Town of Clarkdale Water Resources Management Program Recommendations Report

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WRRC WATER RESOURCES RESEARCH CENTER
THE UNIVERSITY OF ARIZONA College of Agriculture & Life Sciences Cooperative Extension
Water RAPIDS Water Research and Planning Innovations for Dryland Systems
LHC
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Sustainable Clarkdale

The University of Arizona Water Resources Research Center (WRRC) promotes understanding of critical state and regional water management and policy issues through research, community outreach, and public education.

The Water Research and Planning Innovations for Dryland Systems (Water RAPIDS) program at the WRRC specializes in assisting Arizona communities with their water and natural resources planning needs. Our goal is to help communities balance securing future water supplies for residential, commercial, industrial, and agricultural demands with water needs of the natural environment.

The Water RAPIDS team would like to acknowledge the irreplaceable assistance on the project by the Town of Clarkdale: Jodie Filardo, Mayor Doug Von Gausig, Wayne Debrosky, Beth Escobar, Gayle Mabery, and Ellen Yates. Special thanks are due to Laurel Lacher for her assistance with the preparation of this report and all aspects of the project, which went above and beyond her role as project hydrologist. The WRRC is also incredibly thankful for the many hours contributed by the people concerned about water management who provided advice and suggestions to the Town of Clarkdale. Among these experts were our Advisory Committee: Peter Culp, Fred Goldman, Bruce Hallin, Maren Mahoney, John Rasmussen, Linda Stitzer, and Gerry Walker. Their advice and ideas were a critical part of the success of this project.

Front Cover: Dead Horse Ranch State Park, Arizona. Photo by Kelly Mott Lacroix

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Executive Summary

Town of Clarkdale Water Resources Management Program Mission:
Clarkdale provides a water resources management program that meets the needs of residents, businesses and our natural environment equitably in order to be a robust and resilient community.

The waters of the Verde Valley are vital to the humans, plants, and animals living in the midst of its arid landscape. Maintaining dependable water supplies into the future is critical to the vitality of the robust local ecosystems on which the region's residents depend for their livelihoods and quality of life. In 2011, the Town of Clarkdale launched the Sustainable Clarkdale initiative, whose goal is "to provide an entrepreneurial environment rich in innovative, multi-disciplinary solutions, and educational and economic opportunities, resulting in a vibrant and viable future." To support the Sustainable Clarkdale initiative, the Town received a grant from the Walton Family Foundation to create a Water Resources Management Program (WRMP). With this funding, the Town hired two organizations to help build the WRMP: Lacher Hydrological Consulting (LHC) made refinements to an existing regional groundwater model and the University of Arizona Water Resources Research Center (WRRC) developed recommendations for Clarkdale's WRMP.

This report is the culmination of 18 months of work with the Town, during which the WRRC sought to understand the Town's water resource management challenges and to explore available knowledge on water management in Arizona and beyond, in order to provide recommendations for a Clarkdale Water Resources Management Program. The recommendations included in this document are the outcome of consultations with almost 60 experts in water management and a review of over 70 reports and journal articles on municipal water management and planning. In addition to making recommendations, this document is also designed to assist the Town in developing a formal water management program, should it choose to do so, by offering a single source of background information on the hydrology, water resources, and current water management in Clarkdale.

The WRRC assembled a list of the Clarkdale area's water resource management issues based on conversations with Town of Clarkdale staff and in consultation with the project's Advisory Board. These water resource management challenges include: non-revenue water caused by aging infrastructure and municipal interconnections, determination of the best uses for treated effluent, stormwater management, limited revenue due to small town size, the impact of small domestic wells, decreasing Verde River Flows, and a limited groundwater supply.

To address these issues, the WRRC identified over 50 elements for potential inclusion in Clarkdale's WRMP. Many of the challenges are already being addressed by the Town through their current water management, which in many ways, already serves as a model for small town water resources management. Examples of best practices implemented by the Town include:

- Adoption of the Adequate Water Supply Rule and Clarkdale's receipt of a Designation of Adequate Water Supply;
- Adoption of water conservation ordinances;
- Increasing-block-rate billing structure;
- Meter replacement program, installation of radio-read meters, and ongoing efforts to determine and repair system leaks; and
- Construction of a new wastewater treatment plant that produces A+ (highest quality) effluent.

The recommendations proposed here are intended to augment, not replace, these current best practices. Recommendations were chosen based on expert advice, feasibility, and how well they promote the Town's mission for their WRMP. Expert advice was received through the project's advisory committee, a day-long Expert Workshop, individual interviews, and a two day Small Town Water Forum. Recommendations include:

Develop a Comprehensive Water Loss Control Program

The need for development of a comprehensive water loss control program was a common theme in the Expert Workshop, the project team's internal discussions throughout the project, and at the Small Town Water Forum. While the Town has already made strides to decrease the amount of non-revenue water, an ongoing action plan is needed to continue to mitigate and reduce non-revenue water. Limitations in the availability of financial resources, the technical capacity of Town staff, and the availability of staff time to follow through with action items pose potential challenges in the development of a Water-Loss Control Program. To support current efforts, we recommend that the Town follow the EPA three-step process of Water Audit, Intervention, and Evaluation to develop a water loss program. The first step of this process, a water audit, could be completed in the next year.

Engage Public about Water Sustainability and Values

Effective and iterative engagement and education should be the cornerstones of the formation and implementation of Clarkdale's WRMP. The Town should expand upon the public engagement and outreach initiated as part of this project to develop community consensus on achievable objectives in the WRMP and determine community values regarding sustainability, water management, and the Verde River. Challenges to public engagement on water sustainability and values involve the lack of available time, funding, and expertise to engage diverse perspectives, as well as the related challenge of finding ways to encourage cooperation among different views and priorities. Even when resources are tight, limited engagement can be successful provided that goals are well developed and efforts to bring diverse perspectives to the table have been undertaken. The first steps in engagement, which could be completed in the next year, are to identify the Town's goals and available resources for engagement and outreach, and to form a WRMP Citizen Advisory Council. This would give Clarkdale a mechanism to determine next steps for engagement and the other WRMP elements discussed below.

Develop a Strategic Plan for the Reuse of Effluent/Reclaimed Water Recharge

Clarkdale has many choices regarding how to utilize its 134 acre-feet per year of A+ reclaimed water. Given common cultural apprehensions regarding the reuse of effluent, a concerted public outreach effort should be an integral part of this project in order to give voice to public preferences and promote transparency. Developing a strategic plan for the reuse of effluent was the most highly ranked recommendation developed at the Expert Workshop. While multiple different uses are legally allowable and available for consideration by Clarkdale, a groundwater recharge program is likely the best option for utilizing Clarkdale's reclaimed water because it is the most cost effective option. The Town will need to evaluate potential recharge sites through careful analysis of hydrologic characteristics. As it evaluates potential recharge sites through careful analysis of hydrologic characteristics, the Town should also develop a short-term plan for the disposal of treated effluent. The Town should also conduct public information sessions to keep the citizens of Clarkdale apprised of the Town's choices with regards to the use of reclaimed water. Meetings about reclaimed water use should be approached cautiously, to avoid causing confusion and misunderstanding.

Understand and Plan for Stormwater and Rainwater Resources

Rainfall and runoff generated during storm events provide an additional source of water for communities to utilize as part of their water resources portfolio, whether through direct use or recharge into the aquifer. The topic of improved rainwater and stormwater management was a common theme in both the Expert Workshop and the Small Town Water Forum, although there remains a high level of uncertainty about how best to proceed with improving the combined management of these water resources at the municipal scale for small towns. Development of an integrated rainwater harvesting and stormwater harvesting system requires additional data to ensure sound environmental and economic decisions are made for the Town of Clarkdale. To begin implementation of this recommendation in the next year, the Town could invest staff time and resources into developing a rainwater and stormwater harvesting plan, which would lay out unanswered research questions and town goals, and hire a consultant to develop a rainfall/runoff model to begin filling in some of the data gaps and connecting the groundwater hydrology work already done regarding stormwater recharge opportunities.

Link Land Use Planning to Water Management

Clarkdale has the capacity to manage its potable water supply and its wastewater treatment, providing greatly improved flexibility in water resource planning and making the Town well positioned to link water management with land-use objectives in ways that will generate lasting, positive impacts in achieving its water conservation objectives. There are many opportunities to link land use and planning to water management, including: management of stormwater, outdoor water use restrictions, overlay districts, and regional cooperation on ordinances and codes that impact water resources. Actions that the Town could take in the near-term to link land use planning and water management include: tracking localized flooding issues, evaluating opportunities for retaining or redirecting stormflows to protect residents and minimize damage to property and infrastructure, and reviewing building codes for additional opportunities to encourage water harvesting on new construction sites.

Create a Community Water Budget and Partial Demand Offset

A community-wide water budget uses data on water supply and demand as part of a conversation about where and how much water should be used in a community. Once the budget or "cap" for different types of water use, e.g., outdoor residential, turf, commercial, is established, the Town could then require any new use above the budget in that category to partially offset the new demand through additional water conservation measures, onsite stormwater recharge or other mechanisms. Another type of water budget is at the household level, and allows community members to examine their current water use as compared to their historic use and the amount of water they should be using, often based on the number of people in the household and outdoor landscaping. One example of a mechanism for establishing and maintaining a household water budget is the Conserve2Enhace (C2E) program, designed to track household water use and encourage users to donate the money from water savings to local environmental enhancement projects. To begin implementing this recommendation, the Town could use the WRMP Citizen Advisory Council to develop a draft community water budget, which is then explored and changed through a series of community water budget workshops. To implement a C2E program, the first step is to download the C2E Program Development Toolkit and hold a scoping meeting.

Over the past 18 months, the WRRC has been impressed by the Town of Clarkdale's commitment to management of water resources in a sustainable way. The Town has already made great strides toward sound water management, and we believe it has a tremendous capacity to continue to improve and serve as a model community. While the order that the recommendations presented in this report is roughly in terms of priority, the WRRC also recognizes that they are interrelated and in some cases interdependent. We therefore suggest that these recommendations be considered as a whole, and that only the first recommendation, to create a comprehensive water-loss control program, take precedence over the others.

Clarkdale itself, with a population of just over 4,000 people, cannot alone shoulder the burden of improving the imbalances between water supply and demand in order to protect the region's natural environment and economy. Regional cooperation is not included in this document as a recommendation per se because the WRRC was asked to create recommendations for the Town's WRMP. In the Expert Forum, interviews, and the Small Town Forum, however, the need for collaboration across jurisdictions to better manage water on a regional scale was one of the most common themes. Ultimately, Verde Valley residents face a tremendous challenge ahead if they are to succeed in promoting water sustainability and a healthy Verde River. The WRRC believes that while the challenges are great, so are the opportunities. We look forward to seeing the Town of Clarkdale and its neighbors take the next steps to improve water management at community and regional levels.

1. Introduction

The waters of the Verde Valley are vital to the humans, plants, and animals living in the midst of its arid landscape. Maintaining dependable water supplies into the future is critical to the vitality of the robust local ecosystems on which the region's residents depend for their livelihoods and quality of life. In 2011, the Town of Clarkdale launched the Sustainable Clarkdale[1] initiative, whose goal is "to provide an entrepreneurial environment rich in innovative, multi-disciplinary solutions, and educational and economic opportunities, resulting in a vibrant and viable future." As part of this initiative, the Town applied for and received a grant from the Walton Family Foundation to research and craft a direction for a Water Resources Management Program (WRMP). In January 2013, after receiving a grant award, the Town of Clarkdale invited the University of Arizona Water Resources Research Center (WRRC) to assist in the development of recommendations for its WRMP, with a view toward achieving a sustainable and vibrant community, while protecting the Verde River.

Sustainable Clarkdale WRMP project vision: *To ensure water sustainability for Clarkdale.*

Sustainable Clarkdale WRMP mission: *Clarkdale provides a water resources management program that meets the needs of residents, businesses and our natural environment equitably in order to be a robust and resilient community.*

This report is the culmination of 18 months of work with the Town, during which the WRRC sought to understand its water resource management challenges and explore available knowledge on water management in Arizona and beyond to provide recommendations for a Clarkdale Water Resources Management Program. The recommendations included in this document are the outcome of consultations with almost 60 experts in water management and a review of over 70 reports and journal articles on municipal water management and planning. In addition to making recommendations, this document is also designed to assist the Town in developing a formal water management program, should it choose to do so, by offering a single source of background information on the hydrology, water resources, and current water resource management in Clarkdale. Information about local hydrology comes from regional groundwater model refinements by Lacher Hydrological Consulting (LHC). Complete reports on the hydrology of the area, and options for how the town might use its effluent resources in particular, can be found in a separate document produced by Lacher Hydrological Consulting.

1.1 Community Context

The Town of Clarkdale's population is 4,097 (1,295 residents aged 20-60, 1,962 individuals aged 60 and over) with the average household comprised of 2.23 persons (U.S. Census, 2010). A total of 1,836 housing units are located within the town limits, about half of which have been built in the last 20 years. This growth in home construction serves as one measure of

[1] More information regarding the Sustainable Clarkdale initiative may be found on the Town's website at: http://clarkdalesustainabilitypark.org/clarkdale_sust_park.html (Refer in particular to pp. 28-29 of the 2013 Plan.)

Clarkdale's expansion in recent decades. Past growth rates observed in Census records, particularly since 1970, reflect periods of varying population increase, depending on local conditions and broader state and national economic trends. Current estimates predict that the population will grow in the near-term at about 2.5% annually. With the recovery of the overall economy, two subdivisions platted prior to the economic downturn are expected to be developed within the next ten years, resulting in an additional 646 residential lots.

Residents of Clarkdale have a high level of awareness about water conservation. Public attention has been focused on local water management for several years, as indicated by the community support of the Town's purchase of the private water utility in January 2006. Per capita water usage has decreased 46% since the Town acquired the water utility and began implementation of aggressive water management actions to encourage reductions in overall water use, demonstrating a widespread ethos of conservation. The continuation of a multi-year drought has only strengthened residents' awareness of and commitment to wise water use practices.

According to US Census records, the predominant household type in Clarkdale is single-family detached homes (73%). Other types include: townhomes and duplexes (1.7%), apartments (5.8%), and manufactured homes (19.5%). The majority of landscaping in the community is xeriscape. Under Town Ordinance 270, commercial and multi-family developments are required to use low water or drought-tolerant plants from an approved plant list. Single-family homeowners are strongly urged to consider these landscaping guidelines as well. The Town does not have firm statistics on the number of exterior landscapes containing grass or turf, however the Town estimates that fewer than 30% of residences have grass. Some residents are considered heavy water users for landscaping other than grass. For example, approximately 45 residential pools exist in the community ("Clarkdale Community Assessment," 2013; US Census Bureau, 2010). Based on Census results, 51 housing units (less than 3%) are classified as vacant due to seasonal, recreation or occasional use. While annual indoor household water consumption (e.g., use of sinks, dishwashers, showers, toilets) would be lower for part-time residents, there is evidence that many leave their outdoor irrigation systems in full operation even when not occupied, thereby maintaining water use levels comparable to full time residential units.

Several long-standing economic activities, such as farming and ranching, depend on sufficient water flows in the Verde River. Activities tied to ecotourism have also become an ever-larger component of the area's economy. For example, Clarkdale's riparian areas serve as an international flyway for migrating birds and draw many visitors, including small bird-watching groups and large events such as the Verde Valley Birding and Nature Festival. The river itself, as one of the few rivers with dependable surface flows in this semi-arid region, has garnered increased attention for kayaking and fishing. River tourism events combined with ecological, recreational, historical, and/or agricultural elements are also rising in popularity in the Verde Valley. Residents and visitors who participate in these events can take advantage of the region's multiple state and national parks and forests that showcase the community's remarkable cultural and natural resources. All of these examples illustrate how a healthy Verde River directly contributes to a healthy local economy (Von Gausig, O'Banion, & Rooney, 2011b). In its 2012 General Plan, the Town of Clarkdale affirmed a commitment to sustainable economic development, with "a goal of creating a local economy serving a variety of needs while creating long-term strength and stability, minimizing adverse impacts, and reflecting the unique environment and character of Clarkdale" (Clarkdale General Plan, 2012). This and other recent documents created by, or in collaboration with Clarkdale, have strongly emphasized the ecosystem services and economic development opportunities related to a resilient Verde River (Clarkdale Community Assessment, 2008; The Nature Conservancy, 2009; US BOR, ADWR, & Yavapai County WAC, 2011; Von Gausig, O'Banion, & Rooney, 2011a). These documents illustrate a growing recognition of the integral role the Verde River plays in the economic health of Clarkdale.

1.2 Hydrologic Context

The Town of Clarkdale lies on high ground about 200 feet (ft) above the Verde River, at an elevation of 3,560 ft. Clarkdale's immediate environment is arid, averaging only 12 inches of rain each year (Western Regional Climate Center [WRCC], 2014), but it is surrounded by mountainous areas that receive considerably more precipitation and are considered semi-arid. Thirty to forty percent of Clarkdale's precipitation occurs during the summer monsoon season. The majority of the remaining precipitation falls during winter, with fairly extended dry periods between summer and winter (WRCC, 2014). The latitude of the town (approximately 33°44' N), combined with a moderate elevation and surrounding high mountains, contribute to a generally mild climate with an average annual temperature of about 63°F. Winter temperatures often dip below freezing, but daytime temperatures approach 60°F, even in January. In typical winters, the Clarkdale area usually receives small amounts of snowfall (1-3 inches), with more accumulation at higher elevations in the surrounding mountains (WRCC, 2014).

