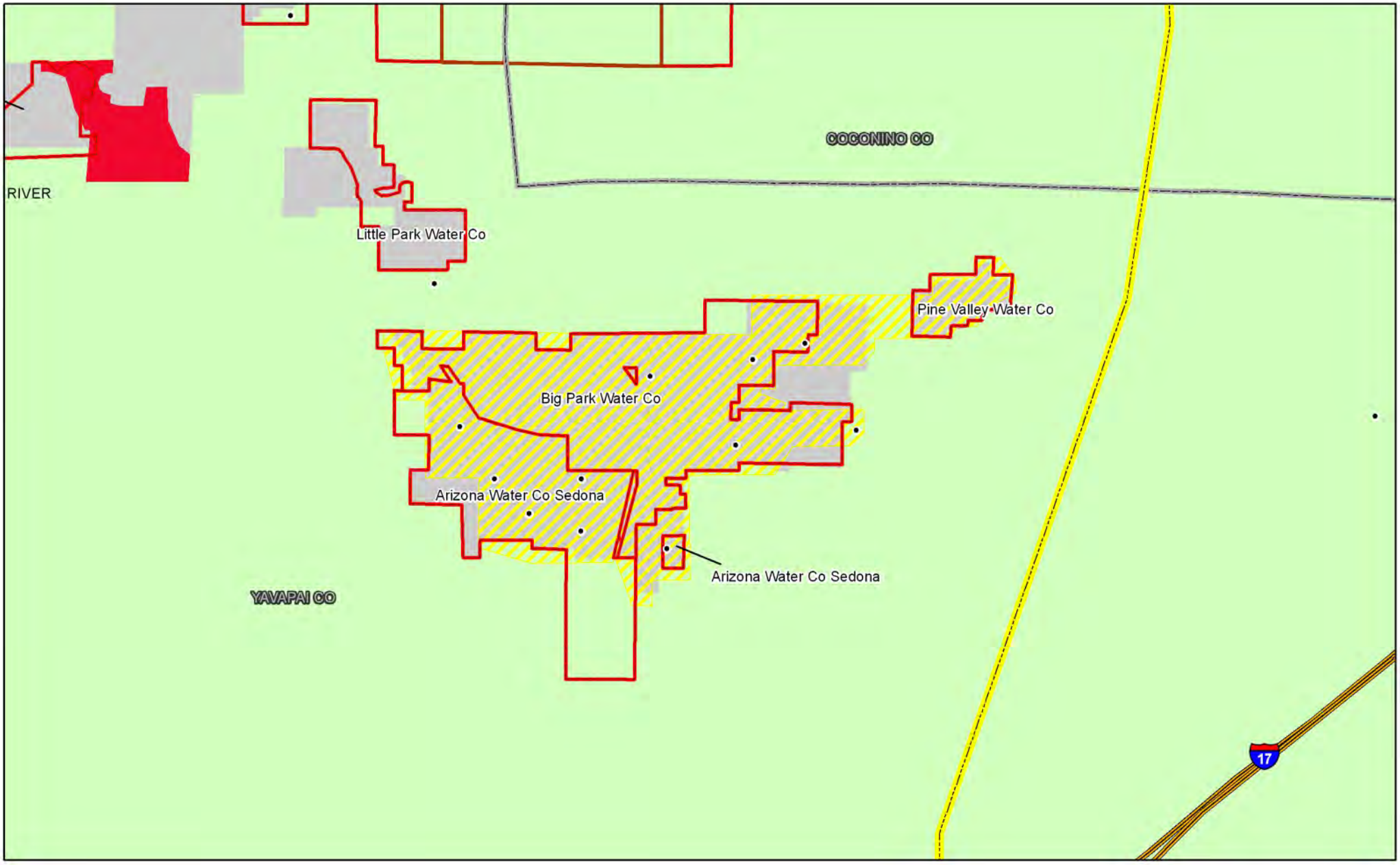
Appendix D

Maps

- **Study Area**
- **Water Planning Areas**
  - **Ashfork**
  - **Big Park**
  - **Camp Verde**
  - **Chino Prescott**
  - **Chino Valley**
  - **Clarkdale**
  - **Cornville**
  - **Cottonwood Verde Village**
  - **Dewey Humboldt**
  - **Humboldt**
  - **Jerome**
  - **Mingus Mountain**
  - **Montezuma**
  - **Paulden**
  - **Prescott**
  - **Prescott CCD**
  - **Prescott Valley**
  - **Sedona**
  - **Verde**
  - **Williamson Valley**


Central Yavapai Highlands
Water Resources
Management Study
CYHWRMS Study Area
Prescott AMA
Subbasins
Big Chino & Verde Valley
Water Planning Areas
Ashfork CCD
Big Park CDP
Camp Verde
Clarkdale
Cornville CDP
Cottonwood
Humboldt CCD
Jerome
Lake Montezuma CDP
Mingus Mountain CCD
Paulden CDP
Prescott CCD
Prescott Valley
Prescott
Sedona
Chino Valley
Dewey-Humboldt
Verde CCD
Verde Village CDP
Williamson Valley WPA
WILLIAMS
FLAGSTAFF
COCONINO CO
YAVAPAI CO
Big Chino Wash
Big Chino Subbasin
Verde River
Verde Valley Subbasin
SEDONA
JEROME
CLARKDALE
COTTONWOOD
CHINO VALLEY
Prescott AMA
PRESCOTT VALLEY
PRESCOTT
DEWEY HUMBOLDT
CAMP VERDE
Hassayampa R.
Agua Fria R.
40
17
N
W
E
S
0
4
8
16
Miles


BN Leasing Corporation
William
Ashfork Development Association
Big Chino Wash
Abra Water Co
Juniper Wells Water Co
Verde Riv
YAVAPAI CO
Burro Creek
Ashfork
ADWR Wells in Production for Water Providers
Verde Basin & Prescott AMA
CYHWRMS Study Area
CC&N
Davis CV Ranch
Big Chino Water Ranch
Charney Ranch
Las Vegas Ranch Estates
Yavapai Ranch
Water Planning Area
Ashfork
Ownership
Other
BLM
Forest
Indian Res.
Local or State Parks
Military
Natl. Parks
Private
State Trust
Wildlife
N
0 1.25 2.5 5
Miles