The Verde River flows south out of the Verde Canyon, emerging from the narrow canyon just a few miles north of Clarkdale. In general, the river is a gaining stream (fed by groundwater) through most of the middle Verde Valley (Garner and Bills, 2012). A significant diversion created and maintained by Freeport-McMoRan, Inc., just upstream of Clarkdale supplies water to Peck's Lake on the east side of the river. Several major diversions downstream of Clarkdale temporarily dry portions of the river at times during peak irrigation periods in the summer, although efforts are underway to automate irrigation headgates and keep more water in the river.

Blasch, et al. (2006, p. 56) summarizes the hydrologic setting of the Verde Valley, as follows: Precipitation in the mountains along the valley margins and along the Mogollon escarpment to the north recharges the local groundwater system. Groundwater from the Mogollon escarpment flows south-southwest through Paleozoic formations of the C and Redwall-Muav aquifers down into the valley where it discharges as springs and seeps in and along tributaries to the Verde River and/or through the Verde Formation aquifer and associated alluvium toward the southeast where it is discharged as surface water in the Verde River. Precipitation in the

Black Hills area south and west of Clarkdale infiltrates through fractures and faults in the Precambrian bedrock as well as through ephemeral washes to discharge as springs and seeps along the mountain front (as at Jerome) or through the Verde sediments and alluvium before discharging as baseflow in the Verde River. As a result of the interconnected hydrology, groundwater extraction wells in the valley and along its edges intercept groundwater that would otherwise discharge as baseflow in the Verde River. Aquifer storage depletion by pumping near the river can also reduce groundwater discharge to the river or even induce seepage from the river over time (Leake and Pool, 2010, pp. 4-5).

1.2.1 Available Water Resources

The Town depends completely on groundwater for its water supply. Clarkdale owns six public water supply wells, four of which are connected to the distribution system and two of which are currently in use (SGC, 2010). Total production capacity for the Town's system is estimated at 2,210 gallons per minute (gpm) or 3,567 acre-feet per year (AF/yr) (SGC, 2010). Total average annual production since 2009 is approximately 400 AF/yr. The Mountain Gate well supplies about 40% of Clarkdale's total potable water production, while the Haskell Springs well supplies the other 60%. Although not currently in use, water from the Town's "Reservoir" (or "89A") well requires treatment for arsenic which is accomplished at the Town's arsenic treatment facility adjacent to the well. In addition to the expensive treatment required for the Reservoir well, that well has a structural problem with the casing that may limit its production capacity. The Mescal well, estimated to have a production capacity of more than 400 gpm (645 AF/yr), is being prepared for production to supply new development at the Mountain Gate subdivision. The other two wells not in use at this time are both near the existing Haskell Springs well. Unlike the Town's other wells, which produce from the Tertiary Verde Formation and interbedded Tertiary colluvial sediments, the Haskell Springs wells produce from fractured bedrock of the older (Paleozoic) strata uplifted by the Verde fault system, including the Redwall limestone and the Martin formation (SGC, 2010). The fracture-flow nature of the aquifer there increases the likelihood of hydraulic communication between wells (pers. comm. Chris Catalano, 2014). Within the Town limits, Clarkdale's Utility Department supplies 95% of the water while private domestic wells supply most of the remaining 5%. At present, there are approximately 398 active domestic private wells in the town, and no limitations exist on installation of new wells within town limits. Industrial pumping occurs at the Phoenix Cement plant, owned by the Salt River-Maricopa Indian Community, northwest of town.

As of 2013, there were 1,867 connections in total to the municipally-owned water utility. All connections are metered, allowing for individualized water billing based on consumption rates. Clarkdale presently uses an increasing-block water rate structure to encourage conservation (rates increase more steeply at higher water use levels). Typical water use for a Clarkdale residential connection (5/8" meter) is about 3,800 gallons in December. While most residents adhere to desert-landscaping practices, water consumption does increase in the warmer months. Average consumption for residential hook-ups in June is close to 7,000 gallons. Figure 1 illustrates the monthly cost of residential water for 4,000 and for 8,000 gallons at Clarkdale, Cottonwood, Sedona, and Prescott. As the figure indicates, Clarkdale's rates are similar to those for Cottonwood residences outside the city limits, and significantly higher than those for Prescott, with the difference increasing with higher water use.

The number of connections, based on type of user, is as follows: 1,498 single-family residential, 297 multi-family residential (8 actual units with 297 users), 35 commercial, 19 other, and 18 government connections. In 2012, total production was 224,961,700 gallons (690 AF/yr), or an average daily demand of 616,333 gallons, which is 25% of the 2.4-million gallon per day (mgd) (2,690 AF/yr) current system capacity (i.e., from the two currently active wells). In 2013, total production was 215,220,000 gallons (660 AF/yr) and average daily demand dropped to 589,643 gallons. Average demand in gallons per capita per day (gpcd) was 67 in 2012, dropping to 57 gpcd in 2013.

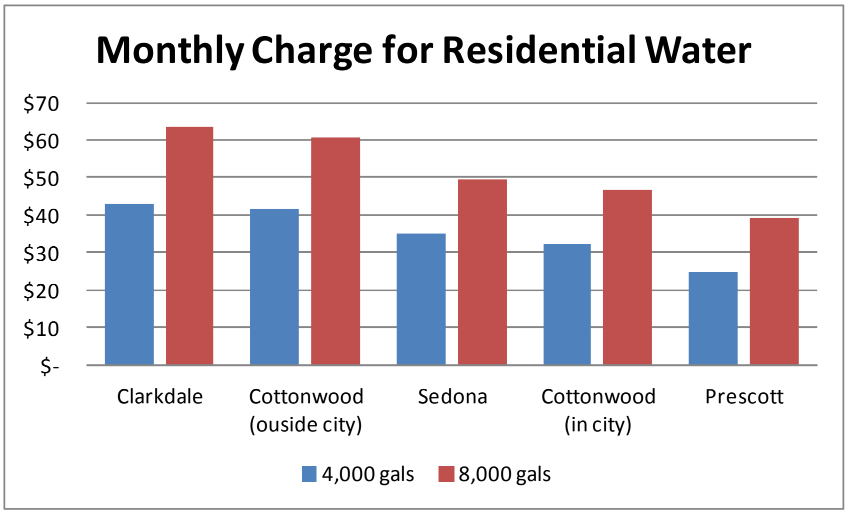


Figure 1. Monthly charge for 4,000 and 8,000 gallons of water with 5/8" meter in Clarkdale, Cottonwood, Sedona, and Prescott.

Clarkdale's water supply distribution system has been plagued by persistent, high unaccounted-for water loss. When the Town acquired its water system from Cottonwood Water Works in 2006, an interconnection between the two systems remained in place. This interconnection provides a measure of security for both communities, which can, and do, receive water from and deliver water to each other in times of need. At present, Clarkdale buys and sells water from/to Cottonwood at a low fixed cost of $1.50 per 1000 gallons. The amount of water transferred from Clarkdale to Cottonwood is measured at a meter in Cottonwood. Some uncertainty about the nature of the interconnection between the two municipalities still exists, and Clarkdale is planning to phase out the known interconnection within five years (pers. comm., Debrosky, 2014). While a lack of as-built drawings of the water system complicates matters, the Utility is addressing any and all leaks that come to its attention. Figure 2 plots the total percentage of unaccounted-for water versus total water use, including sales to Cottonwood and other users. While the correlation is not perfect, the plots indicate at least some correspondence between higher water use and lower unaccounted-for water.

Figure 2. Percent unaccounted-for water and total water used (gals) for Town of Clarkdale 2010-2014 [left column] and total unaccounted-for water (gals) and total water use (gals) 2010-2014 [right column].

Approximately 50% of residents in Clarkdale are on septic systems. There are currently 1,080 sewer connections feeding into the wastewater treatment plant (WWTP). Notably, a few large subdivisions, like Black Hills and Foothills Terrace, are currently not connected to the municipal sewer system.

The Town produces 43,728,500 gallons (134 AF) of A+ effluent each year, from its wastewater treatment plant (WWTP). Currently, the Town disposes of all effluent through land application for the irrigation of off-river riparian habitat along Bitter Creek. The maximum capacity of the WWTP is 350,000 gallons per day (gpd), and average treatment volume is 130,000 gpd. The process of wastewater treatment is through activated sludge with nitrification and denitrification and tertiary filtration (Clarkdale Community Assessment, 2013).

1.2.2 Current Status and Projections of Groundwater Levels

To understand how water resource conditions are changing in the Verde Valley, Lacher Hydrological Consulting modeled local groundwater flow and Verde River baseflow with the U.S. Geological Survey's (USGS) Northern Arizona regional groundwater-flow model (NARGFM) released in 2011 (Pool et al., 2011). See Lacher, 2014 for a full summary of hydrologic conditions at Clarkdale, Arizona. Groundwater simulations cover two time periods: the historic period from 1910 to 2006, and into the future from 2006 to 2076. Figure 3 shows simulated 1910 groundwater flow conditions in the Clarkdale area prior to any significant groundwater development. As the arrows in the figure indicate, groundwater generally moved down valley parallel to the Verde River from the surrounding mountain recharge areas. Figure 4 shows simulated groundwater elevations (heads) and flow paths in the same area of the main aquifer near Clarkdale in 2006, which marks the end of the transient calibration period for the NARGFM. This figure shows a pumping-induced cone of depression with drawdowns exceeding 200 ft. in the Clarkdale-Cottonwood area. Groundwater flow paths are diverted toward the area immediately west of Cottonwood rather than proceeding along their historical down-valley trajectories. By 2076 (Figure 5), simulated heads reflect a deeper (over 300 ft.) cone of depression southwest of Cottonwood and southeast of Clarkdale. Groundwater flow paths are more sharply diverted from their historical down-valley trajectories, with the cone of depression capturing groundwater from all directions.

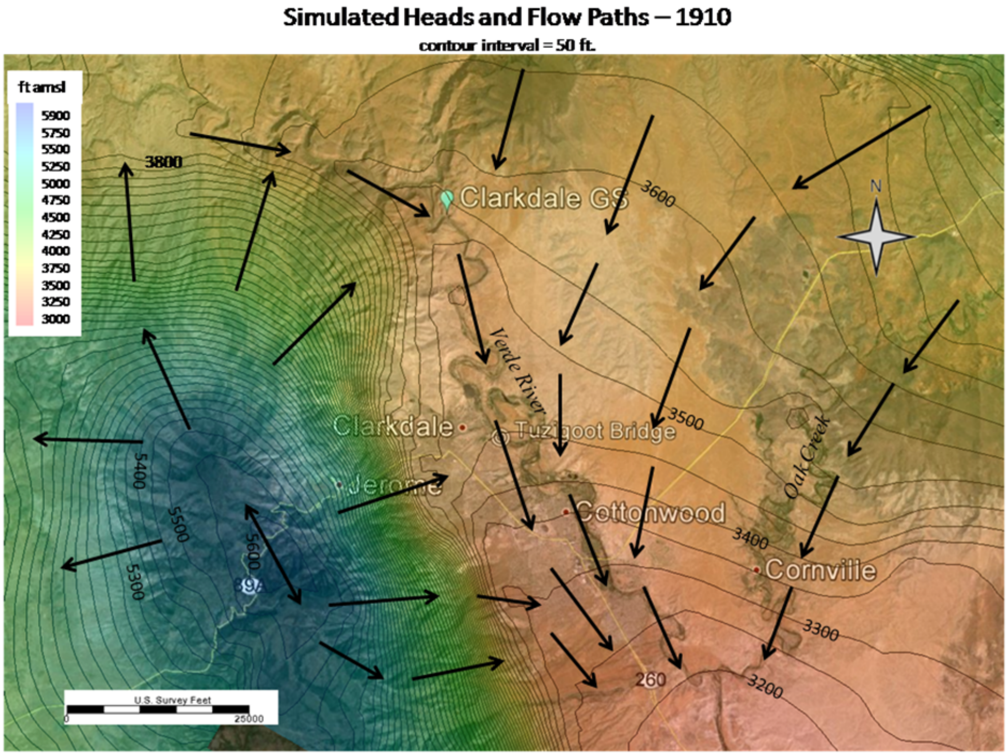


Figure 3: Simulated pre-development (1910) groundwater levels and flow paths in the regional aquifer near Clarkdale.

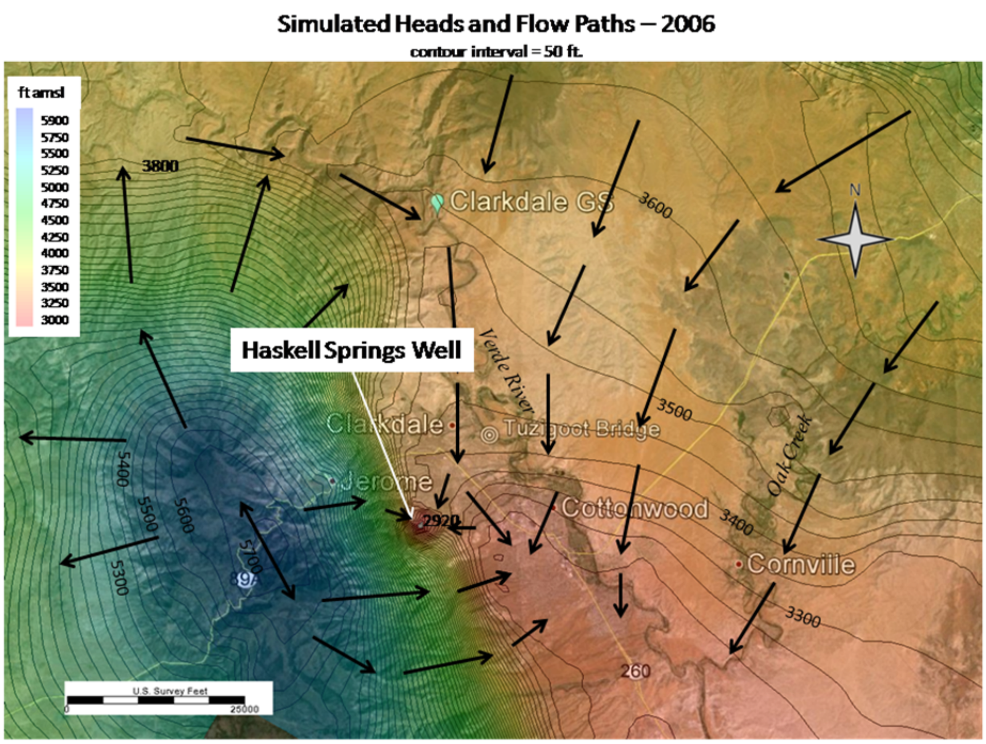


Figure 4: Simulated groundwater levels and flow paths in the regional aquifer near Clarkdale 2006.

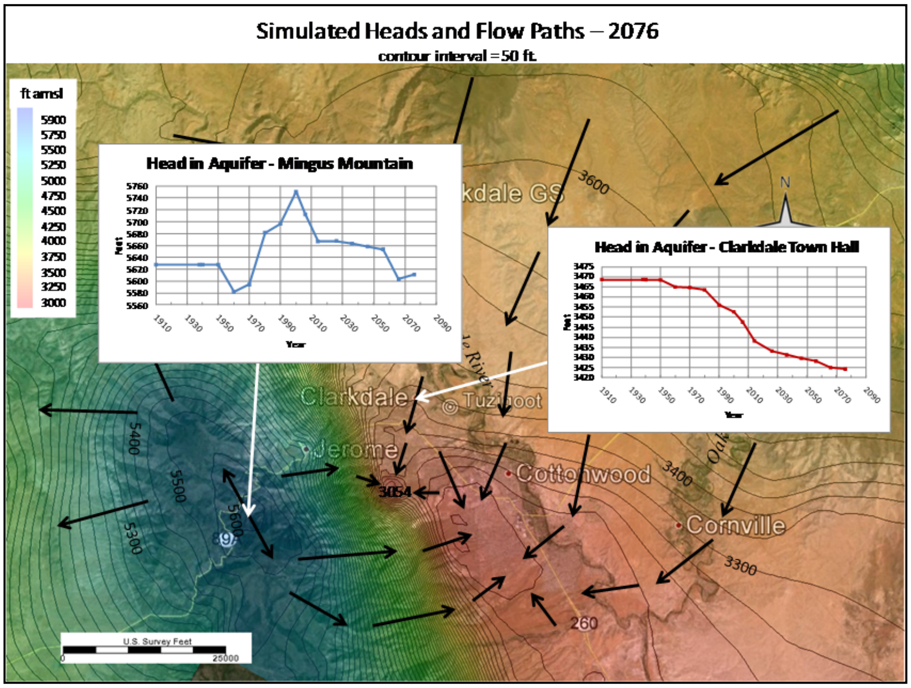


Figure 5: Simulated groundwater levels and flow paths in the regional aquifer near Clarkdale in 2076.

1.2.3 Verde River Baseflow Projections

Figure 6 shows the simulated shift of baseflow change in part of the Verde River and Oak Creek over the period 1910 to 2006. Although the Verde River shows variable levels of baseflow decline, the simulated decline at the "Verde River near Clarkdale" steam-flow gaging station maintained by the USGS was on the order of 4% over the 20th century. By 2076, simulated baseflow declines on the Verde River are more pronounced (Figure 7), with baseflow declining by an estimated 9% at the Clarkdale gaging station from 1910 conditions.