Big Park

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N

Water Planning Area

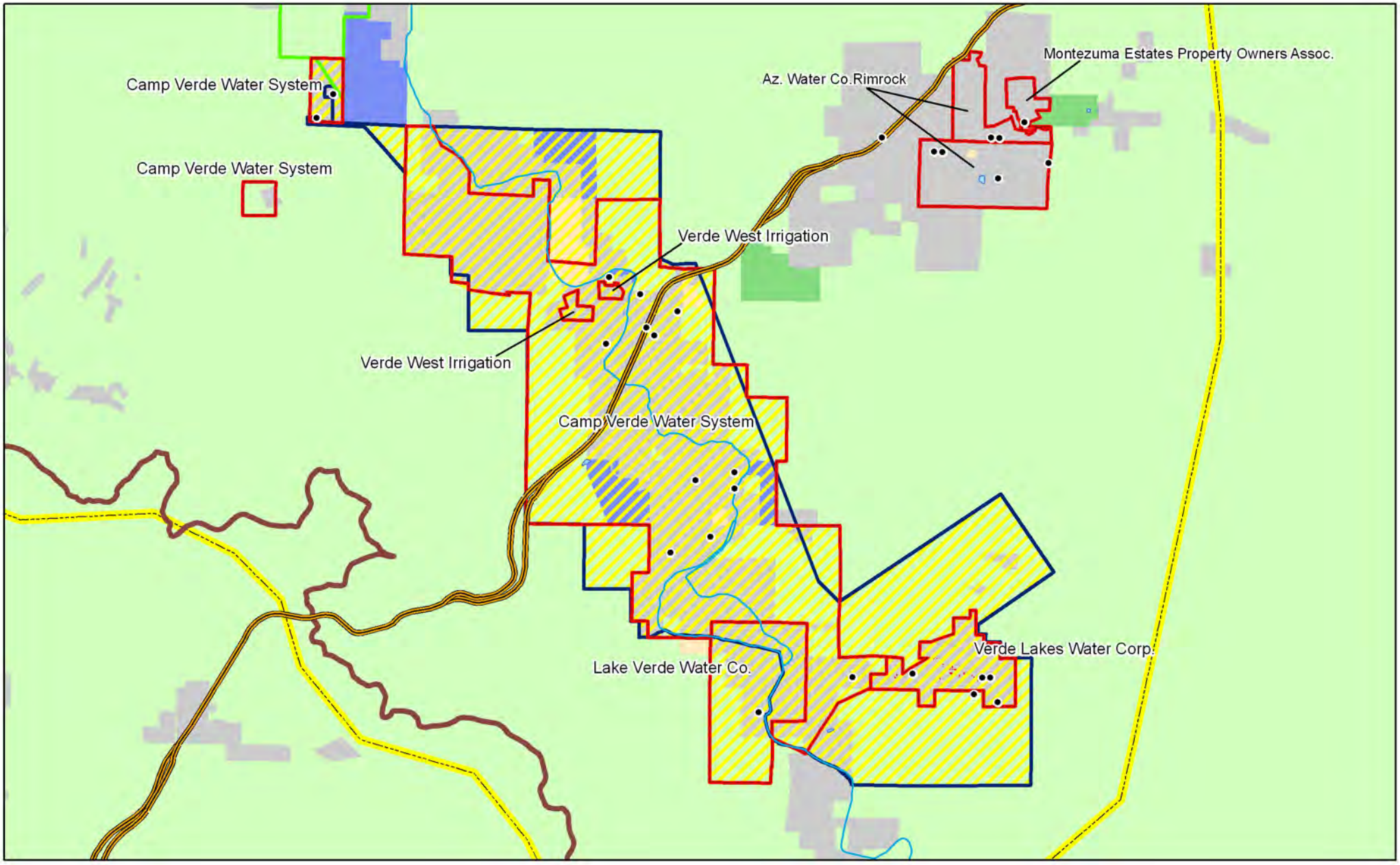
- Big Park

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 0.3 0.6 1.2 Miles



Camp Verde

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N

Water Planning Area

- Camp Verde

City Boundary

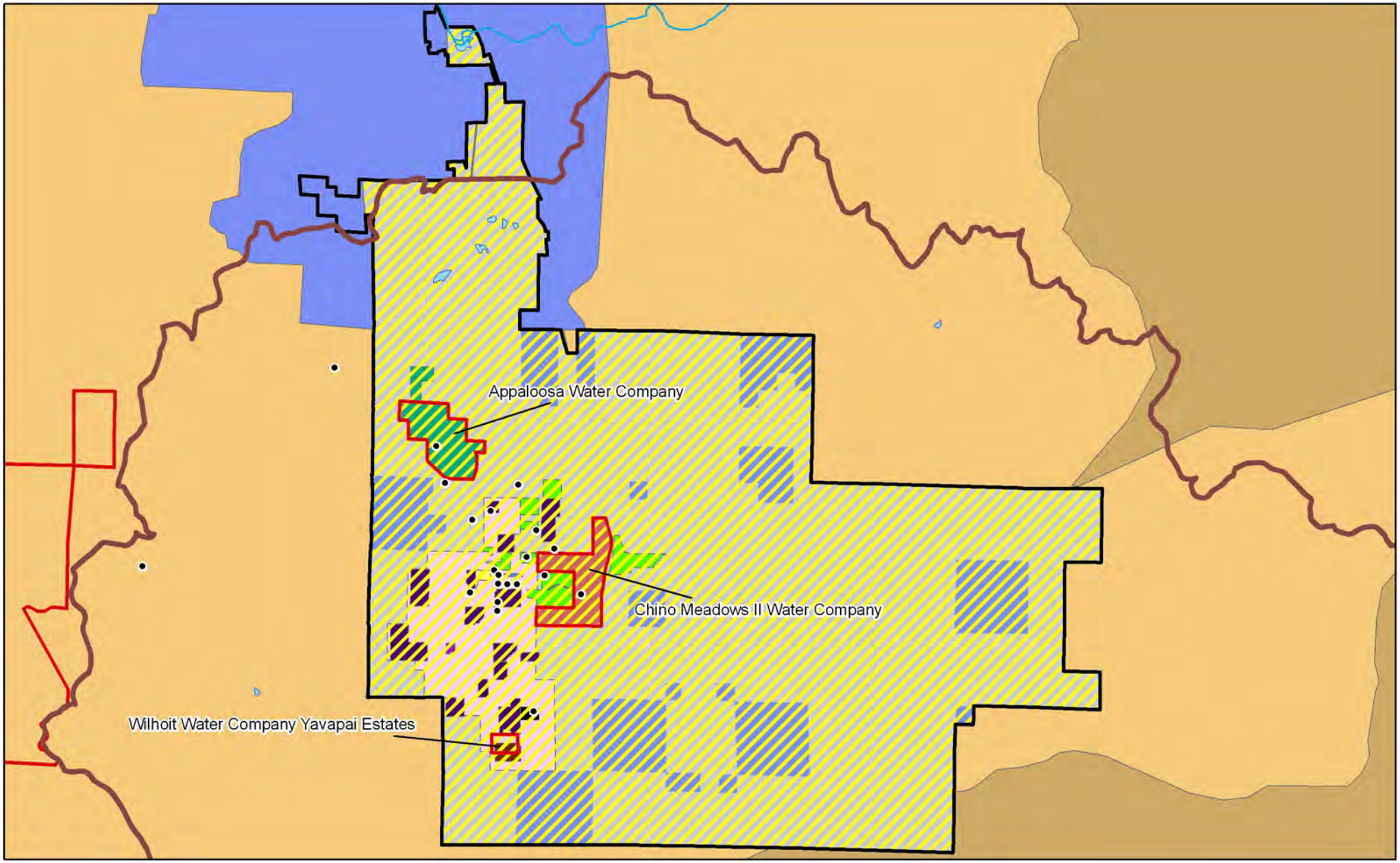
- Camp Verde

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 1 2 4 Miles



Chino Valley

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N
- Chino Valley Town Bndy

Water Planning Area

- Town of Chino Valley

Water Service Area

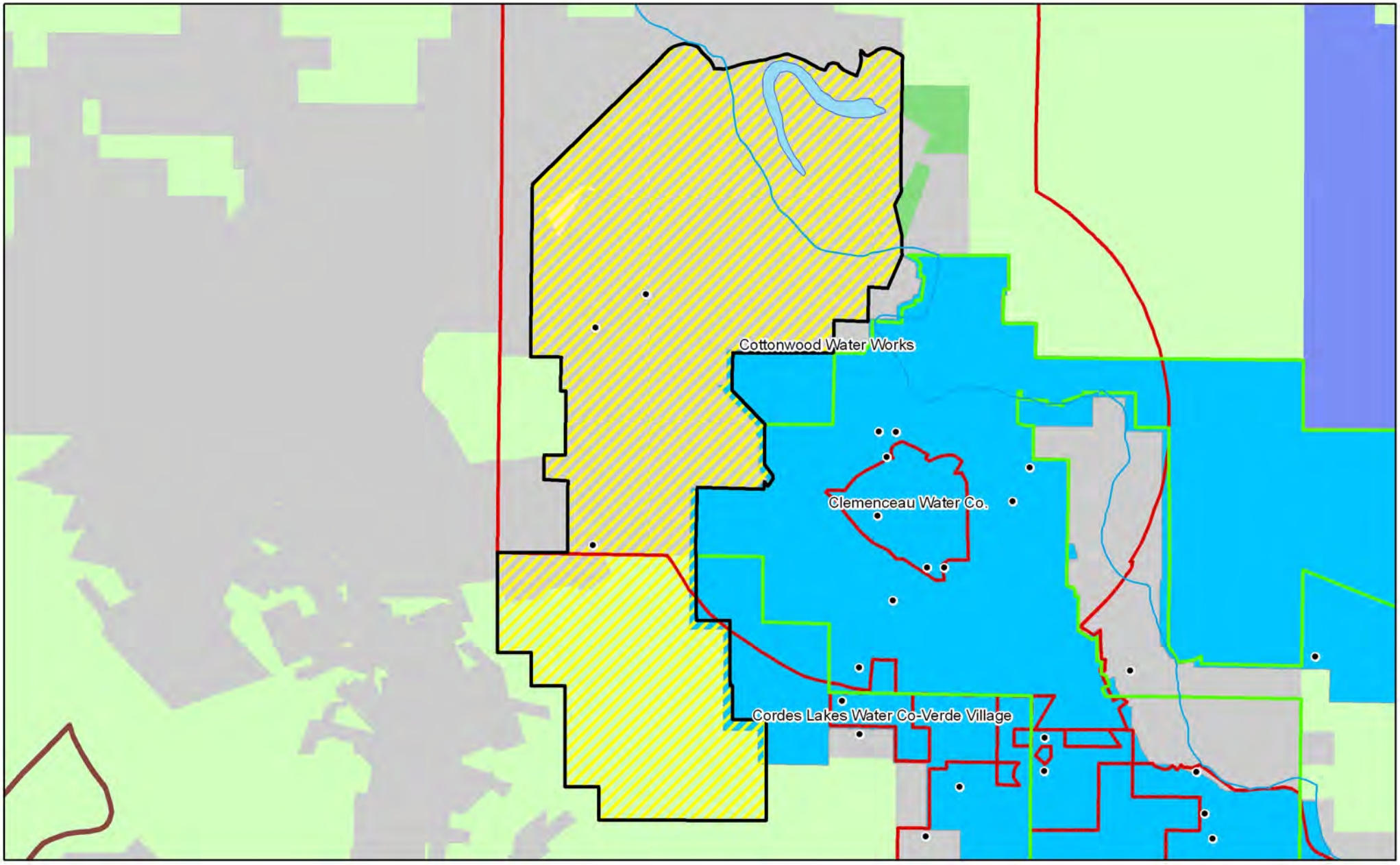
- Appaloosa Water Co.
- Chino Valley Irrigation
- Mountain View MHP
- H & R Enterprises
- Chino Meadows II Water Co.
- Town of Chino Valley
- Quail Ridge WID
- Barbon L.L.C.

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 0.5 1 2 Miles



Clarkdale

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N
- Clarkdale City Boundary
- Cottonwood Service Area