1.2.4 Clarkdale's Impact on Groundwater and Surface Water Resources

In order to quantify the impacts of Clarkdale's municipal groundwater extraction and recharge on the underlying aquifer and on baseflow in the Verde River, capture simulations were run using the Northern Arizona Regional Groundwater Flow Model (NARGFM) (Pool et al., 2011). The amount of baseflow captured by the Clarkdale municipal wells was calculated from the difference between two simulations of this model:

- Simulation 1: All historic pumping and recharge in the entire model area (northern Arizona down to the Salt River) through 2006 plus future pumping and recharge to 2076.
- Simulation 2: Same historic and future pumping and recharge as first simulation but without the pumping from Clarkdale's municipal water system.

Subtracting the two simulation results provided the simulated impact of the Town's past, present, and projected future pumping on groundwater levels, aquifer storage, and Verde River baseflow.

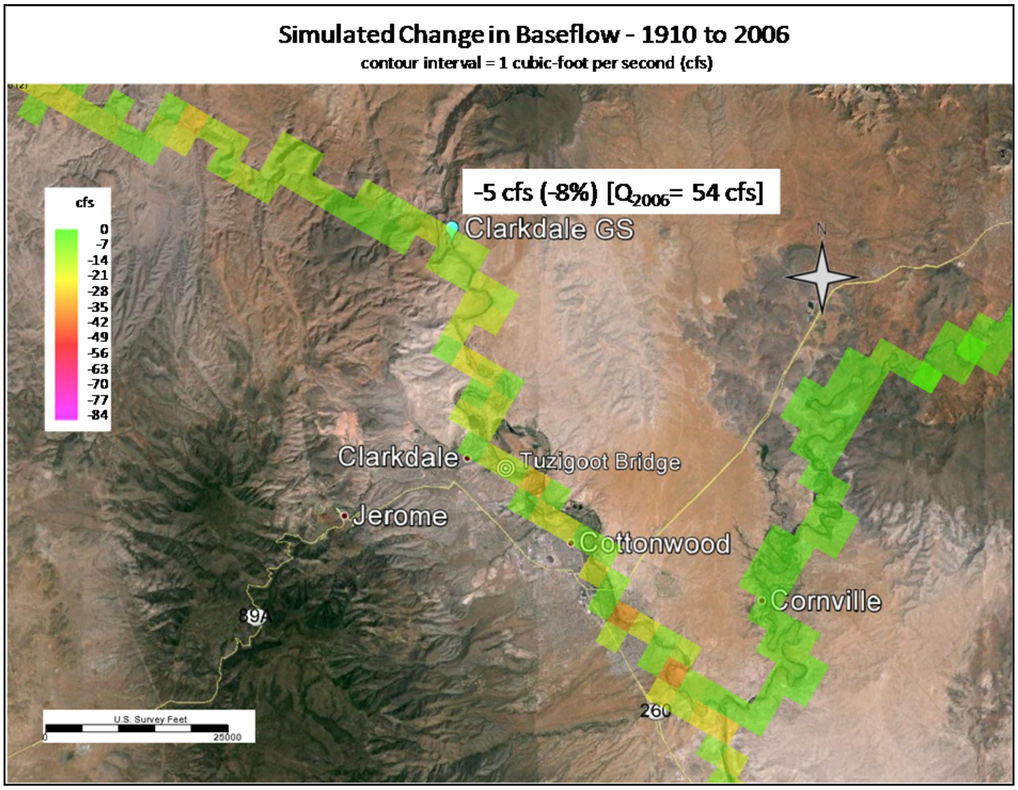


Figure 6. Simulated change in baseflow in the Verde River near Clarkdale and along Oak Creek near Cornville between 1910 and 2006.

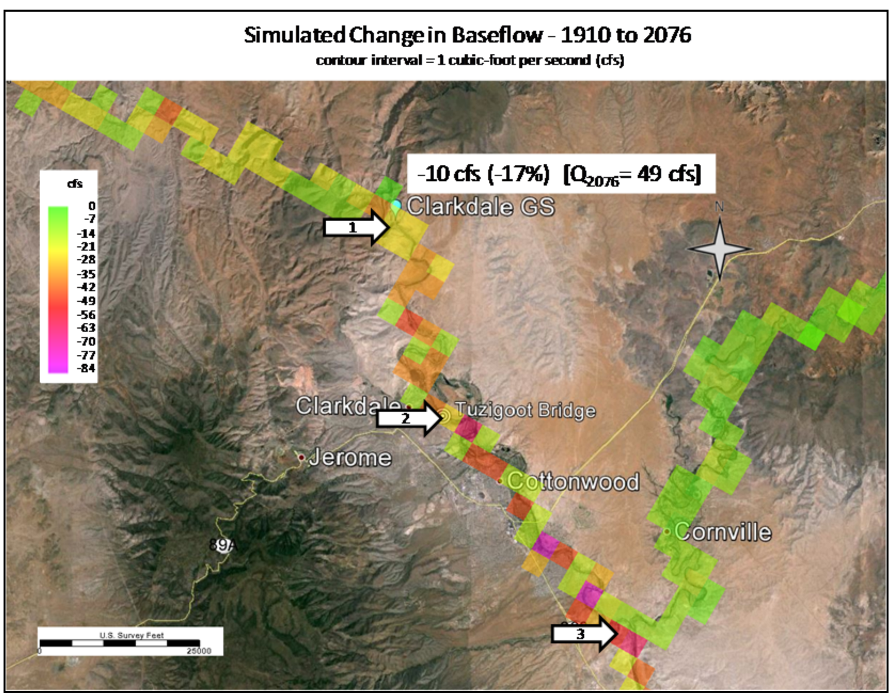


Figure 7. Simulated change in baseflow in the Verde River near Clarkdale and along Oak Creek near Cornville between 1910 and 2076.

Key findings from these simulations are:

Groundwater Levels

- Historic pumping from Clarkdale's wells has already (as of 2014) lowered groundwater levels by approximately 3.3 ft or more under the Verde River (Figure 8).
- By 2076, the areal extent of the cone of depression from Clarkdale's wells will be larger, extending east past the Verde River and south almost to the Oak Creek confluence (Figure 9).

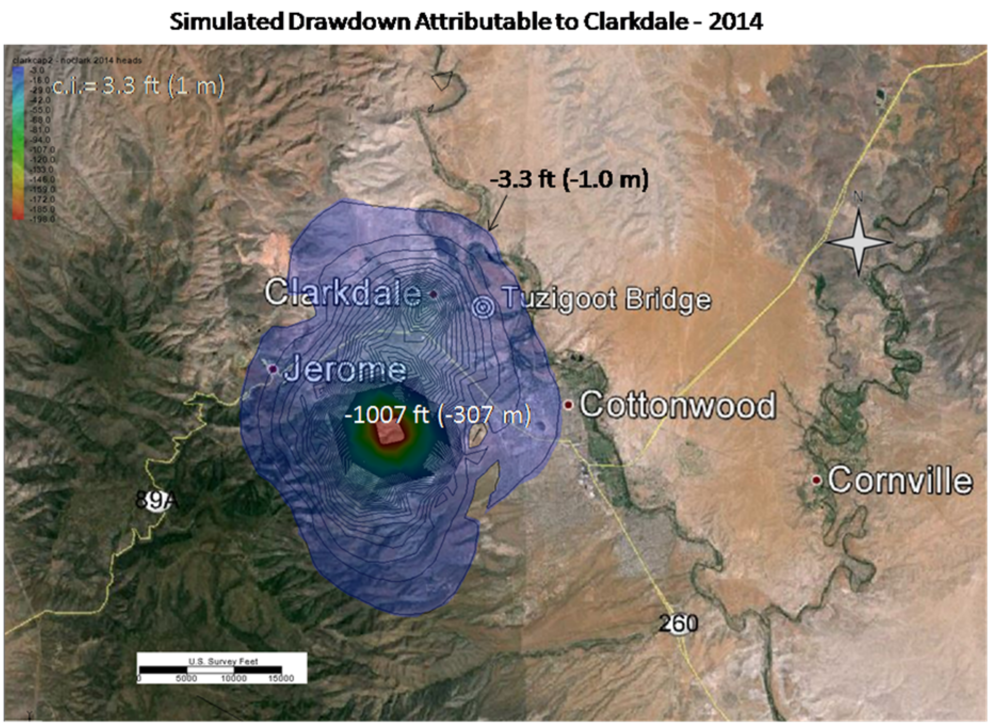


Figure 8. Simulated drawdown attributable to Clarkdale municipal pumping and recharge for the period 1910-2014.

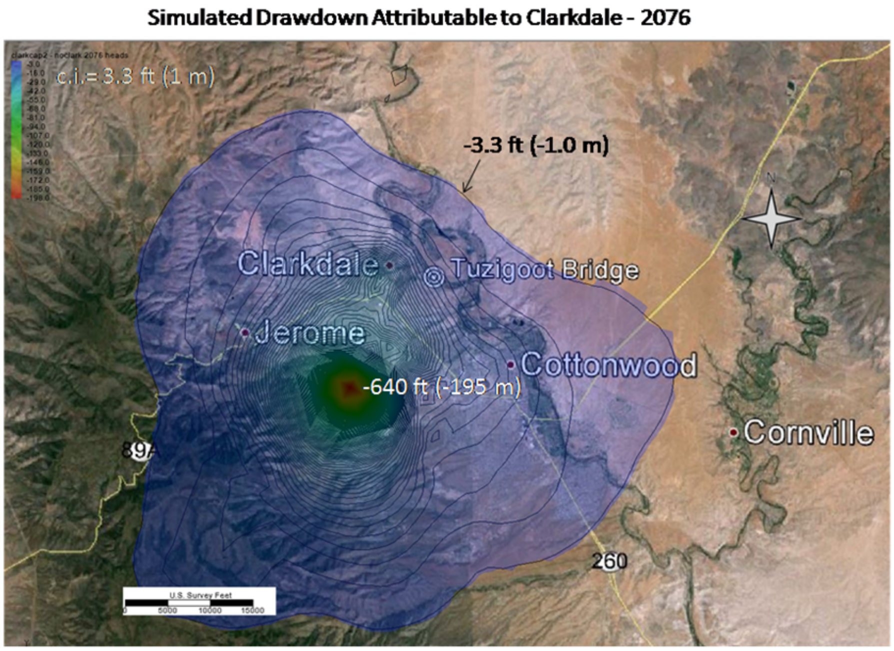


Figure 9. Simulated drawdown attributable to Clarkdale municipal pumping and recharge for the period 1910-2076.

<u>Baseflow in the Verde River and Aquifer Storage</u> (Figure 10):

- Prior to 2006, Clarkdale's wells derived most of their water from aquifer storage and had no significant impact on baseflow in the Verde River.
- The simulated increase in pumping between 2006 and 2014 (to 700 AF/yr) resulted in a 200-AF increase in simulated aquifer storage depletion and 100 AF of simulated depletion in Verde River baseflow.
- After 2006, simulated pumping begins to capture streamflow rather than just extracting groundwater from aquifer storage.
- By 2056, simulated baseflow capture begins to exceed groundwater storage as a fraction of water pumped by Clarkdale wells.
- By 2076, Clarkdale's simulated pumping is capturing of 380 AF/yr (roughly 0.5 cubic-feet per second (cfs)) of Verde River baseflow and consuming about 330 AF/yr in aquifer storage.
- According to the simulations, Clarkdale's existing well production will not be limited prior to 2076 (provided Haskell Springs well pumping is reduced and the Mescal well is utilized). However, Clarkdale's pumping has already begun to impact the Verde River. Although the Verde River remains a gaining stream in this section of the Verde Valley, this pattern could eventually weaken or even reverse if baseflow capture continues.

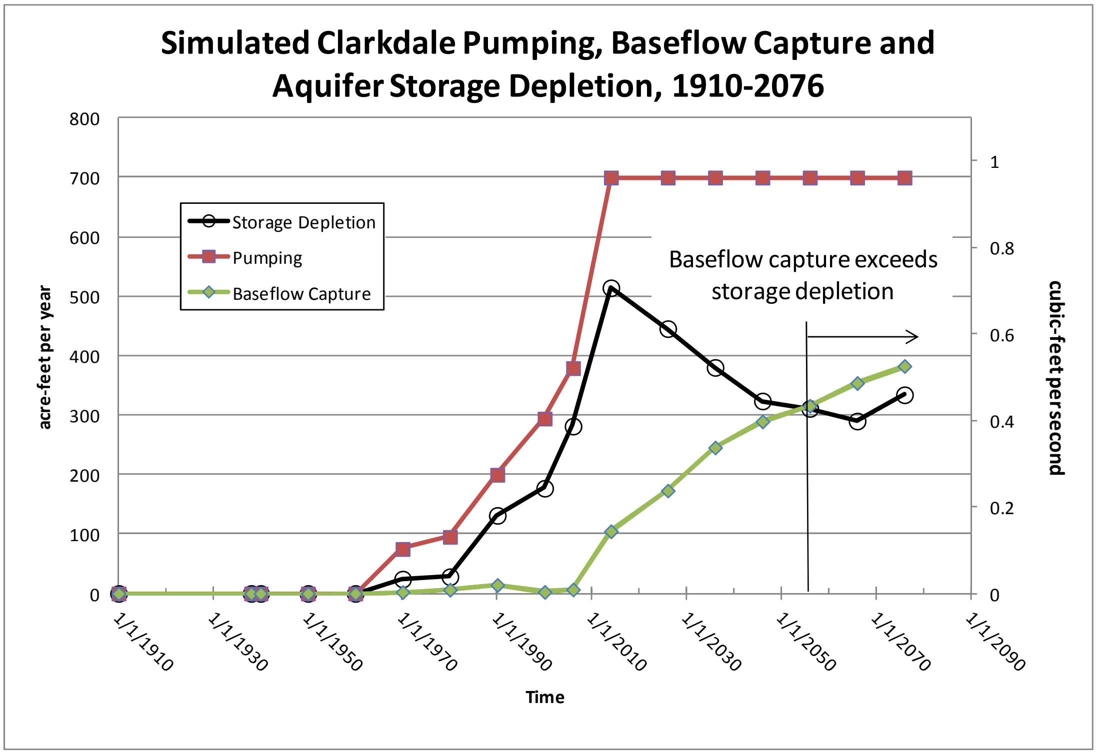


Figure 10. Simulated Clarkdale pumping and associated aquifer storage depletion and baseflow capture for the period 1910-2076. Beginning in 2056, simulated baseflow capture comprises a greater fraction of Clarkdale's pumping than does aquifer storage depletion.

1.2.5 Water Management Scenarios

In order to evaluate the sensitivity of Verde River baseflow to potential water management actions taken by the Town of Clarkdale, the following scenarios were studied using NARGFM published by the USGS in 2011. All scenarios apply a natural recharge pattern that includes the current (2000-2014) drought, and then repeats the simulated recharge regime of the 1910-1970 period in the NARGFM. Some simulated pumping outside of Clarkdale was moved to deeper aquifer layers in order to prevent any model cells in the vicinity of Clarkdale from drying up and limiting pumping. Locations of key water management features are shown in Figure 11.

1. Status Quo: All municipal (muni) and non-municipal (non-muni) pumping and artificial recharge in Clarkdale remains constant from 2014-2076. Non-muni pumping is 5% of muni pumping after 2014. Clarkdale's wastewater treatment facility (WWTF) recharge is 9% of total pumping, as in the NARGFM.
2. Central Yavapai Highlands Water Resources Management Study (CYHWRMS) Projected Demand: Clarkdale muni pumping is increased linearly from 700 AF/yr in 2014 to 2218 AF/yr in 2050, in accordance with CYHWRMS projected demand. Simulated pumping after 2050 is grown at half the rate of the 2014-2050 rate of growth. Two new wells were required to meet Clarkdale demand. WWTF recharge is 30% of total pumping. Non-muni pumping is held constant as in the status-quo scenario, so it drops as a percentage of total pumping from 5% in 2014 to 1% in 2076.

3. CYHWRMS with RIVER Recharge: Same as scenario 2 except that all Clarkdale WWTF recharge is moved from its present location to a site adjacent to the river (and the existing treatment plant).
4. CYHWRMS with WELL-FIELD Recharge: Same as scenario 2 except that WWTF recharge is moved to the 89A municipal well (no longer in service).
5. 50% CYHWRMS Demand: Same as scenario 2 except with 50% of projected CYHWRMS demand and WWTF recharge from 2014-2076. No change in non-muni pumping from status-quo, so non-muni pumping drops from 5% to 3% of total Clarkdale pumping from 2014 to 2076.
6. Total Reuse: Same as status-quo scenario except that municipal pumping is reduced by half from 2014-2076 and WWTF recharge ceases after 2014.

Summary of Water Management Scenario Simulation Results

Location of pumping and recharge are important factors in Clarkdale's net effect on Verde baseflows, as summarized in Figure 12. Of the three highest-pumping/highest recharge scenarios (2-4), scenario 4 had the greatest negative impact on the Verde River because recharge occurred near the pumping center rather than near the river (Figure 12). The lowest-pumping scenario (6) still produced some impact on the Verde because no recharge occurred after 2014. The moderate-pumping scenario (5) was nearly as protective of the Verde River as the status-quo scenario (1), even with higher pumping and even though recharge was maintained at its present location in Bitter Creek rather than being moved next to the river. This result indicates that the quantity of recharge and the location of recharge, together, are more significant than the amount of pumping for the time period of this simulation. Scenario (3) exhibits the greatest aquifer storage loss but, as in all of the scenarios, storage loss begins to taper near the end of the simulation period in response to increased stream capture and WWTF recharge.