Water Planning Area

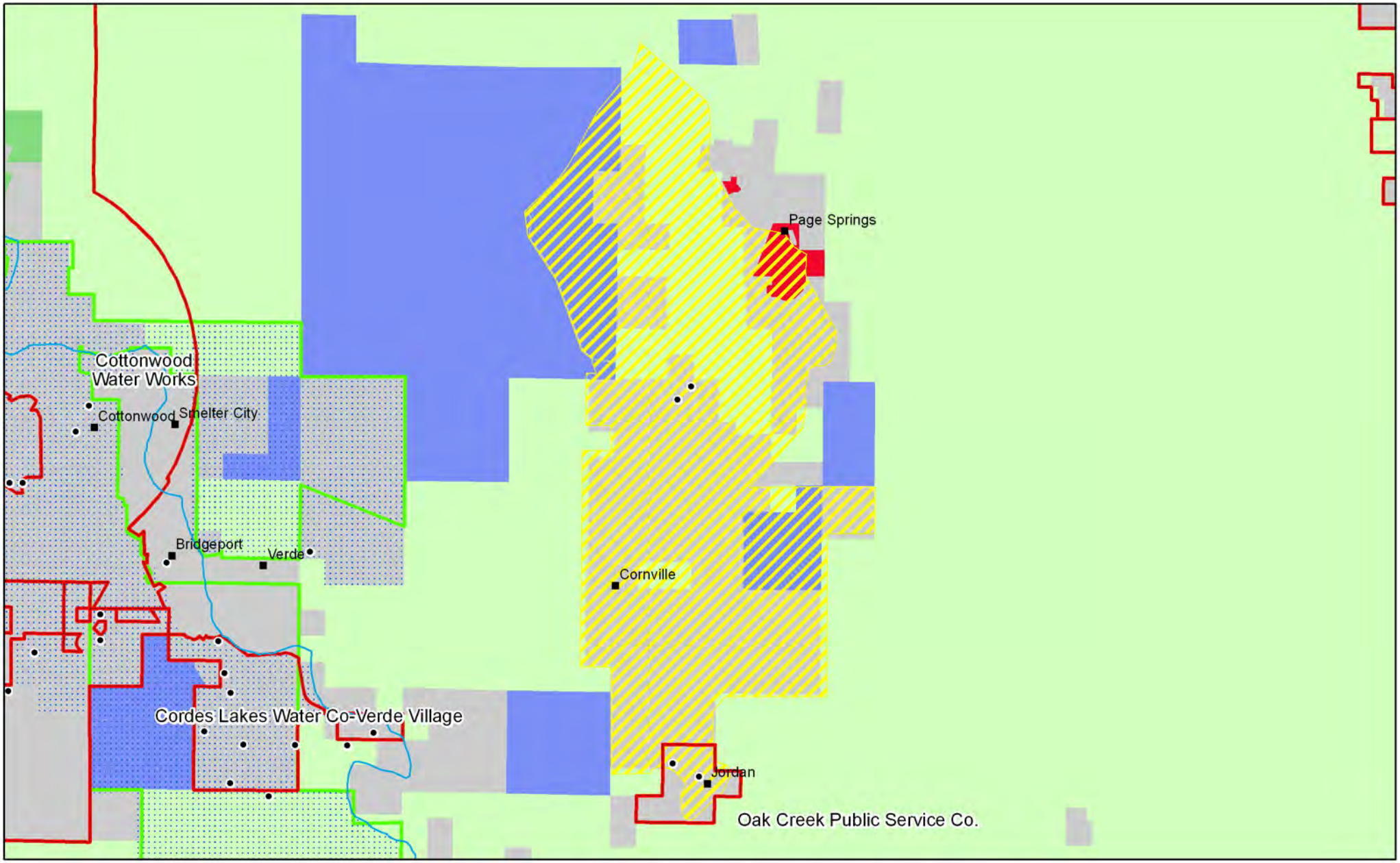
- Camp Verde

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 0.4 0.8 1.6 Miles



Cornville

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N
- Cottonwood City Boundary

Water Planning Area

- Cornville

Water Service Area

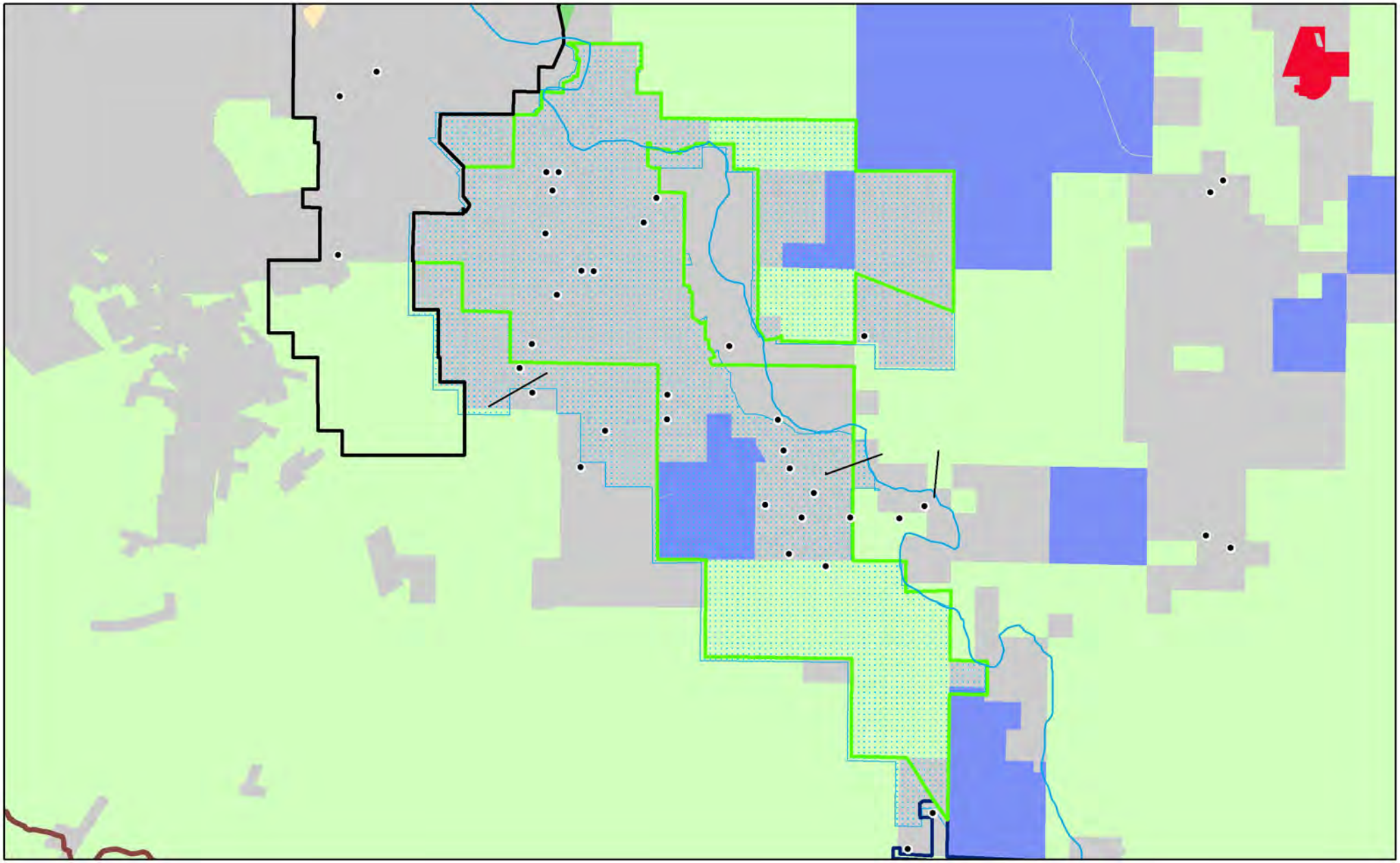
- Cottonwood Service Area

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 0.4 0.8 1.6 Miles



Cottonwood

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area

City Boundary

- Cottonwood

Water Service Area

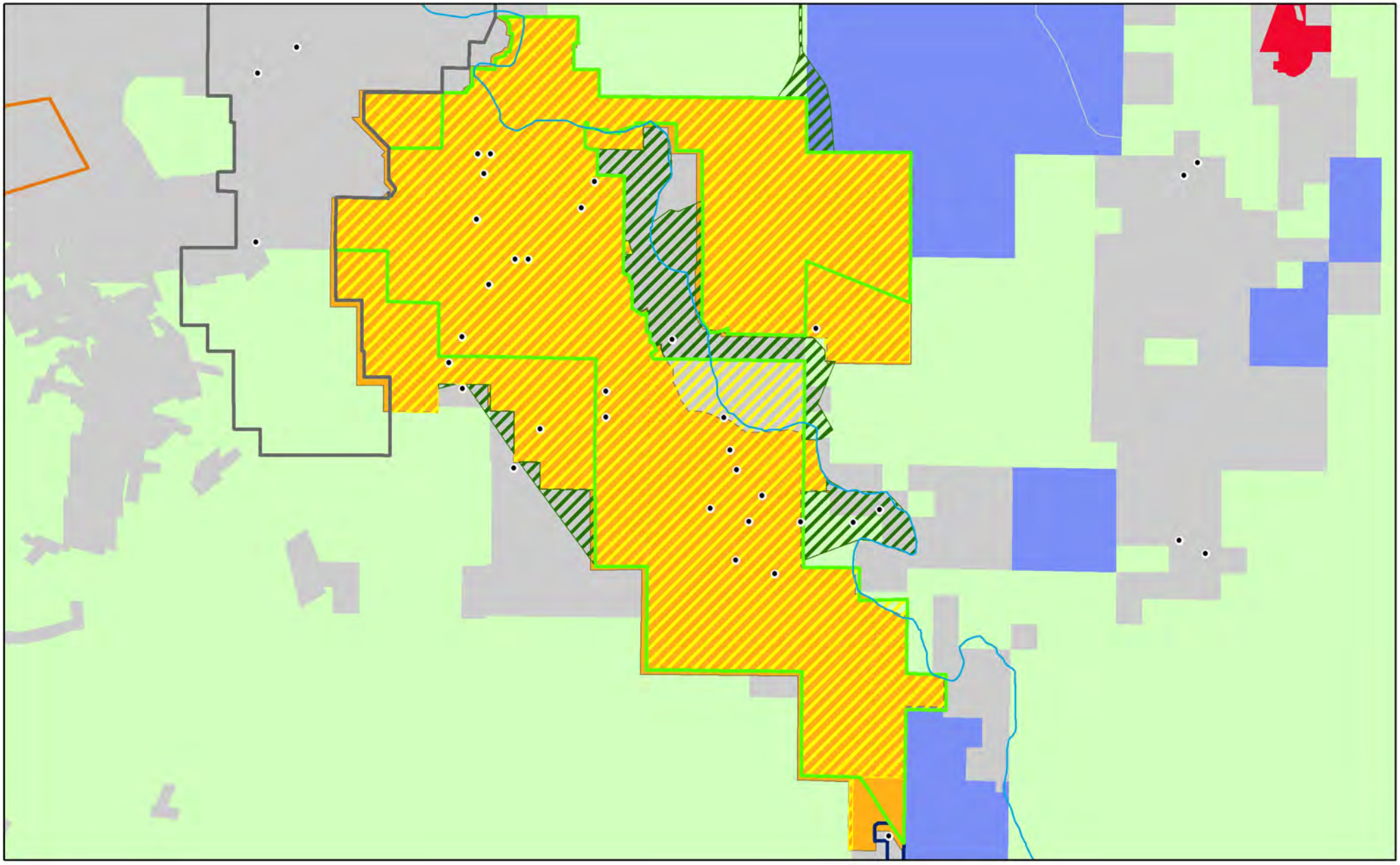
- Cottonwood Service Area

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 0.5 1 2 Miles



Cottonwood-Verde Village

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- Cottonwood City Boundary

Water Planning Area

- Cottonwood
- Verde Village

Water Service Area

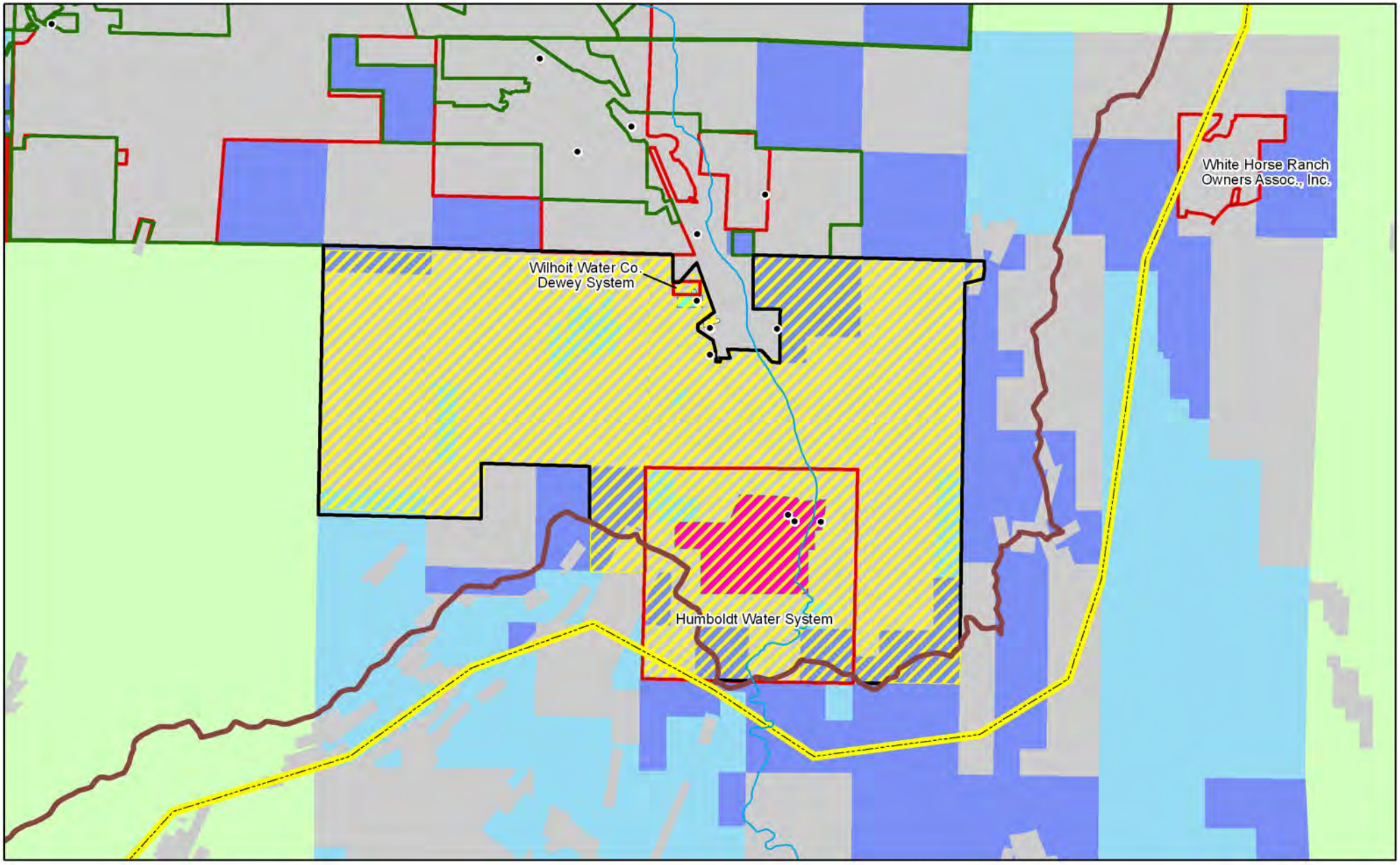
- Cottonwood Service Area

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 0.4 0.8 1.6 Miles



Dewey Humboldt

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N
- Dewey Humboldt Town Bndy

Water Planning Area

- Dewey Humboldt

Water Service Area

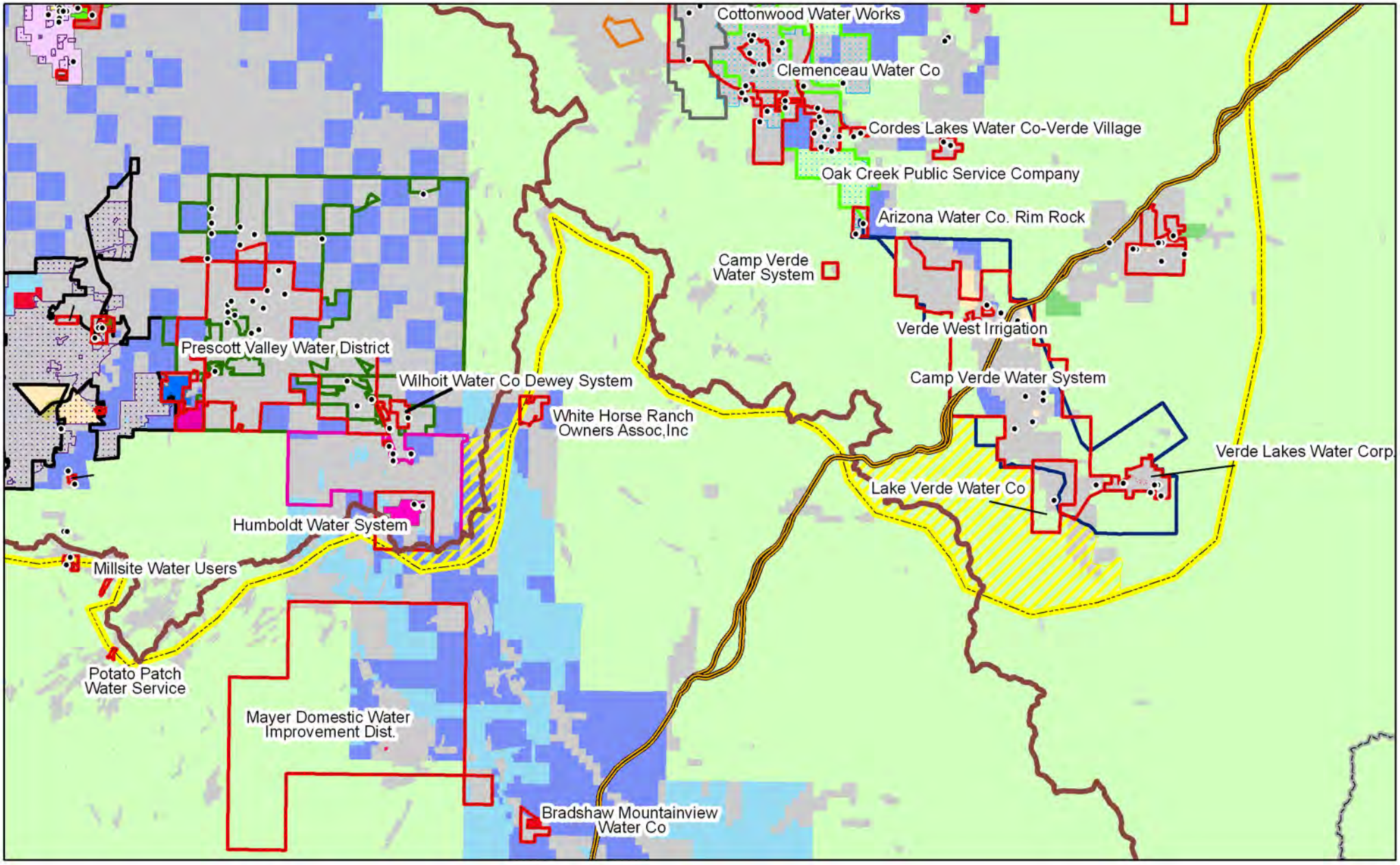
- Humboldt Water Co.
- Wilhoit Water Co.

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 0.5 1 2 Miles



Humboldt

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N
- Dewey-Humboldt
- Camp Verde
- Cottonwood
- City of Prescott
- Prescott Valley