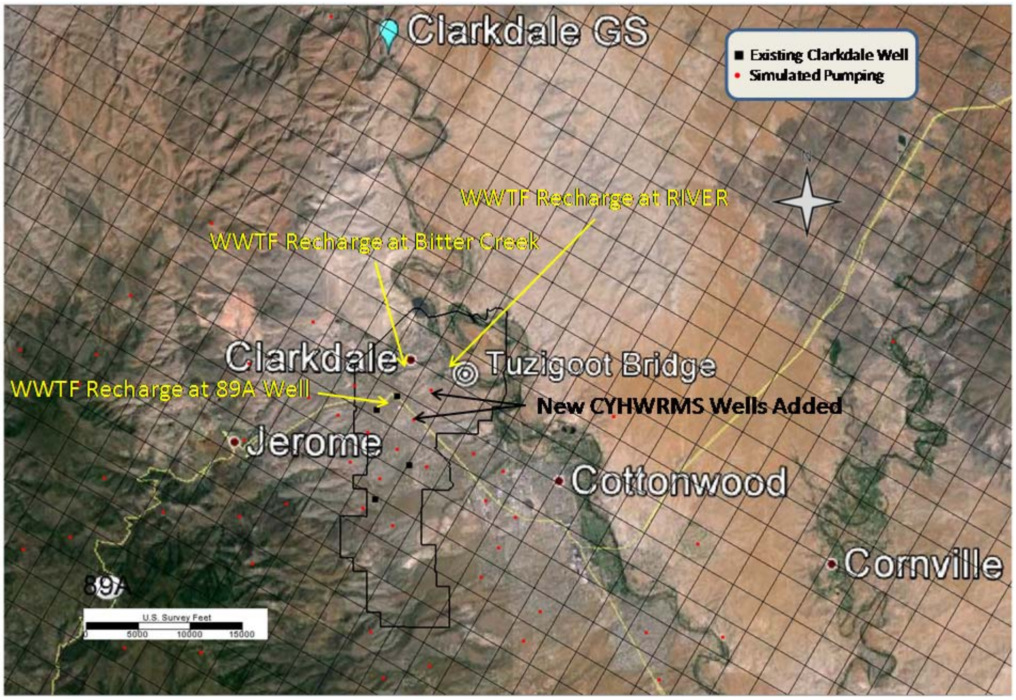


Figure 11. Map of key features of water management scenarios in Clarkdale.

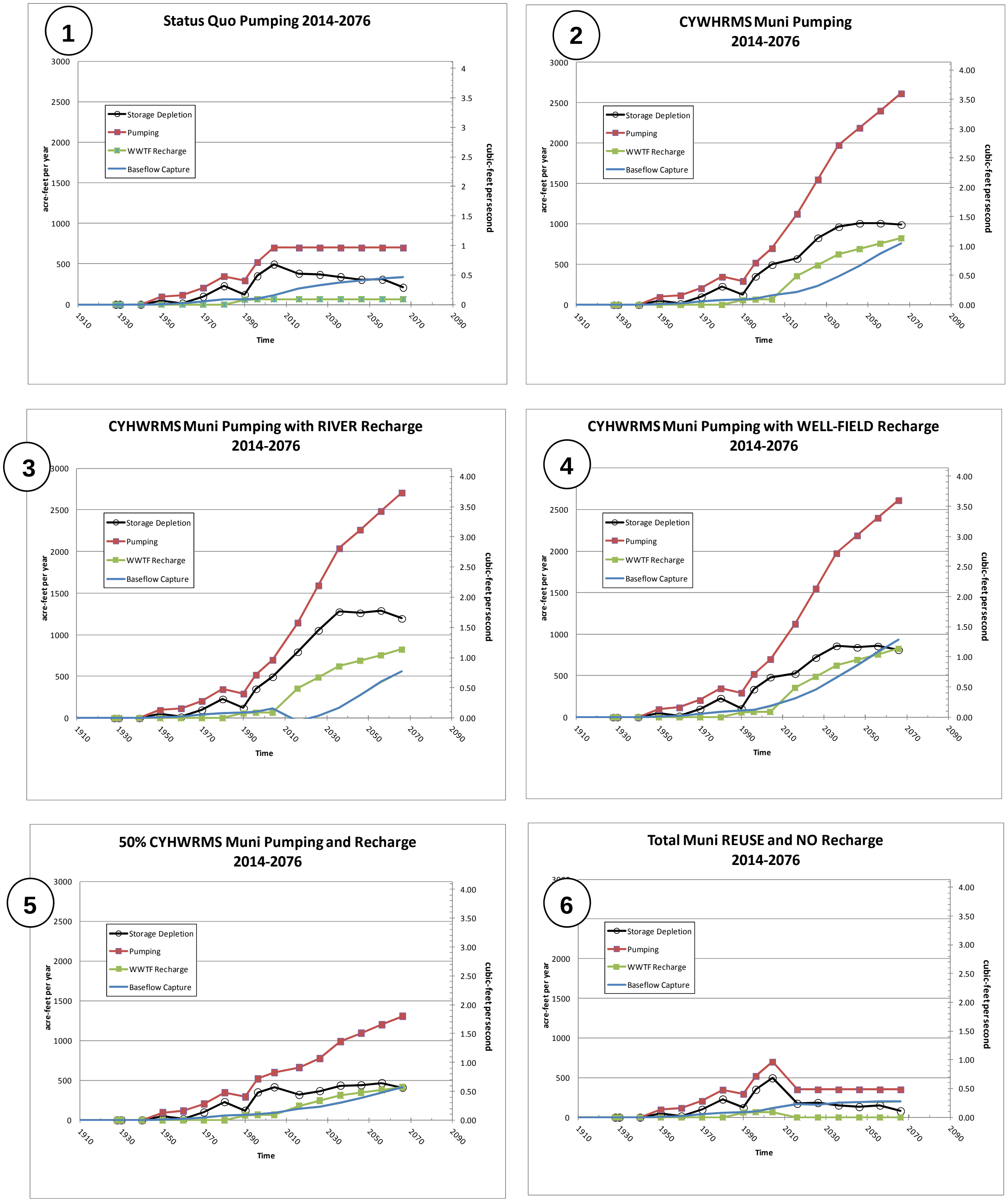


Figure 12. Simulated pumping and wastewater treatment facility recharge for six water management scenarios and resultant aquifer storage depletion and baseflow capture.

2. Process for developing the WRMP Recommendations

Developing the recommendations for Clarkdale's Water Resources Management Program began with internal conversations between the WRRC, Town of Clarkdale staff and Laurel Lacher of Lacher Hydrological Consulting (LHC) (Figure 13). The Town Team included Wayne Debrosky, Beth Escobar, Jodi Filardo, Gayle Mabery, Doug Von Gausig, and Ellen Yates. WRRC staff on the project included Christopher Fullerton, Kelly Mott Lacroix and Candice Rupprecht. All WRMP team members were present for advisory board meetings and the Expert and Small Town Water Forums.

During initial meetings, the WRRC worked with the Town to set goals for the project and identify initial water resource management concerns that could focus modeling by LHC and research by the WRRC. Early in the process, it was determined it would be beneficial to spend the first portion of the project understanding the baseline conditions, and offering this understanding to the public, prior to embarking on the development of recommendations. As a result, the Town hosted two public meetings. The first meeting, on April 30, 2013, introduced the project and basic concepts of groundwater and surface water interactions (referred to as "Groundwater 101"). The next meeting, on August 7, 2013, introduced the concept of a groundwater model and presented initial findings from the Verde Valley modeling.

In June 2013, the WRRC facilitated the formation of an Advisory Board for the project. The role of the Advisory Board was to provide input on policies and messaging for the Town of Clarkdale's WRMP; suggest options for creation of a long-term water resources management program based on Advisory Board expertise and experience; and review interim and final reports on the WRMP. Advisory Board members are listed in Table 1.

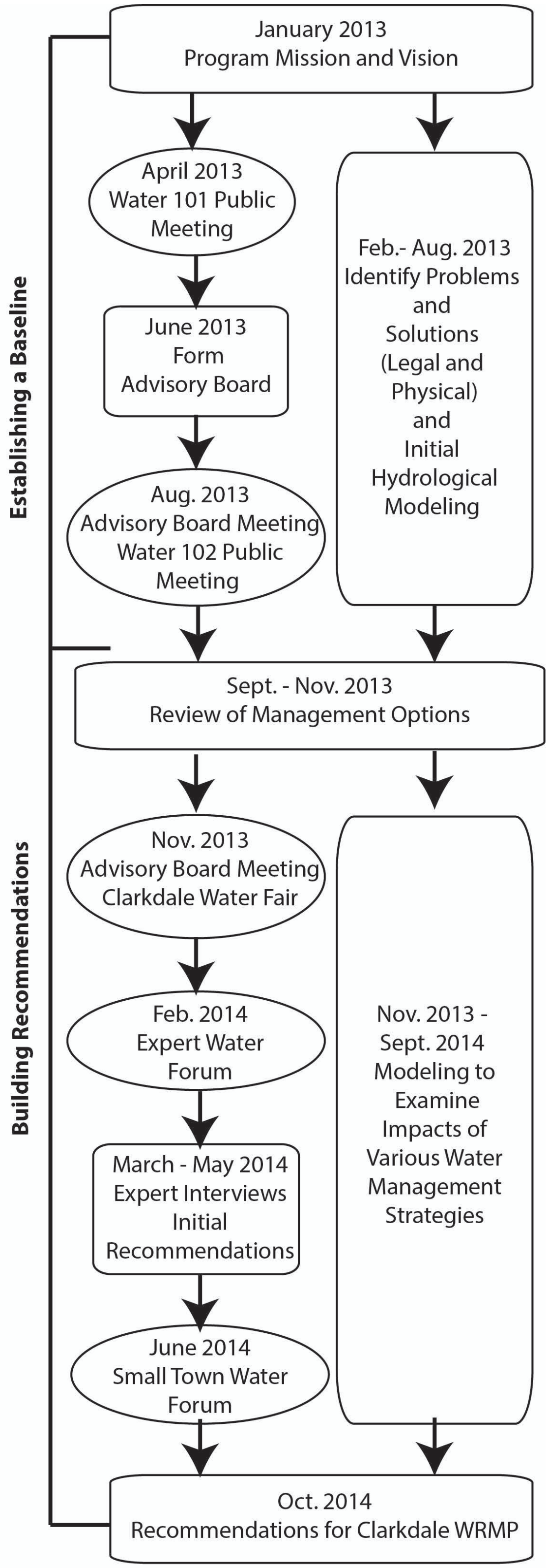


Figure 13. Process for developing the WRMP Recommendations

Table 1: WRMP Advisory Board Members

Name	Representing
Peter Culp	Attorney, Squire Sanders LLP
Fred Goldman	Civil Engineer
Bruce Hallin	Salt River Project
Maren Mahoney	Arizona State University, Energy Policy Innovation Council
John Rasmussen	Yavapai County, Water Advisory Committee
Linda Stitzer	Western Resource Advocates
Gerry Walker	Arizona Department of Water Resources

The first meeting with the Advisory Board was held on August 7, 2013. At this meeting, the WRRC presented an initial matrix of water management options and worked with the Advisory Board to identify additional management options and areas for further research (see Appendix A: Background Materials for WRMP Recommendations for a copy of the original Water Management Matrix). Between August 2013 and November 2013, the WRRC conducted extensive research on existing water management strategies based on the challenges identified by the town and solutions suggested by the Advisory Board. An annotated bibliography of this research is included here as part of Appendix A. On November 5, 2013, the WRMP team met with the Advisory Board to select the Expert Meeting themes that would drive development of the WRMP report, and to identify experts to participate in the Expert Meetings. After the Advisory Board meeting, the Town hosted a Water Fair in an open-house format to provide additional information on water management and planning in Clarkdale to the general public.

Between November 2013 and January 2014, the WRRC, together with the Town and LHC, created a Water Primer for the Town of Clarkdale (Primer). The Primer was the culmination of the first phase of the project to understand the baseline physical and legal conditions for water resources management, and included water management challenges facing the Town and potential strategies or meeting those water management challenges. Challenges and solutions were articulated by Town staff, the WRRC, LHC and the WRMP Advisory Board. Most of the introduction (Section 1) and the water resource issues (Section 3) in this document were originally presented in the Primer.

The Primer was then used to inform and stimulate dialogue at a one-day Expert Water Forum held on February 25, 2014. The goal of the Expert Forum was to discuss the Town's water resource challenges and gather the experts' thoughts on how the Town should develop its WRMP. The WRRC used the recommendations received at the Expert Water Forum to guide a set of focused interviews with additional experts. Attendees at the Expert Forum and those contacted in eight additional follow-up interviewees are listed in Table 2. During this time LHC worked to refine the existing groundwater model and examine how possible water resource management decisions might impact the aquifer. More detail on this work is available in a separate report published by LHC.

Table 2: Expert Water Forum Attendees and Follow-up Expert Interviewees. Follow-up interviewees are marked with an *

Name	Representing
Tracey Bouvette*	Southeastern Colorado Water Conservancy District
Peter Culp	Squire Sanders
Cado Daily*	University of Arizona Cooperative Extension
Marilyn DeRosa	City of Tempe
Ron Doba	NAMUA
Brad Garner	US Geological Survey
Jocelyn Gibbon	Freshwater Policy
Vivian Gonzales	US Bureau of Reclamation
Bruce Hallin	Salt River Project
Lisa Henderson	Governor's Office of Energy Policy
Adam Hutchinson*	Orange County Water District
Brad Lancaster*	Rainwater Harvesting Expert
Maren Mahoney	Arizona State University, Energy Policy Innovation Council
Amy McCoy	Ecosystem Economics
Doug McMillan	Retired Engineer
Noah Mundt	Lincus Energy
Nick Paretti	US Geological Survey
Ray Quay	Arizona State University, Decision Center for a Desert City
Daniel Ransom*	City of Tucson, Formerly Town of Santa Fe
John Rasmussen	Yavapai Water Advisory Council
Anonymous*	Power Industry
Linda Stitzer	Western Resource Advocates
Sandy Sutton	Water Infrastructure Finance Authority
Tim Thomure*	HDR, Water & Natural Resources business group
Doug Toy	City of Chandler
Dave Venable*	Mayor, Town of Cloudcroft, NM
Gerry Walker	Arizona Department of Water Resources

Using research on other water resource management programs and input from experts between March and May 2014, the WRRC developed initial recommendations for the Town's WRMP. To vet these recommendations, and connect them to other small towns in Arizona, Clarkdale and the WRRC convened a 2-day Small Town Water Forum June 26-27, 2014. The goal of the Small Town Water Forum was to provide mayors and utility managers from small towns across Arizona with an opportunity to share their water resource management stories and successes and to explore what tools small towns need to improve their water resources management. Attendees at the Small Town Water Forum are shown on Table 3. A summary from the Small Town Water Forum is included here as Appendix B. The thoughts and ideas from this Small Town Water Forum were also incorporated into the recommendations presented here.

Table 3: Small Town Water Forum Participants

Name	City/Town
Ron Long	Camp Verde
Charles German	Camp Verde
Stan Bullard	Camp Verde
Tony Gioia	Camp Verde
Chris Marley	Chino Valley
Cado Daily	Cochise County Cooperative Extension
Roger Biggs	Cottonwood
Nick Bacon	Energy Policy Innovation Council
Peggy Tovrea	Jerome
Jane Moore	Jerome
Adam Hutchinson	Orange County Water District
Buzz Walker	Payson
Andy Romance	Pinetop-Lakeside
Chris Gibbs	Safford
Eric Buckley	Safford
Charles Mosley	Sedona
Keith Self	Sedona
Scott Dooley	Sierra Vista
Jean Van Pelt	Southeastern Colorado Water Conservancy District
Tracy Bouvette	Southeastern Colorado Water Conservancy District
Bob Rivera	Thatcher
Linda Stitzer	Western Resource Advocates
Sara Konrad	WIFA
Andrew Smith	WIFA
John Rasmussen	Yavapai Water Advisory Committee

3. Water Resource Issues

As noted in the introduction, the mission for the project is: *"To ensure water sustainability for Clarkdale* and the mission of the Sustainable Clarkdale WRMP is: *to provide a water resources management program that meets the needs of residents, businesses and our natural environment equitably in order to be a robust and resilient community."* This mission helped guide discussions of water resource issues and selection of recommendations.

In discussing water resource issues and recommended actions, it is important first to understand the context in which this management occurs. Under the Groundwater Management Act of 1980, certain regions in the state have been designated as Active Management Areas (AMAs), and special regulations have been enacted within each AMA to guide it toward achieving an AMA-specific goal regarding the protection of groundwater resources. Although Clarkdale is not within an Active Management Area, it has implemented another legal tool to assert some influence over new developments within the Town Limits. Under the enabling legislation known as SB 1575, Clarkdale has passed a Water Adequacy Rule (Section 4.1), which requires new subdivisions to obtain a determination of an adequate 100-year supply of water from the Arizona Department of Water Resources before final approval will be granted for applications pending before the Town of Clarkdale. There are otherwise no direct restrictions on groundwater use or well drilling, provided that an appropriate permit is obtained from the Arizona Department of Water Resources (ADWR). Furthermore, Clarkdale is currently groundwater dependent and does not hold surface water rights to the Verde River. The following water resource issues were assembled by the WRRC based on conversations with Town of Clarkdale staff and in consultation with the project's Advisory Board. These issues informed research by the WRRC as well as conversations with experts through the Expert Water Forum, individual expert interviews and the Small Town Water Forum.

3.1 Treated Effluent Utilization

Thanks to the improved wastewater treatment plant, the quality of the effluent produced has been raised from class C (lagoon) rated-effluent to the A+ rating standard. This substantial improvement expands the potential reuse options allowable under state law and raises the question of how best to use this treated effluent in order to best support the mission of the Clarkdale WRMP. This question becomes even more relevant considering that the Town's lease for land owned by Clarkdale Metals, on which Class A+ effluent is currently sprayed along riparian habitat, ended in September 2014. While a temporary lease extension may be an option, the time is ripe for a broader consideration of the different options available.