Water Planning Area

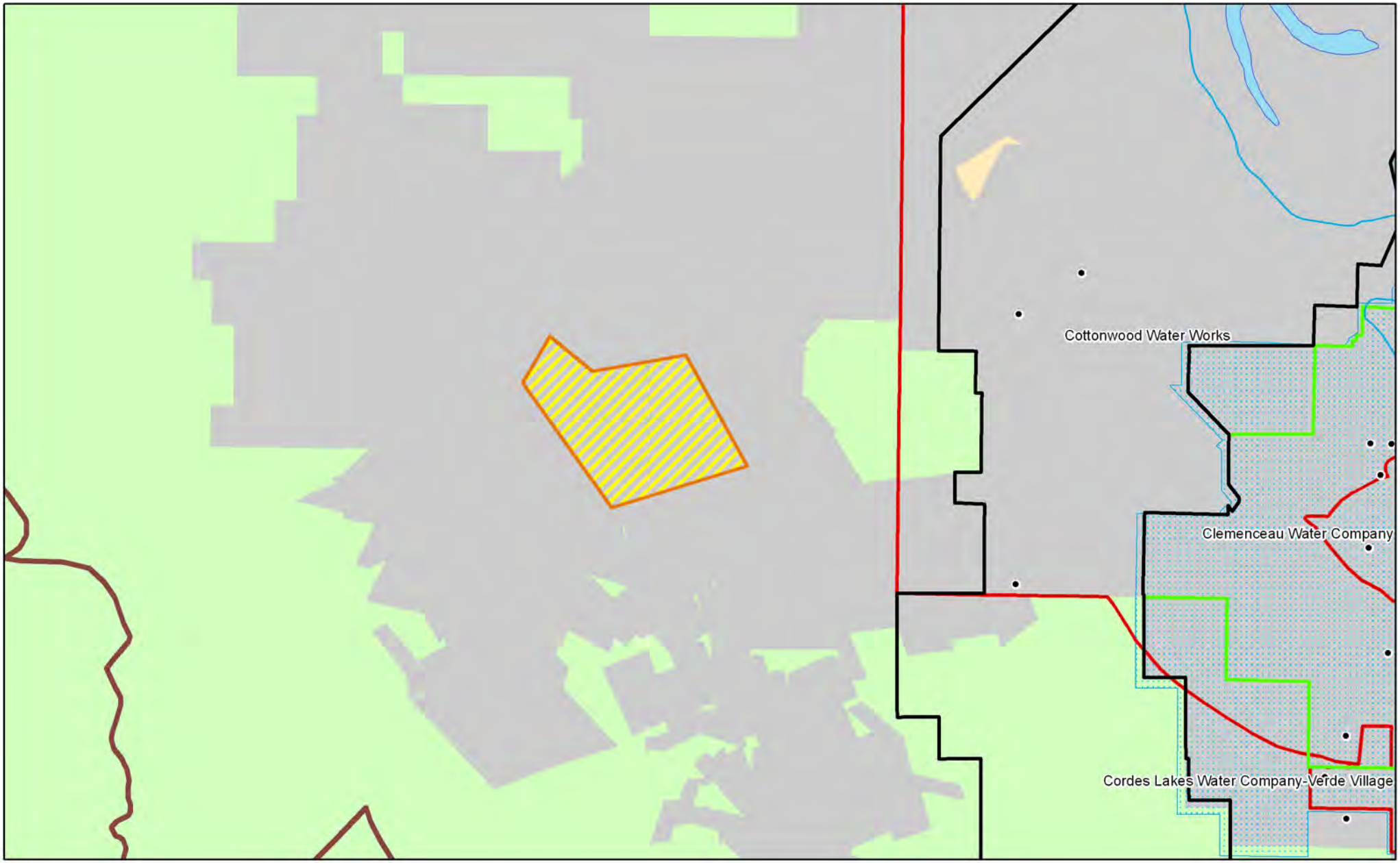
- Humboldt

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 1 2 4 Miles



Jerome

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N

Water Planning Area

- Jerome

City Boundary

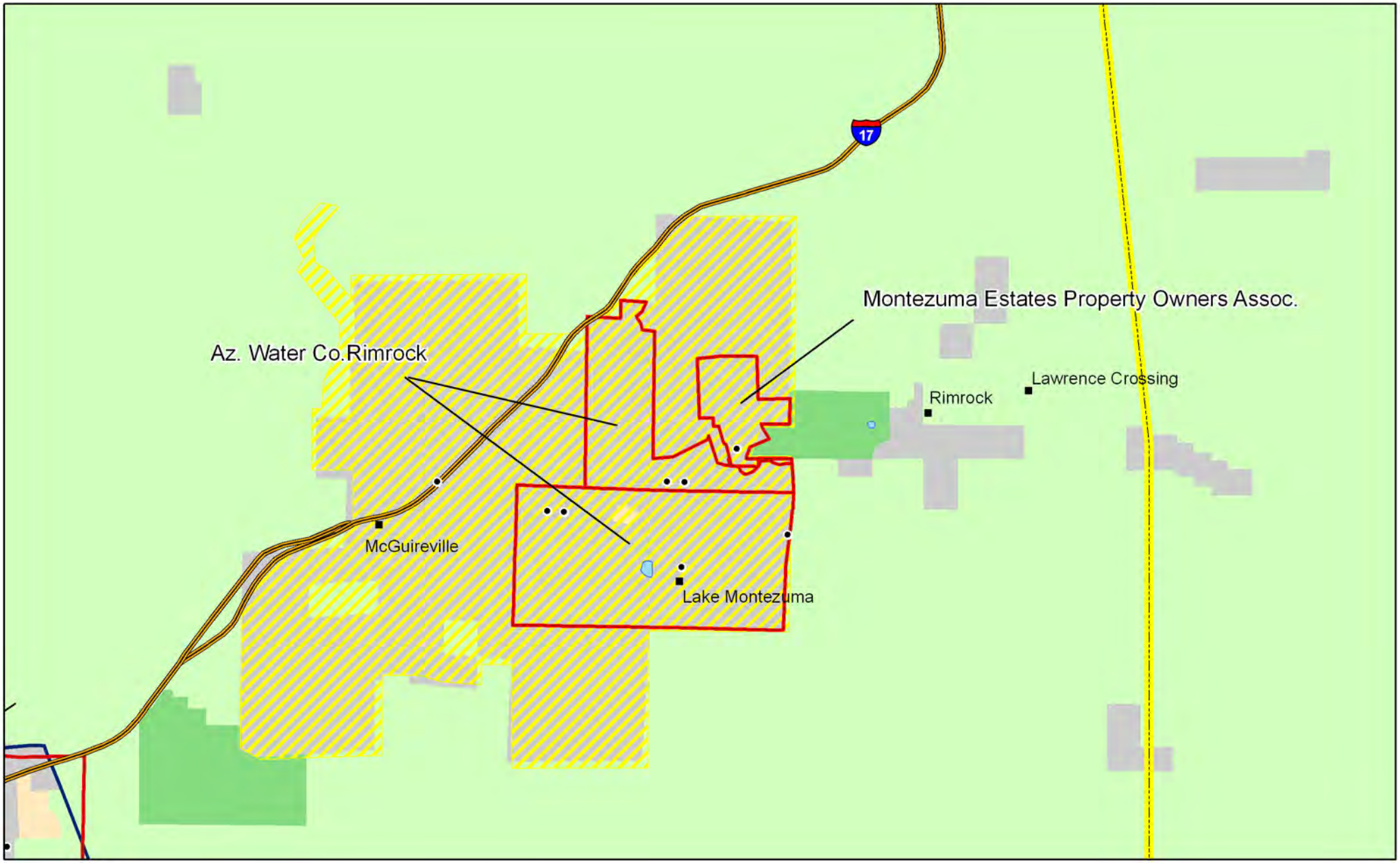
- Jerome

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 0.25 0.5 1 Miles



Lake Montezuma

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N

Water Planning Area

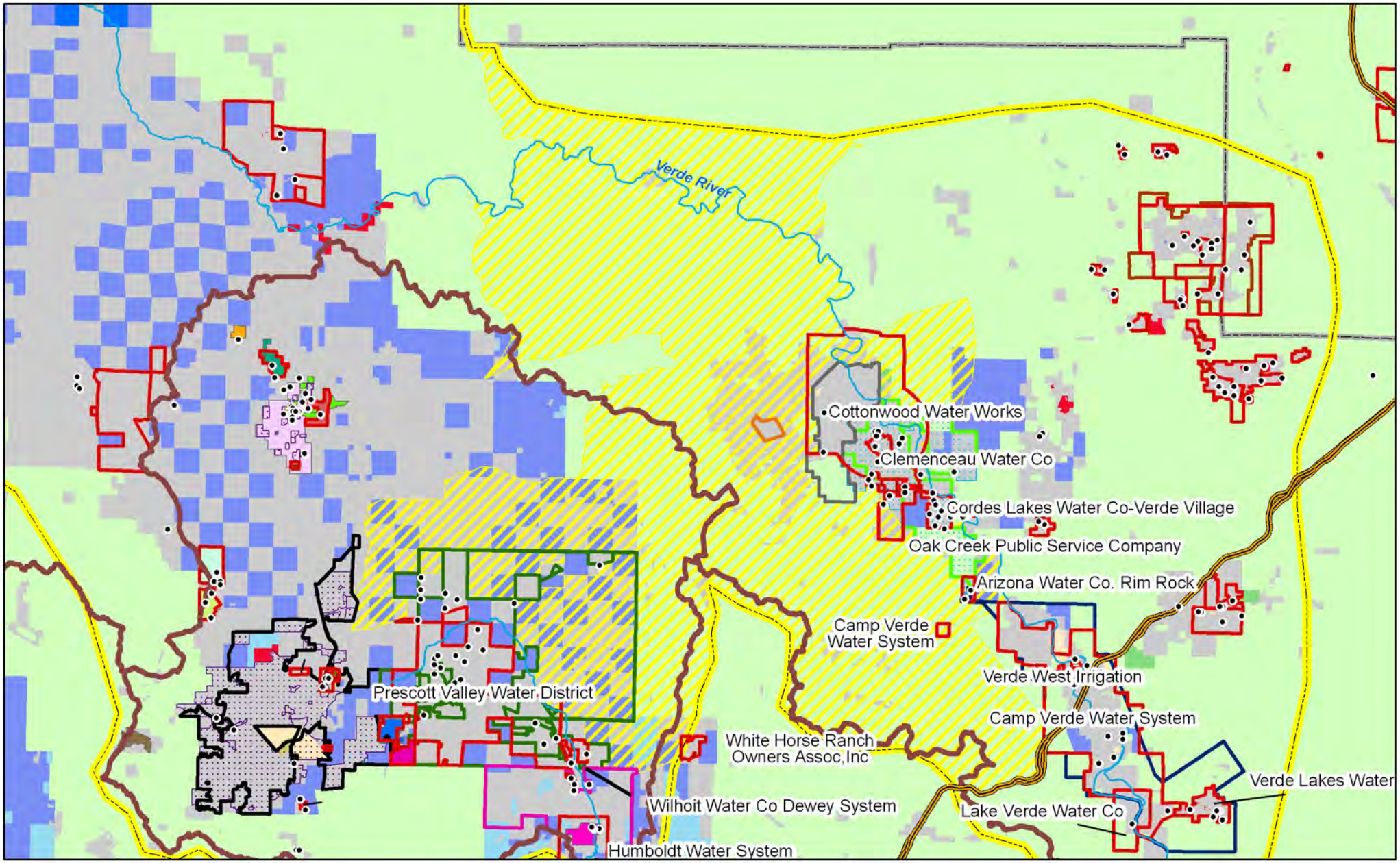
- Lake Montezuma

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 0.3 0.6 1.2 Miles



Mingus Mountain

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N
- Dewey-Humboldt
- Camp Verde
- Cottonwood
- City of Prescott
- Prescott Valley