3.2 Stormwater Management

Much of the precipitation received in Clarkdale arrives in the form of brief, yet intense, monsoon storms. In the aftermath of these heavy rains, large volumes of runoff typically drain into the engineered municipal stormwater system or the ephemeral washes in and around the Town. This stormwater often carries a heavy sediment load, creating maintenance problems as well as contributing to turbidity and sedimentation in the Verde River. There is currently a lack of adequate infrastructure to carefully manage runoff. A redesigned system could detain and recharge excess runoff to offset aquifer depletion by groundwater pumping, be directed to passive irrigation structures to offset the potable water use, or augment the Verde River's baseflows. Such a system of better stormwater management would also help address upland erosion and low-land flooding in the Town, reduce sediment transport to the Verde main stem, and mitigate other damage and maintenance costs associated with complications from runoff.

3.3 Infrastructure

Clarkdale has made substantial improvements in the community's water delivery and management infrastructure since acquiring the water utility in 2006. However, even with investments like system-wide meter replacement and water audits, unaccounted-for water remains high. In 2012, the monthly average unaccounted-for water was 37% of total pumped water, and the monthly average was 35% in 2013. Reasons for this high percentage of unaccounted-for water are under investigation, including a long-standing Municipal Interconnection between Cottonwood, AZ and Clarkdale, AZ as well as the need to replace additional aging infrastructure components (refer to Section 1.2.1 for additional background).

3.4 Town Size

Clarkdale is considered a small town, with a population of less than 5,000 residents. This complicates the development of a sustainable water resources management program, as no models exist for a community of this size. Even with the added flexibility provided by a municipally-owned water utility, a small population creates the challenge of limited revenue for investing in strategies to balance supply and demand. Conversely, this also creates an opportunity to engage Town residents in meaningful discussions and decisions to create a path toward sustainable water management with active support from the Town.

3.5 Small Domestic Wells (<35 gallons per minute)

Clarkdale is located outside of a state-designated Active Management Area. Several existing private wells continue to operate within the service area of the Town's utility. Private well owners bear the responsibility of monitoring the water quality of their wells. In addition, if their wells begin to deliver insufficient production, the owners must pay the expense of navigating the permit process and deepening or drilling a new well. At present, the Town places no restrictions on sewer hook-ups for private well owners, regardless of the lack of water quality information on those wells.

Little water consumption information is available regarding domestic wells under current practices, most of it indirect in nature. At present, only 5% of the Town's total water demand is attributed to private wells, although inadequate data collection leaves some uncertainty regarding this estimate. While some of these wells may be metered, data are generally not reported. Without this information, understanding the state of existing water consumption in Clarkdale is challenging. A voluntary metering program for well owners who are willing share this information with the Town is currently under development. Modeling the extent of potential cones of depression in the aquifer is also complicated. These small domestic wells can affect the utility's available water supplies and the private wells of neighbors.

3.6 Decreasing Verde River Flows

The Verde River remains one of the few in Arizona with consistent perennial surface flows, making it an especially scarce and valuable resource in this semi-arid state. However, observations of stream flow in the Verde over time reveal concerning developments. USGS modeling estimates a baseflow decrease of 8% from 1910 to 2006 at the "Verde River near Clarkdale" stream-flow gaging station upstream of Clarkdale, with the rate of reduction of baseflow at this gage accelerating over the last decade. Furthermore, the lowest daily flow on record since measurements began at this gaging station in 1915 occurred in June 2013. Such historically low water levels underscore the importance of understanding interconnections between the river and the extensive surrounding subsurface water flows that feed into and support the baseflow of the river. Better knowledge of the hydrology may allow for more targeted water conservation efforts, more careful well placement and pumping regimes, and perhaps more strategic effluent reuse by the Town of Clarkdale.

3.7 Limited Groundwater Supply

Reports from well owners in adjacent parts of the Verde Valley suggest that groundwater supply levels are experiencing at least locally significant drops. Owners of several wells near the mountain front in Clarkdale have stated that their wells have already gone dry. Individuals living in the vicinity of Tavasci Road, Shiloh Trail, Coyote Hill Road, and Hogan Hill have traditionally relied on well water, but recent developments have made their reliance on private wells especially problematic. A long-time resident on Coyote Hill Road originally drilled a well to a depth of 500 feet, but has been forced to drill deeper in the last few years to reach water. Residents in and around Shiloh Trail and Coyote Hill will be tying into the municipal water system in the near future. Individuals in the Hogan Hill area will be tying in as well after Shiloh Hill connections are established. Tavasci Road owners have indicated that they are not able to drill new wells and are reviewing their limited options. While some owners have chosen to attempt to replenish their water supplies by deepening existing wells, no one has drilled a new well. While some of these recent shortages may be exacerbated by the severe drought of the past 15 years, some of the wells are likely experiencing permanent failure due to aquifer storage depletion by pumping.

Data regarding deepening of wells to reach reliable groundwater supplies have not yet been collected and reviewed for broader analysis. Detailed mapping that utilizes GIS data would allow a more systematic understanding of where wells have gone dry and how these trends may affect others nearby. There may be particular implications for Clarkdale as the geology of the basin (bounded by the Verde fault system on the south and west of Clarkdale) and the location of the Town in proximity to the Verde River may limit the productivity of the municipal utility's pumping wells and the total available aquifer storage capacity.

To the extent that these conditions persist, the Town will need to consider its options in addressing an increasingly uncertain water supply future. Previous discussions have brought up the possibility of seeking relief from deeper aquifers, but these aquifers have not been explored for water quality and productivity in the area underlying Clarkdale. Even if these alternate water sources were available, current hydrological understanding indicates that their utilization could still ultimately deplete baseflows in the Verde River.

4. Current Water Management and Recommendations for the Town of Clarkdale's Water Resources Management Program

4.1 Current Water Management

In many ways, the Town of Clarkdale already serves as a model for small town water resources management given the integral elements of a water resources management program that have already been implemented (Table 4). A brief review of the last 14 years offers context and insight into the current situation regarding water management in Clarkdale and demonstrates how water conservation and best practices have already been implemented. Among these best practices are Clarkdale's:

- Adoption of the Adequate Water Supply Rule and Clarkdale's receipt of a Designation of Adequate Water Supply;
- Adoption of water conservation ordinances, such as the landscape design ordinance that requires the use of low water/drought tolerant plants from an approved plant list for commercial and multi-family developments (Ordinance #270) and the drought plan (Ordinance #296);
- Increasing-block-rate billing structure to encourage water conservation and revised water bill format to make the bills more readable and customer-friendly;
- Meter replacement program and installation of radio-read meters and ongoing efforts to determine and repair system leaks;
- Water conservation demonstration projects;

- Construction of a new wastewater treatment plant that produces A+ (highest quality) effluent.

Table 4: Water Resource Management in Clarkdale 2000 - 2014

YEAR	ACTION
2000	Residents vote for Town water utility
2006	Town acquires local water company
2006	New water service rates billed on an increasing-block, tiered rate structure.
2007	Drought and Water Shortage Preparedness Plans adopted.
2008	Town adopts SB1575 – Adequate Water Supply Requirements.
2010	Town becomes a Designated Water Provider
2012	Town adopts a General Plan, instilling a culture of sustainability
2012	Water Conservation Demonstration Projects – Centennial Plaza.
2012-present	Replacement of aging infrastructure and ongoing funding for water conservation, water resource development and regional organizations.
2013	Complete meter replacement
2013	Full system leak-detection survey identified and fixed 20 leaks.

4.1.1 Land Use and Water Management Practices: Adoption of the Adequate Water Supply Rule, Designation of Adequate Water Supply, and Land Use Ordinances

In 2008, the Town of Clarkdale adopted the provision under ARS §9-463.01 that allows the Town to deny the application for a new subdivision if it cannot demonstrate a 100-year adequate water supply. An adequate water supply is defined in ARS §45-108 such that "sufficient groundwater, surface water or effluent that is of adequate quality will be continuously, legally and physically available to satisfy the water needs of the proposed use for at least one hundred years." The developer must demonstrate the financial capability to construct the water delivery, treatment and storage facilities. Adoption of this provision provides the Town with an important tool for controlling the development of new subdivisions should water supplies be viewed as insufficient. As of September 2014, this provision had not been adopted by greater Yavapai County or adjacent jurisdictions.

In 2010, the Town took another step toward managing its water supply for current and future residents by receiving a Designation of Adequate Water Supply for up to 1,666 acre-feet (AF) of water per year. Much like the adequacy provision required of new subdivisions, this Designation of Adequate Water Supply ensures that, according to ADWR, the Town of Clarkdale has access to a 100-year water supply of sufficient quality that is physically, continuously and legally available to meet the Town's estimated water demand. In order to receive this designation, the Town also had to demonstrate its financial capability to construct adequate delivery, storage and treatment works in a timely manner. To maintain this designation, the Town must submit an annual report that outlines committed demand; demand at build-out for customers with which the Town has entered into an agreement to serve water; compliance with water quality requirements; static water levels of all wells from which the Town withdrew water; and volume of water withdrawn, diverted, or received from each source for delivery to customers. Designations are generally reviewed in greater detail every 15 years (R12-15-715).

In addition to the adequacy rule and designated water provider provision, the Town has also adopted a landscape design ordinance (#270) that requires low-water-use plants from an approved plant list for commercial and multi-family developments. Single-family homes are also encouraged to utilize the low-water-use plant list, but are not required to do so. These elements linking land use to water management demonstrate Clarkdale's commitment to conjunctively managing its land and water resources. As established through the hydrologic conditions discussed in Section 1.2, the Town has, and will continue to have, an impact on its underlying aquifers and the Verde River. While these impacts may be acceptable under the adequacy rule and designated water provider provisions, they likely will not satisfy the Town's stated Water Resources Management Program mission of meeting the needs of residents, businesses and the natural environment equitably in order to be a robust and resilient community. Additional recommendations provided in Section 4.3, particularly under the theme of linking land use and water management, are designed to build upon the Town's current successes.

4.1.2 Water Rates and Water Conservation: Increasing-Block-Rate Billing, Meter Replacement, and Water Conservation Demonstration Projects

Water rates are one of the most frequently cited keys to increasing water conservation (see, for example, Cahill and Lund, 2013). When the Town acquired its utility in 2006, it implemented aggressive increasing-block-rate pricing as part of the potable water fee structure. As of October, 2014, the Clarkdale Water Utility has set pricing at a base fee of $28.30 for up to 1,000 gallons per billing period, with increasing block rates every 5,000 gallons. Because the Town has already been very progressive in its water-rate structures, the WRRC does not include increasing water rates *for conservation purposes* as part of our recommendations. It is important to note, however, that this does not mean that we believe that water rates should remain static into the future. On the contrary, periodic rate increases will be an essential tool for the Town in order to maintain and upgrade its water operation system.

An example of a critical upgrade to the system was the recent implementation of radio-read meters. These allow for increased accuracy, which is important because it can increase consumer water conservation, ensure accurate billing and enable the Town to quickly determine when water loss occurs. All water usage data in Clarkdale is reviewed twice per month to ensure accuracy of billing data sent to customers and to inform customers of possible water leaks. Radio-read meters are a progressive water management tool lauded for their water conservation potential, usefulness of real-time measurements, and the ability of utilities to adjust pricing and water management due to better understanding of use patterns (Giurco, White, and Stewart, 2010). At this time, the Town's water-rate structure for conservation purposes and its metering system are state-of-the-art for a small town.

As discussed in the section on water resource management issues (Section 3), Clarkdale's water delivery infrastructure is aging in some places. While the Town has made substantial improvements in the water delivery and management infrastructure, including replacing the

"Twin 5" and Lower Clarkdale water mains, unaccounted-for water remains relatively high. The Town is actively seeking to resolve this issue and recent water-loss data indicate that they may be close to a solution. Although significant and commendable effort has gone into resolving the unaccounted for water issues in the Town, establishing a system for monitoring and continuously addressing unaccounted-for water issues is a critical piece of the WRRC's recommendations.

4.1.3 Renewable Water Supplies: Construction of a New Wastewater Treatment Plant

In 2013, the Town upgraded its wastewater treatment plant (WWTP), improving the quality of the effluent produced from class C- (lagoon) rated effluent to the A+ rating standard. This WWTP produces an estimated 43,728,500 gallons (134 AF) of A+ effluent each year using an activated sludge with nitrification and denitrification process. Currently, the Town continues to dispose of the effluent in the same manner as prior to the upgrade—through land application for the irrigation of off-river riparian habitat along Bitter Creek. The upgrade of the WWTP is a significant accomplishment by the Town and provides Clarkdale with an important supply of higher quality water it can use to help the Town meet its WRMP vision. We recommend that Clarkdale assess its desired use of reclaimed water supplies into the future, which should include an exploration of those opportunities made available by the increased effluent classification.

4.2 Recommendations for the Town of Clarkdale's Water Resources Management Program

4.2.1 Develop a comprehensive Water Loss Control program

Clarkdale, like many small, rural communities, experiences a high water-loss rate within its municipal water system. System-wide water losses in Clarkdale spiked at over 40% and averaged 35% in 2013 (see Figure 2 in Section 1.2.1). Water loss, defined by the American Water Works Association (AWWA), is the combination of "real" and "apparent" losses. Real losses are considered physical or system losses as a result of leakage from water pipes and storage tanks throughout the system. Apparent losses are considered nonphysical or economic losses as a result of under-billing customers, under-registering meters, and theft. Lost water decreases the physical resource available for use and decreases revenue for the utility because it is not being charged to any water customer. Generally, water losses in small systems are a result of aging infrastructure and corresponding inability of the utility to keep up with needed repairs. Clarkdale has made substantial progress toward combatting these challenges since acquiring the utility in 2006, including 100% meter replacement as of 2013. However, lost and unaccounted-for water remains high and continues to be a source of revenue loss for the utility. To address this problem, the recommendation is to develop a comprehensive plan for tracking and measuring lost and unaccounted-for water, or non-revenue water, in the Clarkdale municipal system. Non-revenue water has replaced lost and unaccounted-for water as the industry standard for addressing system water losses because no matter why the system is experiencing water loss, it is also not billing for that water (American Water Works Association [AWWA], 2012).

Reason for selection

This recommendation was a common theme in the expert workshop, the project team's internal discussions throughout the project, and at the Small Town Water Forum. Clarkdale is not unique in dealing with a high rate of non-revenue water. Communities across the nation, and many in attendance at the Small Town Water Forum, are facing similar challenges and are having to decide whether a water-loss control program is worth the expense and whether the investment will be recovered in an acceptable period of time. The EPA recommends developing a water-loss control program to help identify both real and apparent water losses. Water-loss control programs are considered by the EPA to be the most inexpensive demand-management strategy, especially in the short term (EPA, 2013a).

Developing a plan for the effective tracking and measurement of non-revenue water was the third most highly ranked recommendation developed at the February expert workshop. Suggestions received at the expert workshop ranged from testing valves and specific pressure zones to developing a hydraulic model of the entire water system (an avenue which Clarkdale is actively pursuing). This report recognizes that Clarkdale has already taken several actions to identify potential system losses and address the nearly 40% water-loss rate, including a system-wide meter replacement and twice-monthly account reviews. Continued data collection and analysis will be very effective tools in determining where and when water losses occur. One potential water loss discussed by Town staff is a relic service connection to the Pine Shadows development that is no longer on the Clarkdale system, but may still have an active connection; unfortunately there is no registered meter at this location.

It is recommended that the Town develop an action plan for continuing to mitigate and reduce non-revenue water in Clarkdale. Several experts at the workshop felt that solving the lost water problem should happen before any additional steps are taken to implement a water management program. The many experts in agreement that non-revenue water must be addressed in the short term felt that additional investments to reduce demand (e.g. conservation, water harvesting) are not justified without first controlling water and revenue losses.

Clarkdale has already largely addressed apparent losses by replacing all of the water meters on the system. Opportunities remain for exploring issues of water theft due to old service connections that should have been turned off, but may still be receiving water from the Clarkdale system. AWWA suggests that calculating a water loss percentage is not an effective way to compare water loss over time because it is dependent on water demand, which fluctuates regularly. An increase in demand could lead to a decrease the water loss percentage, even if the volume of non-revenue water has remained constant. However, Figure 2 indicates that Clarkdale's actual non-revenue water may be increasing even with decreasing total water use. Using the AWWA model will provide several indicators to assess water loss throughout the utility.

The EPA recommends developing a water-loss control program as an inexpensive demand management strategy to help identify both real and apparent water losses. A water-loss control program, also known as a real-loss reduction program, utilizes three components to help communities identify water losses: Water Audit, Intervention, and Evaluation.

EPA characterizes water audits into two types: top-down and bottom-up. Top-down audits are typically less expensive to conduct because they involve reviewing paper documents and do not include fieldwork. A bottom-up audit is usually implemented after one or more top- down audits have been completed and allows utility operators to analyze specific areas of a water system. Bottom-up audits are more expensive because they involve field investigations requiring additional staff time and possibly private consultants. The EPA suggests the following steps to include in an audit:

1. Gather information,
2. Determine flows into and out of the distribution system based on estimates or metering,
3. Calculate the standard performance indicator values and assess water-loss standing by comparing these values with ranges of values from audits from other water utilities,
4. Assess where water losses appear to be occurring based on available metering and estimates,
5. Analyze data gaps (e.g., determining if more information is necessary to make comparisons and an informed decision),
6. Consider options and make economic and benefit comparisons of potential actions, and
7. Select the appropriate interventions.