Water Planning Area

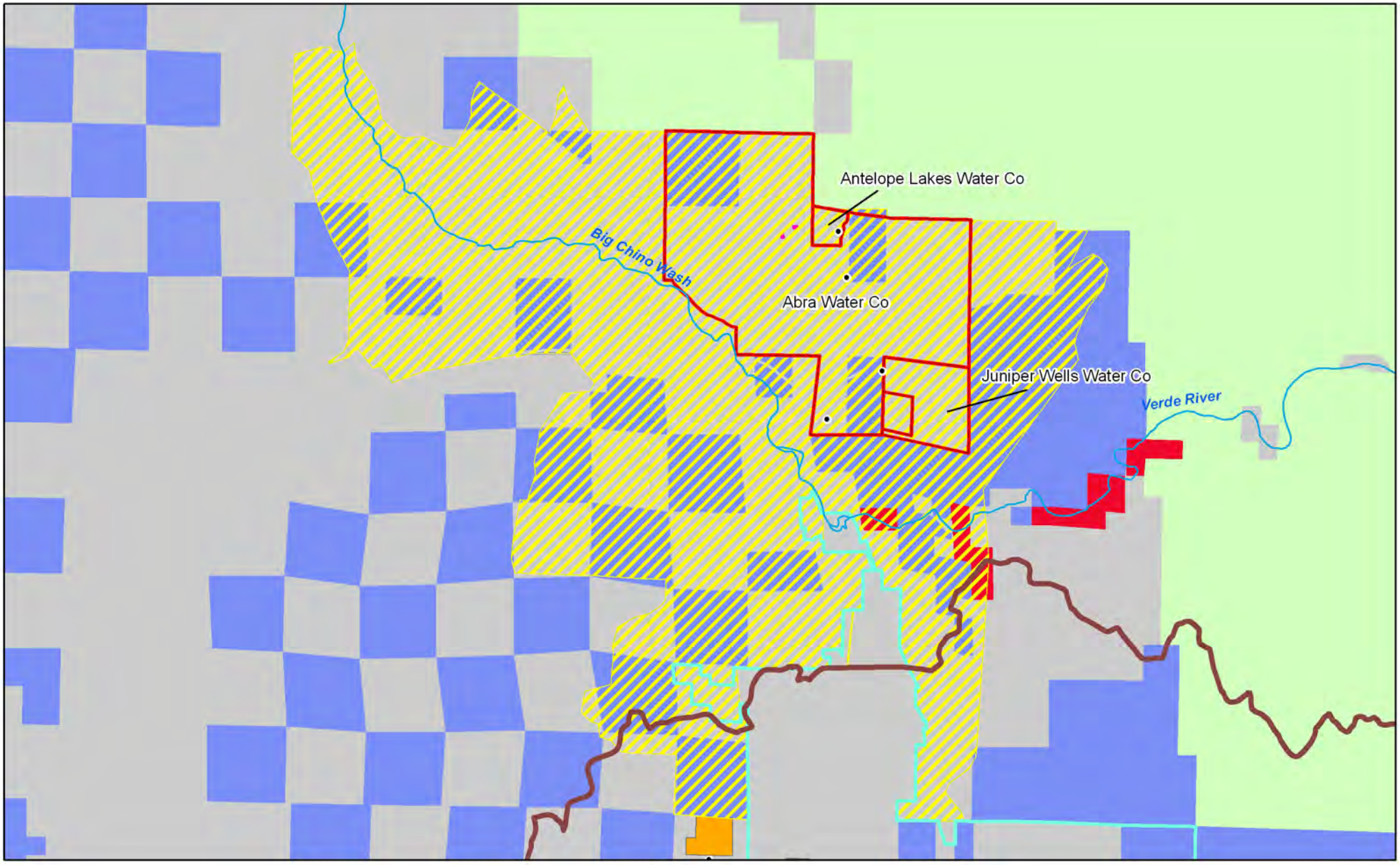
- Mingus Mountain

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 1.25 2.5 5 Miles



Paulden

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N
- Chino Valley

Water Planning Area

- Paulden

Water Service Area

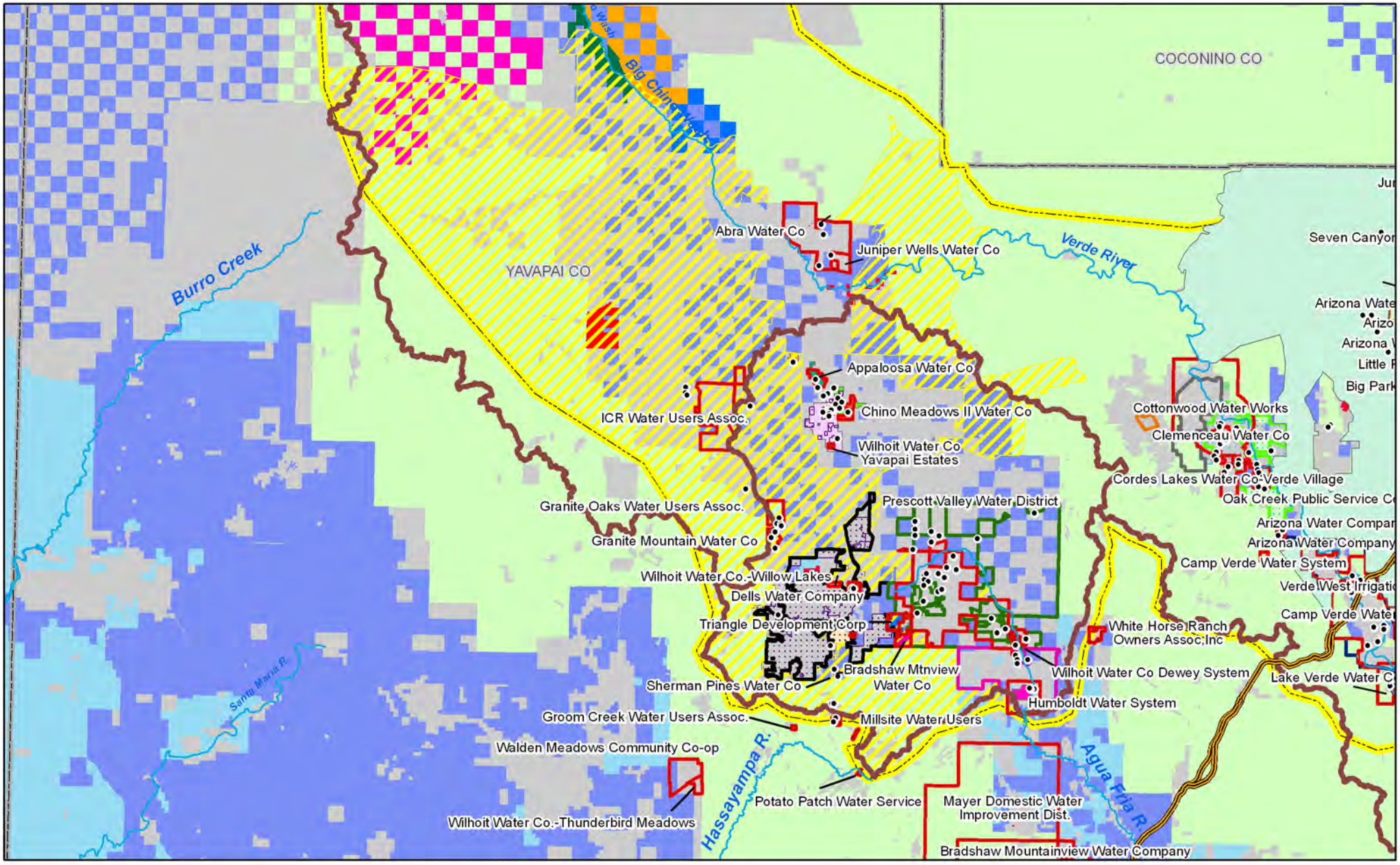
- Quail Ridge WID-Barbon LLC

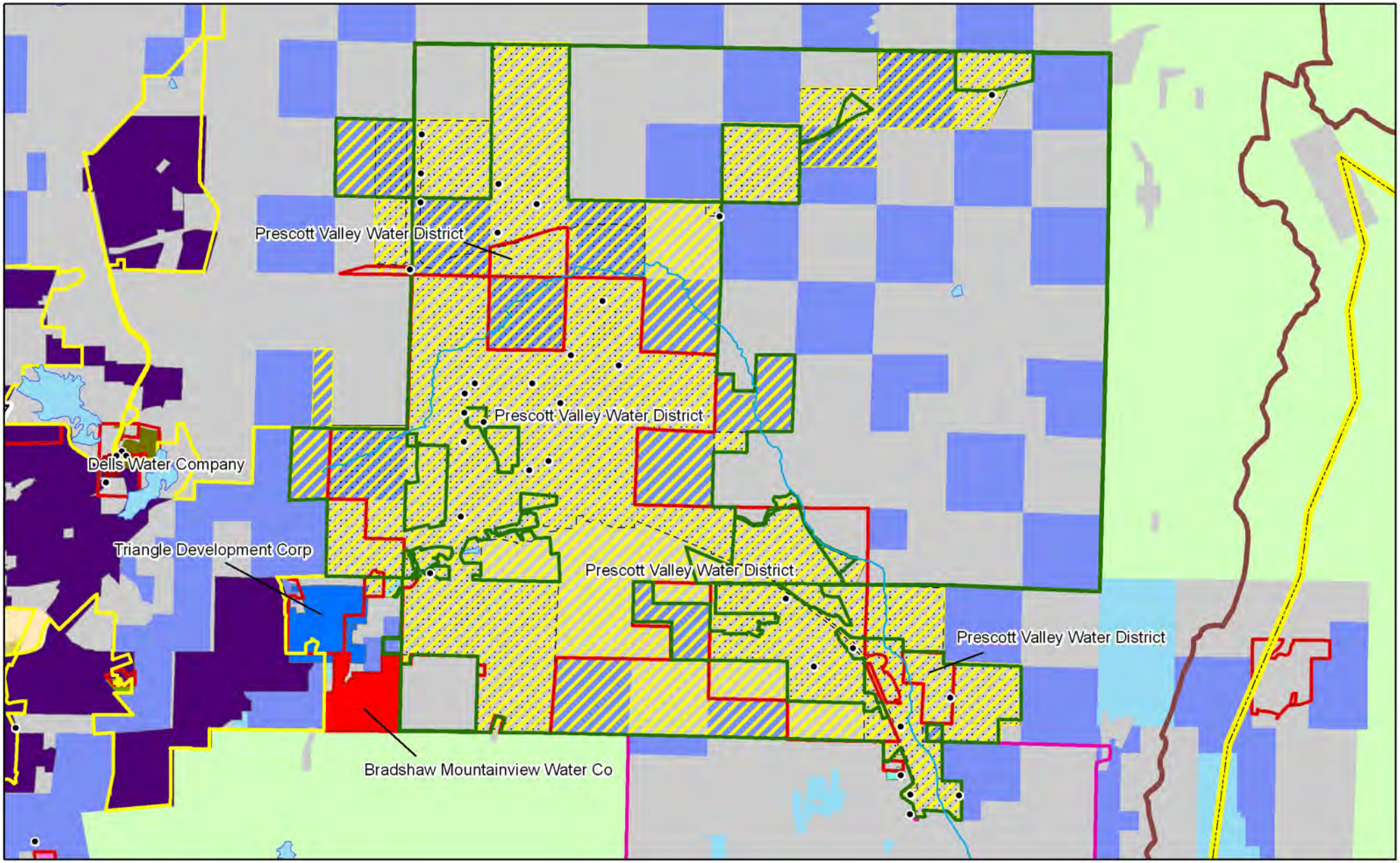
Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 0.3 0.6 1.2 Miles


COCONINO CO
YAVAPAI CO
Burro Creek
Big Chino Wash
Verde River
Santa Maria R.
Hassayampa R.
Agua Fria R.
Abra Water Co
Juniper Wells Water Co
Appaloosa Water Co
Chino Meadows II Water Co
ICR Water Users Assoc.
Wilhoit Water Co
Yavapai Estates
Granite Oaks Water Users Assoc.
Granite Mountain Water Co
Prescott Valley Water District
Wilhoit Water Co.-Willow Lakes
Dells Water Company
Triangle Development Corp
Bradshaw Mtnview Water Co
Sherman Pines Water Co
Groom Creek Water Users Assoc.
Millsite Water Users
Walden Meadows Community Co-op
Wilhoit Water Co.-Thunderbird Meadows
Potato Patch Water Service
Mayer Domestic Water Improvement Dist.
Bradshaw Mountainview Water Company
Humboldt Water System
Wilhoit Water Co Dewey System
White Horse Ranch Owners Assoc Inc
Cottonwood Water Works
Clemenceau Water Co
Cordes Lakes Water Co-Verde Village
Oak Creek Public Service Co
Arizona Water Company
Camp Verde Water System
Verde West Irrigation
Camp Verde Water
Lake Verde Water Co
Seven Canyon
Arizona Water
Little R
Big Park
Prescott CCD
ADWR Wells in Production for Water Providers
Verde Basin & Prescott AMA
CYHWRMS Study Area
CC&N
Dewey-Humboldt
City of Prescott
Prescott Valley
Water Planning Area
Prescott CCD
Ownership
Other
BLM
Forest
Indian Res.
Local or State Parks
Military
Natl. Parks
Private
State Trust
Wildlife
N
0 2 4 8 Miles



Prescott Valley

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N
- Prescott Valley City Boundary

Water Planning Area

- Prescott Valley

Water Service Area

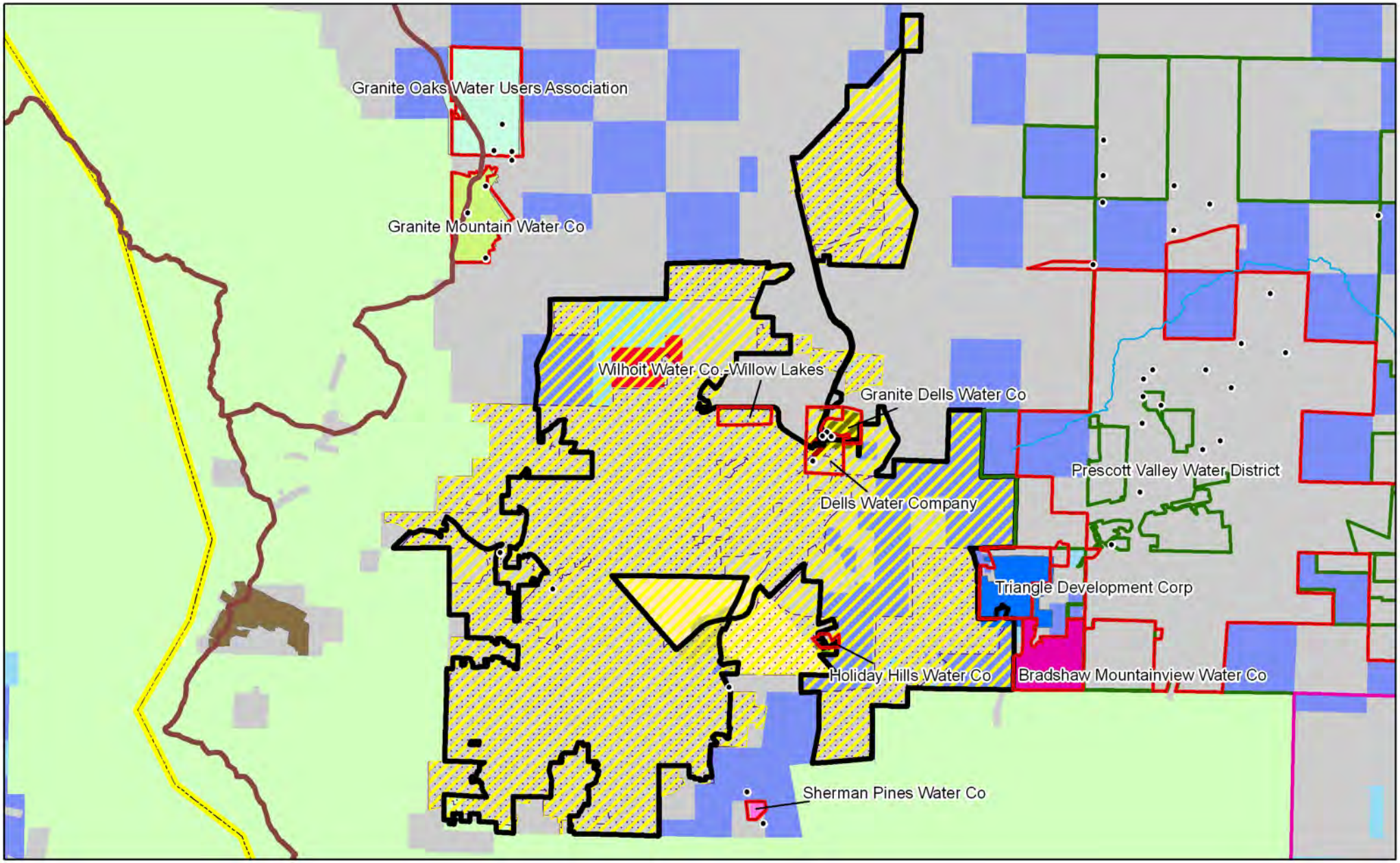
- Prescott Valley Municipal System

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 0.5 1 2 Miles



Prescott

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N
- Prescott City Boundary

Water Planning Area

- Prescott

Water Service Area

- City of Prescott

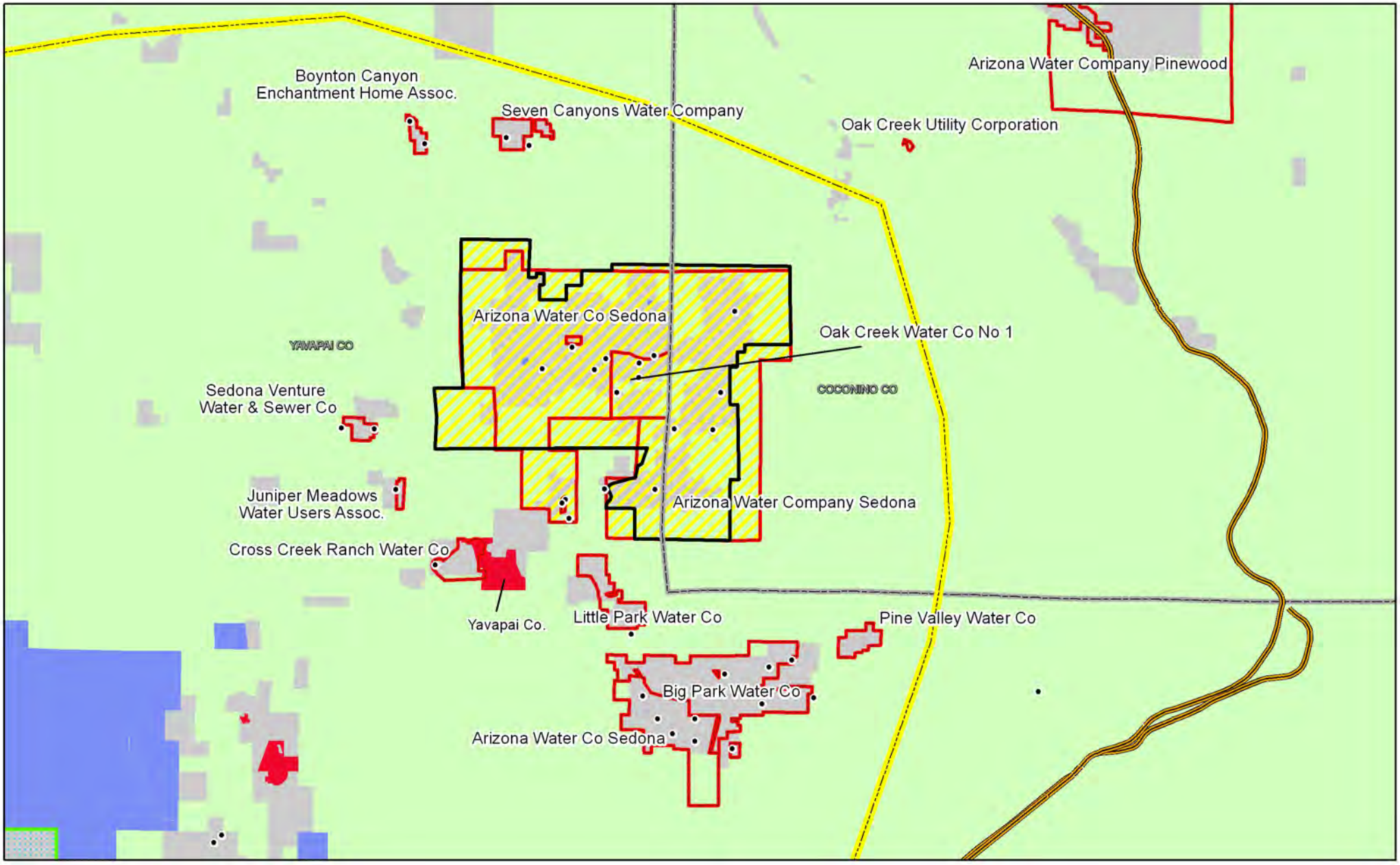
- Granite Dells Water Co.
- Dells Water Co.
- Granite Oaks Water User's Assoc.
- Granite Mtn. Water Co.
- Diamond Valley Water User's Assoc.
- Bradshaw Water Co.