"Top-down" water audits calculate the system-wide volume of real losses by subtracting the authorized consumption volume and the apparent lost volume (customer meter inaccuracies, data handling errors, and unauthorized consumption) from the system input volume, known in Clarkdale as Total Production (Water Research Foundation (WRF), 2014). The AWWA Free Water Audit Software serves as a basic tool to complete a top-down water audit, the first step in developing a water-loss control program. Figure 14 highlights the tools available from AWWA and the WRF to support development of a real-loss reduction strategy that can be used in addition to the EPA materials and that are described in greater detail in this recommendation.

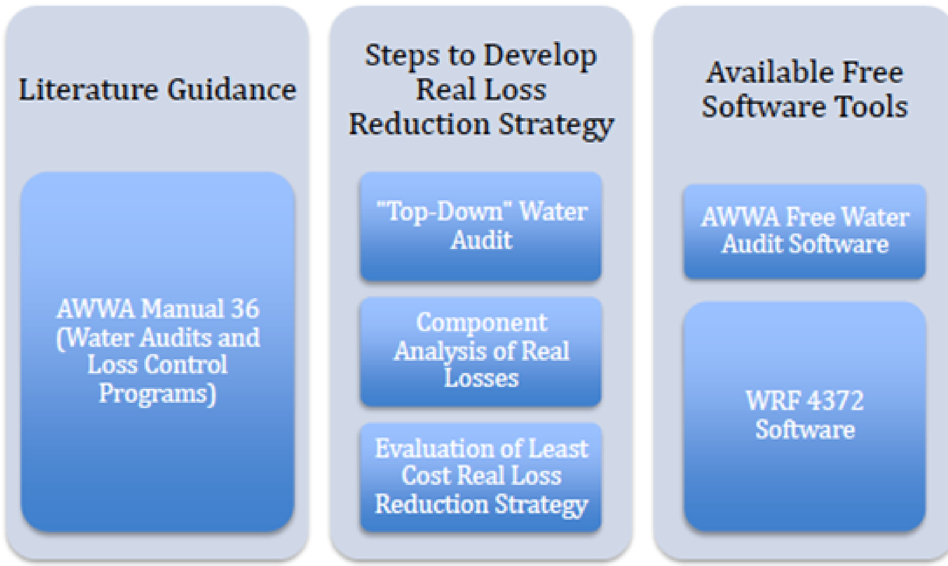


Figure 14 - Steps to Develop a Real-Loss Reduction Strategy and Available Literature and Software Tools for Each Step (WRF, 2014).

The second step of the EPA process for developing a water-loss control program is to identify actions for the Intervention that will be beneficial to the water system and the community. As suggested by the EPA, these actions can include:

1. Gather further information, if necessary,
2. Meter assessment, testing, or a meter-replacement program (Note: Clarkdale has recently completed a comprehensive residential meter replacement program),
3. Detect and locate leaks,
4. Repair or replace pipe,
5. Operation and maintenance programs changes,
6. Administrative processes or policy changes.

In the case of Clarkdale, some of these actions, like meter replacements and leak detection, have already been implemented. Additional actions for the Town to explore should be driven by water audit findings. Finally, once the Audit and Intervention are complete, an Evaluation will need to be done to establish performance indicators that can be used as future benchmarks. This evaluation should identify areas of success and provide the information necessary to create an iterative cycle for the water-loss program.

The WRF recently developed a new model known as the Component Analysis Model (WaterRF 4372) that disaggregates the total volume of real losses calculated in the "top-down" water audit into its three components: Background Leakage, Unreported Leakage, and Reported Leakage. This Excel-based model can be used by the water industry to more effectively calculate the volume of background losses, reported failures and unreported failures (organized by different components of the infrastructure). The model also provides an estimate of the hidden loss volume, which is caused by unreported failures impacting the system (WRF, 2014). Additional features of the WaterRF 4372 Model include a Failure Frequency Analysis comparison and an Economic Intervention Frequency Calculator for proactive leak detection. By combining the component analysis with an evaluation of least cost real-loss reduction strategies, it is possible to calculate the potential financial savings attributable to each leakage component and identify the right combination of intervention tools. Potential intervention tools identified by EPA and WRF are cited at the end of this section. In Clarkdale's' case, the Component Analysis Model should help identify the water leakage(s) causing overall high water-loss rates.

Once the models have been run to determine real losses and the economically feasible options for addressing these losses, physical system testing may be required to ascertain leakages. Water system tests include valve shut-offs, pressure testing, flow monitoring, acoustic detection, electromagnetic field detection, thermal detection, chemical detection and tracer gas utilization. The costs to run these different tests vary from the hundreds to thousands of dollars. Model results and seeking input from a consultant will help narrow down the list of potential tests and associated costs to run them.

Challenges

As suggested by the experts at the February workshop, solving the non-revenue water situation is a straightforward solution toward the goal of a comprehensive Water Resources Management Program in Clarkdale. Limitations in the availability of financial resources, the technical capacity of Town staff, and the availability of staff time to follow through with action items pose potential challenges in the development of a Water-Loss Control Program. Grants may be available to defray the full costs of a water audit and modeling exercise, but with a small utility staff it may be necessary to hire consultants to develop the Water Loss Control Program and conduct the needed water audits. Although having these items in place will provide directives to staff, limited staff capacity to work on additional projects may slow implementation. Addressing the water loss and non-revenue water problem will likely take three years to complete, depending on the financial resources available.

Action Plan

Clarkdale has already taken steps to address the high percentage of non-revenue water. While recent decreases in the water loss percentage reflect the fact that some leaks have been repaired, questions remain about system-wide efficiency. To further current efforts, the WRRC recommends that the Town follow the EPA three-step process to develop a water loss program:

1. Water Audit Phase:
    a. Review the EPA Control and Mitigation of Drinking Water Losses in Distribution Systems report published in 2010 and draft a Water-Loss Control Program for Clarkdale.
    b. If Clarkdale does not already own the AWWA Manual 36, purchase this manual

to help design and plan the Water Loss Control Program or consider hiring a consultant to design a loss-control program, if resources are available.
    c. Use the AWWA Free Water Audit Software to determine overall real and apparent losses.
    d. Use the WRF Component Analysis Model (WaterRF 4372) to determine the breakdown of real losses into three components.
    e. Use the WRF Component Analysis Model (WaterRF 4372) to evaluate and prioritize the least expensive options for reducing real losses.
2. Intervention Phase:
    a. Lay out a plan for implementing actions identified as cost effective in the WRF Component Analysis.
    b. Depending on results from the AWWA Water Audit and the WRF Model, it may be necessary to build a hydraulic model of the water system, as is presently under development for Clarkdale, and then combine these results with physical testing of the system.
    c. Whether or not a hydraulic model is built, physical system testing may be necessary.
3. Evaluation Phase:
    a. Develop metrics for tracking progress, including updating how community water losses are reported.
    b. Establish benchmarks and revisit the Water-Loss Control Program written for Clarkdale.

In the next year, the Town of Clarkdale could:
1. Develop a Water-Loss Control Program, based on the EPA and AWWA resources described in this recommendation, as part of the larger WRMP.
2. Conduct an AWWA Water Audit to determine real and apparent losses. To do this, Town staff will need to determine whether there is internal capacity to conduct this water audit or if financial resources are available to hire an external consultant. Given the staff's small size, we recommend hiring an expert to conduct this audit.

Resources Available
1. Real Loss Component Analysis (Water Research Foundation)
    a. http://www.waterrf.org/Pages/Projects.aspx?PID=4372
    b. The Real Loss Component Analysis is a report describing the WaterRF 4782 Model, how it can be used and its use in two different case studies.
2. Leakage Management Tools (AWWA Research Foundation)
    a. http://www.waterrf.org/PublicReportLibrary/91180.pdf
    b. This report offers a review of leak management practices, methods, tools, equipment and leak detection techniques. It also offers suggestions for developing a water-loss control or leak management program.
3. Leak Repair Data Collection Guide (Water Research Foundation)
    a. http://www.waterrf.org/resources/pages/PublicWebTools-

detail.aspx?ItemID=28

   b. The Leak Repair Data Collection Guide is an open source MS Office Excel spreadsheet designed to aid the industry in collecting consistent failure data. This tool offers guidance to water utilities in the form of a standardized format to document failure events; thereby generating the appropriate data to execute a reliable leakage component analysis. Utilities that carefully document all failure events have a means to define failure trends occurring in its system.

4. Component Analysis of Real Losses Software Model
   a. http://www.waterrf.org/resources/pages/PublicWebTools-detail.aspx?ItemID=27
   b. The Component Analysis Model (the Model) was developed to provide the water industry with a computer-based model for leakage component analysis, failure frequency analysis, economic leakage control intervention strategy evaluation, and display of key water-loss performance indicators. The Model is a complementary analysis tool to the AWWA Free Water Audit Software and was designed using a standard Microsoft Office Excel software program. The Model was developed with the needs of utility users in mind to provide a water-loss analysis software tool that is accessible, user-friendly, and has a reasonable level of complexity.

4.2.2 Public engagement on water sustainability and values

Effective and iterative engagement and education should be the cornerstones of the formation and implementation of Clarkdale's WRMP. The Town should expand upon the public engagement and outreach initiated as part of this project. The goals of this engagement should be to develop a community consensus on achievable objectives in the WRMP and determine community values regarding sustainability, water management and the Verde River. Taken together, these two elements will facilitate the implementation of the WRMP and ensure that it reflects the character of the Town. Determining citizen values for water can be undertaken as an initial step in the WRMP development. Establishing consensus around elements of the WRMP will require a significant time investment by the Town in outreach and education.

Reason for Selection

This recommendation was a common theme in the expert workshop as well as in the current project team's internal discussions. Both the WRRC and LHC have found in other water management and planning efforts that reaching out early and often to the community helps not only prevent tensions or misunderstandings, but also creates an environment where the community becomes part of the planning process, not subject to it. Citizens of Clarkdale have already demonstrated interest in learning more about its water resources and management strategies, as evidenced by more than 20 attendees at the November 2013 open house, many of whom were interested in staying engaged with the project as it moves forward. In the next phase of WRMP development, it will be important to engage with these attendees as well as expand beyond this core group of interested citizens.

Box 1 – Sample Verde River Values from West et al., 2009

- Habitat
- Personal/Emotional/Spiritual Connections
- Biodiversity
- Water for Consumption/Water Supply
- Corridors
- Access to the River
- Agriculture
- Education
- Recreation
- Tourism

At the expert workshop, it was suggested that efforts to engage with the public should give consideration to the "Information Age" and utilize easily understandable messaging that is positive and solution-oriented. When engaging with citizens it will be particularly important to address hot topics like emerging contaminants and the Town's impact to the Verde River. It was also suggested that the Town structure its education plans within manageable timeframes and with firm reference points (e.g., water levels in June). In an interview with the mayor of Cloudcroft, NM, he indicated that to community's decision in support of indirect potable reuse (IPR)/blended would not have been possible without sustained public engagement process over many years (Dave Venable, Personal Communication, June 2014). Finally it will be important for the Town to establish metrics for measuring the usefulness of its engagement and to be able to change its course based on feedback from the community.

The importance of understanding community values and developing consensus around recommendations is also frequently discussed in water management plans and academic literature that analyzes those plans. In 2009, West et al. examined public values for ecosystem services in the Verde River basin. Ecosystem services are "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Brauman, Daily, Duarte, & Mooney, 2007) or "the benefits people obtain from ecosystems" (Millenium Ecosystem Assessment, 2005). Ecosystem services are increasingly used to quantify the value of natural resources to the people who use them. The West et al. (2009) study included interviews with 35 stakeholders in the basin, which led to the creation of an extensive list of watershed-related values (See Box 1 for examples). Interview feedback indicated that a substantial number of participants valued the river, "not as a place to get things from, but as an entity that is valued for its very existence for a wide variety of reasons." In contrast to this conclusion, Von Gausig, O'Banion, & Rooney (2011), found that there is an apparent absence of a strong connections between Verde Valley residents and the river and that there is an under appreciation of the river as a source of significant and sustainable economic activity. The contrasts between these two studies highlights the need to assess values for water and the river at the local level in Clarkdale as planning for the WRMP begins.

The Town should establish a series of guiding principles that they can use to help determine future water management actions as well as to use as a bridge between values and building consensus around objectives for the WRMP. Box 2 shows guiding principles developed as part of a water management plan for Winter Haven, Florida (Singleton, 2011). Another approach

BOX 2
Sustainable Water Resource Management Plan for the City of Winter Haven, Florida

Six Guiding Principles of Sustainable Water Resource Management

1. The total rainfall in the region is that region's water budget—supplies from outside the region are considered to be "borrowed" or "leased" and cannot be counted on during drought or after the watershed is built out.

2. In the long run, it is far more efficient and effective to use the watershed's natural infrastructure to provide multiple water resource benefits than to restore lost hydrologic function using structural, man-made means.

3. Any impacts to hydrology in the watershed should be mitigated in the watershed.

4. The locations of surface water and groundwater storage areas to protect and restore water resources must be integrated into urban and community design.

5. Stormwater, wastewater, and reuse water should be viewed as valuable resources, rather than a form of waste to be disposed of, and these resources should be recycled and recharged at a rate commensurate with use.

6. Each parcel of land in the region should spatially contribute its share to the region's water budget—that is, the post development hydrologic condition should equal, or improve upon, the predevelopment hydrologic condition.

Source: Singleton, 2011

would be for the Town to adopt the five environmental goals established through "Case Studies on the New Water Paradigm" (EPRI & Tetra Tech, 2009). Under these goals, the community makes decisions that are:

1. Carbon neutral or positive
2. Hydrologically neutral or positive
3. Ecologically neutral or positive
4. Nutrient (and other reusable/recyclable waste resource materials) neutral or restorative
5. Air quality neutral or restorative.

In the Ross & Associates Environmental Consulting, Ltd. (2012) publication, Planning for Sustainability: A Handbook for Water and Wastewater Utilities, the author emphasizes the need to establish both utility and community goals, objectives and strategies at the outset of any water planning exercise. This guide, created by the U.S. EPA, grows out of extensive input and consultation from utilities, states, and other stakeholders as part of an effort to devise a handbook that promotes the use of sustainability principles in water management. The Town of Clarkdale has already made progress on establishing its utility sustainability goals and objectives as well as overarching Town sustainability goals through the adoption of the Town's comprehensive plan. An emphasis of the Ross & Associates Environmental Consulting, Ltd., 2012 document that is important for the Town moving forward is to engage with the public such that their values are understood as part of the WRMP, as well as in a way that the public can understand the costs associated with different approaches to achieving (or not achieving) sustainability.

Overall, public engagement and input into water resource management programs is common. In our review of water resource management plans focused on sustainability and the academic literature assessing those plans, we found many examples where the importance of public engagement was highlighted (see for example City of Mountain View, 2011; Colorado Springs Utilities 2008; United Nations, 2010 and Pima County and City of Tucson, 2010). Common throughout these plans and studies are the need to set clear goals, both internally and community-wide, at the onset of planning; allocating adequate time and resources to the engagement process; transparency in the planning process; and ensuring that a diversity of voices are heard in the process. The need for transparency, especially in terms of what is and is not on the table for discussion, was also echoed in the individual expert interviews the WRRC conducted. Finally, engaging with the citizens of a Town can have benefits beyond buy-in for a new water resources management program. In a case study of the Santa Clara Valley Water District in California, Reed (2012) explored how capacity-building among target populations reduced water consumption by 18.22% compared to a control group.

Challenges

Challenges to public engagement on water sustainability and values fall into two related categories: logistics and cooperation. Logistical challenges include available time, funding and expertise to engage diverse perspectives as well as the related challenge of needing to find ways to encourage cooperation among the different views and priorities. Ultimately, the success of the Town's engagement on its water resource management program will depend on the decisions made with regard to resources for the project. Even when resources are tight, limited engagement can be successful provided that goals are well developed and an effort to bring diverse perspectives to the table has been undertaken. Suggestions for overcoming these challenges are included in the action plan, but generally an effective citizen participation program includes[2]:

- Meeting legal requirements (if any)
- Clearly articulating goals and objectives
- Commanding political support
- Being an integral part of the decision-making structure
- Receiving adequate funding, staff and time
- Identifying concerned or affected publics
- Delineating clear roles and responsibilities for participants.

Action Plan

Clarkdale has already made steps towards both achieving a community consensus on achievable objectives in the WRMP and determining community values regarding sustainability, water management and the Verde River. To further current efforts we recommend that the Town:

- Form a WRMP advisory council. This council should consist of local community leaders as well as the Town staff that will be involved in creating and implementing the WRMP. The advisory council should be used as an umbrella organization of citizens for the purposes of engagement on all aspects of the WRMP, including the development of

[2] Taken from Cogan et al., chapter on citizen participation in the Practice of State and Regional Planning (1986), although it is an older resource the suggestions in it are still relevant today.

options for effluent reuse, stormwater management, and any changes to ordinances as part of the WRMP.

- Through a core team of Clarkdale employees and elected officials, examine the goals of outreach and engagement. Based on the advice of external experts, we suggest the primary goals be to develop a community consensus on achievable objectives in the WRMP and determine community values regarding sustainability, water management and the Verde River. These two ideas should be examined to determine if they are the best goals for Clarkdale's outreach and engagement, or if other ideas should be pursued. For example, it has been suggested that a focus on values for sustainability, in particular how the community values the Verde River, may not be relevant to conversations because sound water management in the Town will benefit the river regardless of citizen values.
- Determine financial and personnel resources that can be committed to engagement and outreach.
- Together with the advisory council, create an initial engagement plan. This plan should include both passive (e.g., newsletters) and active (e.g., surveys, meetings and workshops) community engagement. It will be necessary to consider the desired audience(s) within the Town and what methods and timing would be best suited to engage with those groups (e.g., daytime versus nights or weekends).
- Ensure transparency in the process through: 1) making the goals of the process clear; 2) determining and articulating the level of influence the public will have on the final outcomes; and 3) regular communication with the public on progress and how they can participate.

In the next year the Town of Clarkdale could:

1. Determine its goals for engagement and outreach and the resources available for outreach.
2. Form a WRMP advisory council so that Clarkdale has a mechanism for determining next steps on engagement.

Resources Available

1. EPRI and Tetra Tech (2009) Case Studies on the New Water Paradigm
    a. http://www.decentralizedwater.org/documents/DEC6SG06a/Case%20Studies%20on%20New%20Water%20Paradigm.pdf
    b. This report grew out of efforts by the U.S. EPA. to increase emphasis on sustainable water infrastructure at the community and watershed levels. The two areas of Northern Kentucky and Tucson/Pima County, Arizona were selected as case studies, and 35 water resource professionals were brought together to develop a broad framework based on real-world experiences. The participants set out five steps: (1) define sustainability goals, (2) draft sustainability operating principles, (3) promote integrated technological architecture, (4) develop institutional capacity, and (5) encourage a culture of adaptive management.
2. Ross & Associates Environmental Consulting, Ltd (2012) Planning for Sustainability: A

Handbook for Water and Wastewater Utilities

a. http://water.epa.gov/infrastructure/sustain/upload/EPA-s-Planning-for-Sustainability-Handbook.pdf
b. This guide from the U.S. EPA grows out of extensive input and consultation from utilities, states, and other stakeholders as part of an effort to devise a handbook that promotes the use of sustainability principles in water management. The guide walks utilities through a variety of sustainability-oriented planning processes that seek to incorporate both long-term financial accountability and community values. Case studies from water utilities around the country are offered to illustrate successful models of local engagement and careful planning.

3. From Words to Action: Stakeholder Engagement Manual Volume 1 - The Guide to Practitioners' Perspectives on Stakeholder Engagement and Volume 2 - The Practitioners' Handbook on Stakeholder Engagement
   a. http://www.accountability.org/about-us/publications/the-stakeholder-1.html
   b. Stakeholder engagement manuals designed for corporate responsibility efforts to more effectively engage stakeholders. Although their focus is toward companies' efforts to engage with stakeholders, the second volume, in particular, offers a good overview of tools and techniques for engagement.

4.2.3 Develop a Strategic Plan for the Reuse of Effluent/Reclaimed Water Recharge

Clarkdale recognizes the value of the Class A+ effluent produced by its reconstructed wastewater treatment facility that went online in April 2013. This substantial improvement over its previous Class C (lagoon) rating increases the number and types of potential applications of this valuable resource permissible under Arizona law. Clarkdale has many choices regarding how to utilize this water resource. The potential uses exceed the actual annual effluent production level of 134 acre-feet per year (AF/yr). Given common cultural apprehensions regarding the reuse of effluent, a concerted public outreach effort should be an integral part of this project as a way of giving voice to public preferences and promoting transparency. Reuse of treated effluent for open-space irrigation and/or industrial use near the current point of treatment and/or storage tank would offer numerous advantages to the Town, including: a) reducing the demand for new potable water supplies in the future, b) avoiding the costs of groundwater recharge facilities, and c) maintaining local control over Clarkdale's valued resource. Any use of effluent for new irrigation purposes would still increase Clarkdale's total consumptive demand. However, excess irrigation of turf can also result in some groundwater recharge.

While a variety of reuse options deserve consideration, groundwater recharge projects may offer an economically feasible and relatively uncontroversial method of utilizing the Town's reclaimed water resource. Groundwater recharge may serve many purposes including: a) supporting baseflows in the Verde River, b) sustaining higher water levels within the aquifer utilized by production wells, c) polishing effluent above and beyond A+ quality. This recommendation encourages Clarkdale to first identify its goals for effluent reuse or recharge and then develop a thorough understanding of local hydrologic conditions in order to determine how and where potential projects might best serve the Town's recharge goals. Regardless of which goal the Town identifies as its top priority, any recharge or reuse effort is likely to support a resilient Verde River by mitigating the impact of groundwater pumping in Clarkdale on base flows in the river.

Box 3 – Clarkdale's Recycled Water Resource at a Glance

- Rated Class A+ by the State of Arizona
- Current Annual Production: 43,728,500 gal (134 AF)
- Average Daily Treatment Volume: 130,000 gal/day
- Maximum Daily Treatment Capacity: 350,000 gal/day

Reason for Selection

Developing a strategic plan for the reuse of effluent was the most highly ranked recommendation developed at the February Expert Workshop. Those in attendance highlighted the importance of Clarkdale's Class A+ effluent. One participant commented that it is likely Clarkdale's "most valuable resource" in its current water portfolio. Others offered further encouragement that the economic value of this reclaimed water, in particular, not be overlooked. Too often, they noted, communities have made the mistake of undervaluing and underpricing their highly treated reclaimed water relative to other water supplies.

While multiple legally allowable uses are available for consideration by Clarkdale, a few options appear to be favored methods in the current stage of review. Based on initial surveys, groundwater modeling, and feedback from experts, a recharge program already has considerable early support as a preferred reuse of Clarkdale's reclaimed water. Potential recharge sites will require careful analysis of hydrologic characteristics, however, to optimize program operations. Such programs can also target near-stream recharge, such as similar efforts in Sierra Vista, or the use of injection wells or infiltration basins in an effort to stabilize and potentially increase localized groundwater levels directly. The latter option promotes more of a closed system approach that effectively allows the recycling of the water multiple times with less potential loss. However, concerns over "emerging contaminants," those either not yet identified or not yet assigned drinking water standards by the U.S. EPA, may reduce the attractiveness of this option.

Nearly any use of reclaimed water will depend heavily on carefully sited and well-maintained infrastructure to permit optimal functionality. This could range from an extensive network of secondary "purple pipes" for broad distribution of reclaimed water to residential users to injection wells for groundwater recharge. Substantial cost considerations are associated with each reuse option, and would require close review for economic benefits and burdens. More centralized or lumped redistribution systems can be weighed against distributed recharge operations. A thorough understanding of the Town's soils and infiltration potential will be critical in making informed decisions on how to design a recharge system, for example.

The current wastewater treatment facility is capable of treating substantially more wastewater than its current 134 AF/yr. Given the high value of Class A+ effluent, there is an incentive to the Town to find ways to increase the inflow to the plant for treatment. Clarkdale has already taken steps in this direction, such as through requirements for sewer hookups for new developments as well as for mandatory switches from septic systems to municipal sewer system for property owners once access to the sewer system is expanded into previously unserved areas. Since the cost of extending the sewer system in some neighborhoods exceeds the projected benefits, the sewer system will not be available for all residents in the near future. Finding the appropriate balance between the costs and benefits of sewer system expansion will remain an ongoing economic calculation for the town as the cost of such efforts fluctuates over time.

Certain reuse options can support new and existing public amenities. Use of effluent irrigation for a new municipal park near the treatment or storage facility, for example, could provide a community resource while eliminating the need for construction of new large potable water mains and additional potable water storage tanks and/or wells. A near-stream recharge project, such as the Gilbert Riparian Area, can provide multiple benefits. The recharge process itself could offer benefits to groundwater levels as well as buffer the base flows of the Verde River from the impacts of groundwater pumping. Further, wetland or riparian habitat created at the site of the recharge project could become a magnet for wildlife, serving as a community park and ecotourism attraction. If a regional groundwater management plan were ever to materialize, one participant at the Expert Workshop noted that Clarkdale may find itself eligible for credits for the Town's contribution toward stabilized groundwater levels and the support of the base flows in the Verde River. It should be noted that such an approach would likely also result in the migration of a sizeable percentage of the effluent to downstream flows and the subsequent loss of this water resource in Clarkdale. Other options, such as recharge in areas where groundwater is less likely to migrate, would create more of a closed system and keep the water available for recycling. In either case, careful tracking of the amount of effluent recharged by Clarkdale's facility would be essential.

Another participant in the Expert Workshop highlighted the possibility that some effluent reuse options may serve to replace existing groundwater uses (e.g., for irrigation). Such an approach would benefit the aquifer by leading to decreased pumping rates (as well as a decrease in associated pumping costs). A basic reduction in pumping can be a cheaper solution than the alternative of operating an injection well (with the related installation of expensive new infrastructure to transport reclaimed water to the well site). Further, recharge permits may be prohibitively expensive to obtain and maintain for a Town the size of Clarkdale.

The cost of drilling and maintaining wells is also a point worth consideration. Given current experiences of localized groundwater level declines, there may be opportunities to design recharge operations to buffer existing municipal wells from anticipated groundwater declines. The mound of recharged water could assist in maintaining the long-term productivity of these existing wells and prevent or delay the need for the drilling of new wells. Likewise, offsetting the need for potable water for irrigation with treated effluent also extends the life of existing potable water infrastructure.

Challenges

In order to implement several of the different options for the use of reclaimed water, substantial infrastructure investments will need to be made. These costs can be amortized over several years through financial instruments like long-term municipal bonds or low-interest loans from entities like the Arizona Water Infrastructure Finance Authority. The magnitude of such expenses, however, can lock the Town into that course of action for years or perhaps decades. Furthermore, changing course can be difficult because of the sunk costs and the limitations that such financing can create on the Town's long-term indebtedness and bond rating, for example. A careful assessment of the relative economic trade-offs of the different options now can reap extended benefits, as well as avoid certain foreseeable problems.

Many other cities and towns have explored the most efficient applications of their reclaimed water. The City of Mountain View, CA, has applied its effluent for indirect potable reuse (IPR) in outdoor irrigation. The city also has developed active groundwater recharge projects as a way of addressing a legacy of over pumping and continued active pumping (City of Mountain View, 2011). The city has a population of 70,000 residents and over 17,000 metered service connections, however, and it possesses a substantially larger volume of effluent than Clarkdale. Communities like Mountain View throughout the arid West have developed IPR via "purple pipes" that water public parks and recreation areas, as well as private commercial and/or or residential landscaped areas. Tucson is another example of a city with extensive reclaimed water infrastructure. In other places, such as the City of Chandler, there is concern about the use of reclaimed water via a purple pipes system because of a perceived risk of cross-contamination with potable resources (Doug Toy, Pers. Comm., Sept. 2014).

Although water-efficient, installing and maintaining a secondary delivery infrastructure is expensive, and Clarkdale's small size limits its ability take advantage of economies of scale. Attempting to deliver reclaimed water to individual residential customers for outdoor water use would very likely be too costly. Any implementation of IPR in Clarkdale would likely only be cost effective if such efforts were targeted at specific large-volume water users, such as the Phoenix Cement plant (not on Clarkdale's municipal water system) or potential high-value crop agriculturalists or community parks in low-lying areas of town. An agreement with such significant water users could result in an offset of groundwater that these companies would otherwise pump if the reclaimed water source were unavailable. A detailed cost-benefit analysis in conjunction with community outreach would be needed to determine whether the economics of such an arrangement would be preferable to municipally managed aquifer recharge projects.

The potential uses for reclaimed water continue to vary with fluctuations in public perceptions, technological improvements, and changes in regulatory conditions. Staying aware of these developments will be critical for realizing the full potential of reclaimed water. Providing regular opportunities for public engagement in the management of reclaimed water projects will remain crucial for maintaining community support. One member of the Expert Panel urged the Town to remain vigilant regarding the issue of contaminants of emerging concern (CECs) in effluent streams. With increasing general awareness regarding minute levels of residual pharmaceutical products and other unregulated chemicals and pathogens in reclaimed water, there is a strong need to promote transparency and proactive community dialogue. This is especially important when reclaimed water is applied to enhance streamflows or recharge aquifers that provide drinking water, where there can be increased public sensitivity. Governmental entities as disparate as Flagstaff, Arizona, and the Environmental Protection Division of the State of Georgia have found themselves struggling to defend their processes for addressing CECs in proposed projects regarding the reuse of reclaimed water. Clarkdale has a remarkable recent history of effective public involvement and government transparency in water planning, and a continuing commitment to this process will keep residents informed and engaged in efforts to determine how to manage CECs in the Town's reuse plans. In addition, Clarkdale's Utility Director, or his appointee, should remain informed of the proceedings of the Arizona Panel on Emerging Contaminants (APEC) (https:// azdeq.gov/environ/water/apec/ index.html).

Given the discussion at the Expert Meeting and recent developments in neighboring states, the possibility of direct potable reuse (DPR) deserves mention in this recommendation. At present, the laws of the State of Arizona do not permit such an approach, even for high-quality treated effluent. The APEC is currently reviewing this policy; however, due in part to the continuing drought as well as the recent implementation of DPR projects elsewhere (C. Rock, personal communication, 02/18/2014). Such projects are either in operation or under construction in Southwestern communities such as Cloudcroft, NM; Big Spring, TX; and Wichita Falls, TX; as well as farther abroad in large cities like Windhoek, Namibia and Singapore. In the absence of special waivers or pilot program funding, these administrative challenges and uncertainties will likely narrow the range of possible applications for pursuing feasible DPR options.

Even if reforms to the current state regulatory regime would allow DPR to be considered in Clarkdale, a major public outreach campaign would be advisable to determine the community's willingness to explore such a path. Inadequate public involvement in water supply planning has caused significant headaches and political pushback in a variety of cities and towns. Despite the concerns outlined above, DPR could offer substantial benefits to Clarkdale, including a decrease in the demand of groundwater pumping which would, in turn, reduce the Town's impact on flows in the Verde River and greatly extend the life cycle of existing infrastructure.

Continuing research to understand how current and future pumping will impact the aquifer will be important in choosing locations for possible groundwater recharge projects. Staying current on developments in recharge technology and regulations will also enable Clarkdale to learn from similar initiatives in other communities and take advantage of new avenues for the use of reclaimed water.

Action Plan

Clarkdale should continue to expand its efforts to make the highest and best use of its Class A+ effluent. This will involve further study of possible recharge sites and sustained engagement with members of the public to ensure robust support for the use of reclaimed water in the community. Realizing these objectives should involve the following actions:

- Develop a plan for public education and outreach to inform residents of the various options and prioritize community goals for use of treated effluent.
- Identify prospective geographic areas and applications for effluent reuse and/or recharge and prioritize goals for such efforts.
- Begin a detailed soils investigation and hydrologic assessment in identified target areas of Clarkdale to better understand infiltration rates, connectivity to the aquifer, and general suitability for recharge efforts.
- Invest resources into determining the comparable short- and long-term financial obligations associated with different effluent reuse options. An outside consultant may prove helpful.
- Evaluate the "decision horizon" tied to the various options and the extent to which a specific use will constrain the Town legally and financially into the future.
- Reach out to potential state/federal agencies and private foundations to investigate possible funding opportunities for pilot projects.
- Continue public outreach and communication as information becomes available; solicit feedback on favored and disfavored choices.

In the next year, the Town of Clarkdale could:

1. Develop a short-term plan for the disposal of effluent, in light of the changed circumstances regarding the renewal of the lease for continued surface spraying of effluent on the Clarkdale Metals Corporation property.
2. Conduct public information sessions to keep the citizens of Clarkdale apprised of the Town's choices with regards to the use of reclaimed water. Meetings about reclaimed water use should be approached cautiously, as bringing choices to the public about the use of this water resource too early may cause confusion and misunderstanding.

Box 4 – Examples of Existing Successful Efforts

- Rainwater harvesting and storage at the Town's Memorial Clubhouse and parking lot
- Planting of arid-adapted plants in passive rainwater harvesting basins

4.2.4 Understand and Plan for Stormwater and Rainwater Resources

Rainfall and the resulting stormwater that are generated during storm events provide an additional source of water for communities to utilize as part of their water resources portfolios, whether through direct use or recharge into the aquifer. Historically, the primary challenges to depending on rainwater and stormwater as reliable water resources have been the unpredictable timing and quantity of rainfall. However, new technologies and planning approaches have been developed to capitalize on these two "free" resources by capturing and detaining water that otherwise would have to be collected and carried away, often without beneficial use. Before Clarkdale can begin utilizing rainwater and stormwater resources, additional information will be required to make smart land-use decisions that consider how these two resources are captured, detained and, in some cases, retained. This recommendation explores the additional research questions and planning decisions that will need to be made to determine whether rainfall and stormwater capture are viable water resources for Clarkdale.

Reason for selection

The topic of improved rainwater and stormwater management was a common theme in both the Expert Workshop and the Small Town Water Forum, although there remains a high level of uncertainly about how best to proceed with improving the combined management of these water resources at the municipal scale for small towns. Most experts felt that localized rainwater harvesting is feasible, but may not lead to much additional water supply. Conversely, macro-rainwater harvesting could lead to a significant boost in Clarkdale's available water supply because of the large land area water would be collected from, yet there are serious questions about the legal aspects and feasibility of large-scale projects within the context of the Town's climate and geography.