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 0.5 1 2 Miles



Sedona

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N

Water Planning Area

- Sedona

City Boundary

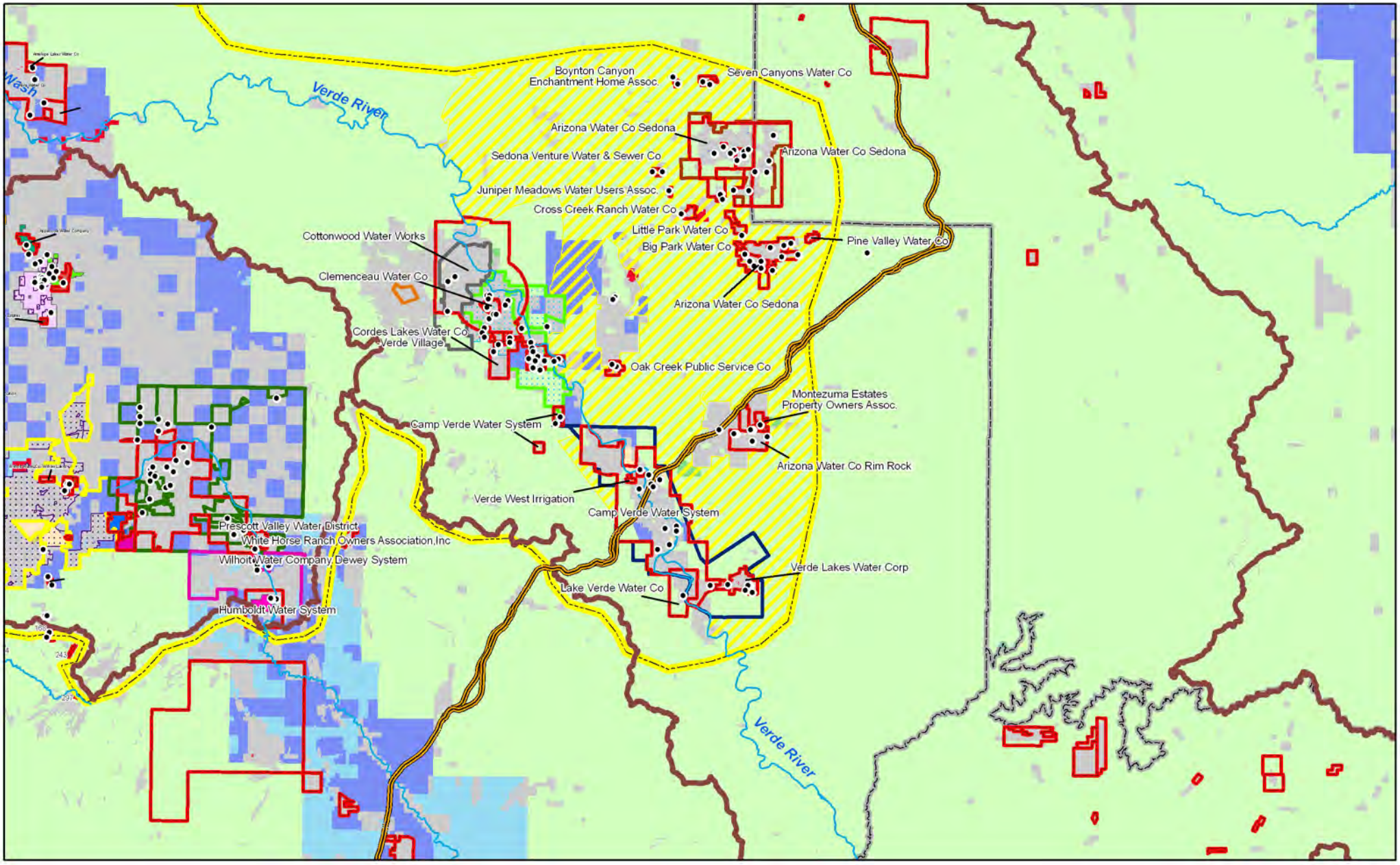
- Sedona

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 0.5 1 2 Miles



Verde

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N

- Camp Verde
- Cottonwood
- Sedona

Water Planning Area

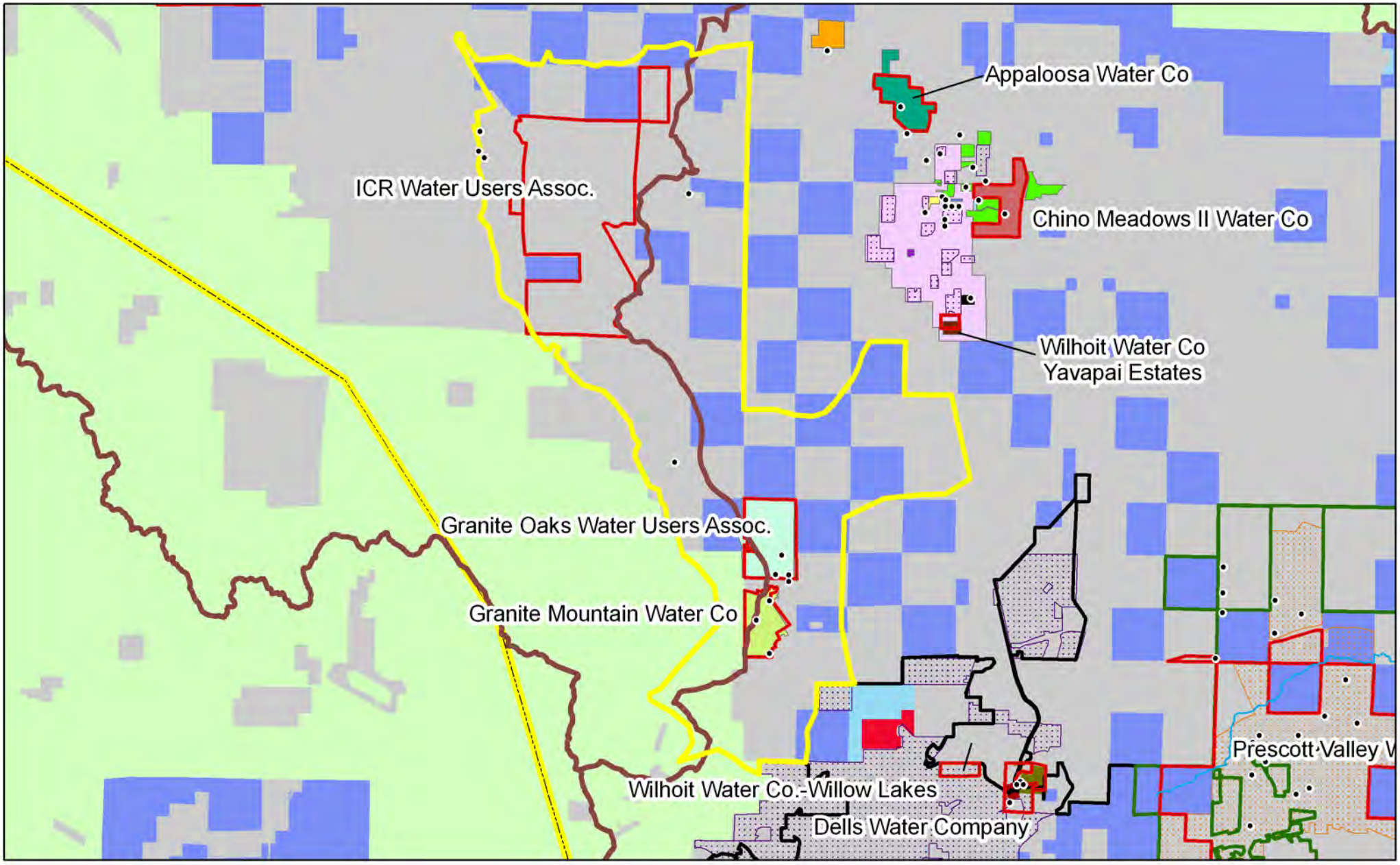
- Verde

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 2 4 8 Miles



Williamson Valley CCD

- ADWR Wells in Production for Water Providers
- Verde Basin & Prescott AMA
- CYHWRMS Study Area
- CC&N
- Dewey-Humboldt
- City of Prescott
- Prescott Valley

Water Planning Area

- Williamson Valley CCD

Ownership

- Other
- BLM
- Forest
- Indian Res.
- Local or State Parks
- Military
- Natl. Parks
- Private
- State Trust
- Wildlife

N

0 0.5 1 2 Miles