The development of a diverse portfolio of water supplies is increasingly popular as a way to alleviate drought conditions and prepare for future changes in climate and population growth. Water managers are increasingly looking to rainwater and stormwater as potential components in these water supply portfolios. The recommendation that came out of the Expert Workshop focused on better understanding the geography, existing infrastructure, and capacity of Clarkdale to utilize these supplies, rather than assuming Clarkdale can depend on these resources. Before decisions can be made about investing in the infrastructure and storage capacity needed to utilize these resources, experts felt that the Town should conduct a data-gap analysis that includes:

- Rainfall-runoff modeling of land area and connectivity of impervious surfaces to

estimate potential appropriable[3] stormwater capture (i.e., "urban-enhanced runoff");
- Analysis of runoff paths from the Black Hills to the Verde River that pass through Clarkdale and locations of existing stormwater detention and retention;
- Analysis of rooftop and catchment areas to estimate the potential rainwater capture and urban-enhanced runoff;
- Site-specific analyses to determine suitable locations to recharge stormwater into the aquifer;
- Calculation of evapotranspiration for the Verde Valley to estimate water available for salvage (via reduced evapotranspiration loss);
- Calculation of costs to develop alternative supplies as compared to other demand management strategies and/or supply alternatives;
- Improved zoning for effective management and utilization of stormwater and rainwater.

These data gaps represent a broad view of the information missing but necessary to develop a comprehensive rainwater and stormwater management plan for Clarkdale. Studies listed under the data-gap analysis discussion above should be completed first to determine physically feasible options. On-site investigations will be more expensive and would follow at a much later stage after significant preliminary work to identify potential strategies and locations has been completed. Although not all data gaps need to be addressed concurrently, knowing the costs of different scales and zoning options would inform the Town's decision-making.

The Small Town Water Forum highlighted several communities that are exploring rainwater and stormwater harvesting options, suggesting that additional open forums will be an important strategy as towns begin to implement innovative water management solutions. For example, in Sierra Vista, a sophisticated network of near-river recharge basins has been constructed to capture stormwater and sheet flow, allowing the water to percolate into the aquifer and sustain baseflows instead of quickly flowing downstream. New development in the Sierra Vista area is required to recharge any volumes of stormwater from new impervious areas (Dooley 2014). Chino Valley is also exploring opportunities to collect stormwater that could augment aquifer injection projects to address the community's problem with sheet flooding and an undersized stormwater system. Chandler requires all new development to retain 100% of stormwater for the 100-year, 2-hour storm event (Chandler City Code – Chapter 45), thereby distributing the cost of this additional recharge effort across the private sector.

To develop recommendations and identify challenges for rainwater harvesting in particular, the WRRC also hosted a Desert Rainwater Harvesting Initiative (DWHI) Water Harvesting Assessment Toolbox exercise. The DWHI toolbox was created by the WRRC to help communities in the Southwestern U.S. identify water resource challenges, understand the role and benefits water harvesting can play in meeting these challenges, and implement locally-

[3] Stormwater is legally appropriable under certain circumstances. In general, it can be appropriated: a) before it enters a natural channel and b) up to the amount exceeding natural runoff as a result of manmade impervious surfaces ("urban-enhanced runoff").

appropriate water harvesting efforts. The Toolbox is intended for use by a wide range of water resource decision makers and community members.

The Toolbox exercise was conducted with the Town of Clarkdale on Wednesday, October 1, 2014. Attendees included several officials from Clarkdale, as well as other water managers and individuals from across the Verde Valley. The exercise was facilitated by water harvesting expert Ann Audrey, with the additional assistance of Jackie Moxley and Christopher Fullerton of the Water Resources Research Center. The group reviewed the online resources available and participated in a demonstration of these web-supported tools with the Verde Valley as an example site. The worksheets were completed to provide an understanding of the most pressing current and medium-term issues as well as develop a general estimate of available rainwater/stormwater resources. Templates of the supporting documents of the DWHI are included in this Report in Appendix A: Background Materials for the WRMP.

Challenges

Arid climates present unique challenges in planning for, and dealing with, rainfall and subsequent stormwater because total rainfall is low, but extreme events are not uncommon. This water source cannot be predictably relied upon, and yet extreme events require engineering designs to accommodate large volumes of water when necessary. Best Management Practices (BMPs) designed for arid regions also have to consider high evaporation rates, rapidly increasing impervious area that can significantly increase flow rates, outdoor uses commonly producing runoff due to soil conditions and varying levels of pollution from storm events, depending on storm frequency.

In addition to the unpredictable nature of rainfall in the Southwest, issues such as cost, legality, and public acceptance are also potential roadblocks that could slow the adoption and implementation of rainwater harvesting and stormwater systems. Under the law of prior appropriation, stormwater capture can become a source of controversy with downstream diverters possessing senior water rights. Rainwater generally does not encounter such complications if captured on a resident's premises. When done in conjunction with xeriscaping, education and outreach programs are important to help in the transition from turf grass.

Data on the cost of these practices is fairly limited, but indicate that the installation of these types of options at the level of the individual household are usually more expensive at present than continued reliance on the potable supply. One study led by the Cochise Water Project in Sierra Vista estimated the cost per acre-foot of a residential rainwater harvesting system at $1,320 (WRA, 2014). Commercial-scale rainwater harvesting systems can range from $10,000-$30,000 per AF, although the cost per AF tends to be lower than for residential systems (Sustainable Cities Institute, 2014). If the goal is to reduce potable supply use and funding is available, rainwater and stormwater may be highly effective options to augment supply. Public acceptance, as discussed further in Recommendation 4.3.6, will be critically important to the success of community-wide water harvesting program. Community members will need to understand the overall goals of the program, the role of a resident and community benefits.

Harvesting water at the community scale also requires significant engineering work to build the infrastructure for additional capture, conveyance and storage of harvested water. The cost for design phase and implementation may vary greatly depending on the level of concentration or distribution of the system (e.g., distributed versus single-point collection systems) as well as other design options.

Action Plan

As was noted by several experts during the February workshop, development of an integrated rainwater harvesting and stormwater harvesting system requires additional data to ensure sound environmental and economic decisions are made for the Town of Clarkdale.
Development of a stormwater-harvesting plan should include the following tasks:

- Review the Pima County Low Impact Development and Green Infrastructure Guidance Manual.
- Create/utilize a rainfall/runoff model that explores: how surface water moves through the watershed; connectivity of impervious surfaces and the impact on drainage time, volume, frequency and intensity; predicted recharge volumes as part of a recharge model for different levels of capture; and feasible capture and recharge sites.
- Coordination of land use planning with stormwater management opportunities. (See Section 4.3.5 below.)

Development of a rainwater-harvesting plan requires the following tasks:

- Analysis of rooftop and catchment areas to estimate potential rainwater capture volume.
- Analysis of outdoor water demand that could be met by rainwater harvesting.
- Assessment of storage capacity required to match volume and timing of harvested rainwater with outdoor water demand.

In the next year, the Town of Clarkdale could:

1. Invest staff time and resources into developing a rainwater and stormwater harvesting plan, laying out unanswered research questions and town goals.
2. Hire a consultant to develop a rainfall/runoff model to begin filling in some of the data gaps and connecting the groundwater hydrology work already done to stormwater recharge opportunities.

Resources Available

Sustainable Cities Institute, 2014. *Rainwater & Stormwater Harvesting.* (http://www.sustainablecitiesinstitute.org/topics/water-and-green-infrastructure/urban-forestry/rainwater-and-stormwater-harvesting)

American Society of Landscape Architects Green Infrastructure Online Guide (http://www.asla.org/greeninfrastructure.aspx)

Pima County Low Impact Development and Green Infrastructure Guidance Manual (http://webcms.pima.gov/cms/one.aspx?portalId=169&pageId=65263)

4.2.5 Link Land Use Planning to Water Management

Local governments have long exercised their police power to design and implement long-term community planning through land-use regulations. Clarkdale has its origins as a master-planned community as part of the mining industry, and the influences of such early planning continue to shape the Town through the present day. Clarkdale now has the capacity to manage its potable water supply and its wastewater treatment, providing greatly improved flexibility in water resource planning. The Town is now particularly well positioned to link water management with land-use objectives in ways that will generate lasting, positive impacts in achieving its water conservation objectives.

Reason for Selection

The topic of integrated water and land-use management was a common theme in both the Expert Workshop and the Small Town Water Forum, although there were differing opinions on how best to combine the management of these water resources in a municipality the size of Clarkdale. In addition, there was understandable overlap between discussions regarding rainwater and stormwater harvesting. Capturing rainwater on site was generally perceived as advisable, when possible. However, landscape-scale stormwater harvesting would be most appropriate in an integrated management approach, particularly in regard to public lands and rights of way. Information obtained from the execution of the recommendation on rainwater and stormwater harvesting should be used to inform regular revisions to land-use ordinances in Clarkdale. For example, data collected from the rainfall/runoff model can be used to guide collection of stormwater from existing impervious surfaces, as well as to guide requirements for new construction to minimize heavy runoff at these sites.

Communities across the country have been adjusting their planning processes to better integrate water resource management and land-use controls. There are significant long-term benefits to careful design and implementation of these efforts. Given some of the predicted impacts of climate change on the Southwest, such as more frequent extreme precipitation events, where roads and other public infrastructure, private property, and even lives will be endangered, such planning will have lasting positive benefits (Garfin et al., 2014). Capturing runoff, for instance, has become an important element in mitigating the potential impact of flooding from such intense storms. The use of passive water harvesting and retention basins also promotes groundwater recharge, reduces erosion and sediment transport, and may enhance minimum flows in nearby waterways. Widespread, decentralized water harvesting at the level of individual residences and businesses (particularly passive water-harvesting projects) can reduce the required capacity and operation and maintenance burden on public infrastructure. Efforts at targeting integrated planning for land use and water management overlap with other recommendations in this report, such as the management of stormwater and rainwater resources. As pointed out elsewhere, collecting more comprehensive data on the type and character of these water resources and tying this information to specific neighborhoods in Clarkdale will be vital to link water management issues effectively with land-use plans.

Public utilities have often led by example, since municipally-owned utilities can coordinate data sharing and water management activities with their colleagues in municipal government in zoning and land use planning departments. This process can be more complicated in communities where utilities are privately owned and questions about proprietary data may limit cooperation and information-sharing. Nillumbik and Manningham, in Australia, and other such exemplary municipalities are notable successes in this integrative approach (e.g., Tess, 2013; Shire of Nillumbik, 2008; Town of Manningham, 2005). Clarkdale is well positioned in this regard, given the town's operational control over both wastewater management and the potable water supply.

Challenges

In discussions with water planning experts, there was a strong emphasis on the importance of understanding the influence of seasonality and different precipitation regimes in order to appreciate how water flows across the landscape. Soil survey information can assist in planning the location of decentralized detention impoundments and infiltration ponds for recharge programs. This information can also help in encouraging existing residents to design their outdoor areas in ways that either keep water onsite (Lancaster, 2014) or divert it in ways that take advantage of existing infrastructure and topographic features.

Beneficial changes in outdoor water-use patterns have already been noted in Clarkdale. There is potential for additional savings of potable water by retooling the combination of "carrots" and "sticks" for addressing outdoor irrigation in ways that promote xeriscaping, rainwater harvesting, watering strategies, and drip irrigation. This has been emphasized as an important approach in the Phoenix area in addressing a water demands from a growing population, long-term drought, and increasing uncertainty regarding water reliability in the face of a changing regional climate (Chetri, 2011). Detailed reports from outside of Arizona offer useful guidance as well. The State of New Hampshire released a Water Conservation Plan Guidance Document for Community Water Systems, which offers several illustrative approaches to integrated planning that would be transferable to an arid environment like Clarkdale (Bennett & Herbold, 2011).

Building on Clarkdale's current efforts, options can be tailored toward existing versus new construction. Additional incentives can promote the switch to arid-adapted landscapes for existing residents. Other requirements can be set for new construction, such as the plumbing for grey-water systems (as in Tucson) and the minimal use of turf grass. Outdoor water-use restrictions (tied to potentially significant fines) have been credited with substantial reductions in per-capita water use in Australia and California (Cahill & Lund, 2013).

Overlay districts have been incorporated elsewhere in zoning plans to protect areas of historic and ecological importance, establish buffers or setbacks from waterways, and protect wellheads (Singleton, 2011). Given Clarkdale's varied topography, with rises, ridges, flood-prone washes, and the riparian areas adjacent to the Verde River itself, adjusting land-use planning to the specific landscape contours and conditions of different parts of town would offer substantial benefits to water resource management. Careful consideration of these factors could also lessen the impact of extreme precipitation events on roadways and city-owned infrastructure, as well as on private lands, and would therefore minimize any resulting damage and lessen maintenance and reconstruction costs. Another mechanism that could be used to protect sensitive lands is conservation easements. For more information on conservation easements see the resources at the end of this recommendation.

Determining the feasibility of different land-use planning strategies in light of water management goals is especially important in smaller towns like Clarkdale, where limited public funds compete for a broad variety of high-value investments. In a 'Top Ten" review of water management projects conducted by the Colorado Springs Utilities for its Water Conservation Plan 2008-2012, data- and technology-driven efforts in particular were found to contribute to better measurement outcomes and adaptive management. An ongoing commitment to collecting data as part of new land-use planning will assist the Town in determining the effectiveness of the new plans and in adapting them as new information emerges.

Another potential aspect of integrated land-use management relates to the Town's ability to control the drilling of new wells. At present, while property owners seeking to drill new wells would need to follow the notice procedure with the Arizona Department of Water Resources, there is currently no restriction at the state or local level that would directly prevent the drilling of new private wells (less than 35 gallons/minute) within the Town limits. This element is important in several respects. Clarkdale's ability to create and manage a community water budget depends in part on having reliable estimates of the amount of groundwater being pumped. While the Town can currently develop rough estimates of the amount of water being pumped from private wells, increases in the number of private unmetered wells would increase the overall uncertainty in groundwater pumping and potentially have negative impacts on the Town's wells. Given discussions regarding urban agriculture and other potentially sizeable water-using activities, the ability to act on this issue would be very important for the Town. This example highlights how Clarkdale's goals from a land-use perspective can be strongly interconnected with water management planning.

Regional cooperation in integrated land-use planning will likely be an important element in the future in protecting the resilience of the watershed. Clarkdale is not the only community along the Verde River with a legacy of groundwater over pumping, and the cumulative effects of the pumping activity are projected to have a negative impact on the flows of the river. As mentioned earlier, certain regions in the state have been designated as Active Management Areas (AMAs) under the Groundwater Management Act of 1980, and special regulations have been enacted within each AMA to guide it toward achieving an AMA-specific goal regarding the protection of groundwater resources. There is the possibility that a new AMA or a similar groundwater management entity could be created to bring about a coordinated regional approach that would offer more effective protections for the Verde and for sustainable development within the watershed as well. Such a designation would require action at the state level, however, and there is currently little evidence of regional consensus in favor of such an approach. Unless and until a regional plan emerges, Clarkdale can be an early adopter of an integrated planning process for land use and water management and lead by example.

Action Plan

Given the importance of detailed and current data (such as the rainfall/runoff modeling) in achieving greater efficacy of integrated planning efforts, land-use ordinances should be regularly revisited as other components of these Recommendations are achieved for enhanced integration of water- and land-use components.

- Review the data from the completion of the rainfall/runoff modeling from the Recommendation on rainwater/stormwater harvesting (Section 4.3.4).
- Complete a "Top Ten" Review similar to the one conducted by the Colorado Springs utility to inform land-use planning, develop improved data collection, and guide adaptive management strategies.
- Investigate opportunities to use incentives as well as restrictions on the drilling of new wells within the town limits.
- Consider implementing incentives for landowners who make substantial modifications to their properties for incorporating on-site passive or direct water harvesting to curtail runoff into public rights of way.
- Develop additional high-visibility water harvesting demonstration sites on public land, complete with signage to describe the "how-to" elements of these projects as well as explain the public benefits.
- Evaluate the current land-use plan and develop an overlay district to guide construction or other activities in sensitive water resource management areas, such as locations with ecological importance or with proximity to wellheads. (Refer to federal resources on source water protection, EPA, 2013b).

In the next year, Clarkdale could:

1. Complete a Desert Water Harvesting Initiative evaluation (see prior Recommendation) and use the results to identify neighborhood-specific water harvesting opportunities.
2. Develop a methodology for tracking localized flooding issues and, in combination with the incoming data from modeling, evaluate opportunities for retaining or redirecting such stormflows to protect residents and minimize damage to property and infrastructure.
3. Review the building code for additional opportunities to encourage water harvesting on new construction sites.

Resources Available

Cahill, R., & Lund, J. (2013). Residential Water Conservation in Australia and California. Journal

of Water Resources Planning and Management, (139), 117–119.
Closas, A., Schuring, M., & Rodriguez, D. (2012). *Integrated Urban Water Management - Lessons and Recommendations from Regional Experiences in Latin America, Central Asia, and Africa* (WPP Case Profile No. No. 1).
Colorado Springs Utilities. (2008). *Colorado Springs Water Conservation Plan 2008-2012*. Colorado Springs, CO.
Pezzetti, T. (2011). *Guidebook to Assist Urban Water Suppliers to Prepare a 2010 Urban Water Mgmt Plan.pdf*. California Department of Water Resources.
Pima County, & City of Tucson. (2010). *City / County Water & Wastewater Infrastructure, Supply and Planning Study: 2011-2015 Action Plan for Water Sustainability*. Tucson, AZ: Pima County & City of Tucson.
Riverside Public Utilities. (2011). *City of Riverside Final 2010 Urban Water Management Plan*. Riverside Public Works.
Ross & Associates Environmental Consulting, Ltd. (2012). *Planning for Sustainability: A Handbook for Water and Wastewater Utilities* (No. EPA-832-R-12-001). Washington, D.C.: Environmental Protection Agency.

4.2.6 Create a Community Water Budget

One of the keys to effective and sustainable water management is setting and managing for specific goals and targets. This can be done through the creation of a community water budget, which is an innovative approach that can take multiple forms. At its simplest it is an accounting of the inputs (water supply) and the outputs (water uses) in a community. Working as a community to understand where the water comes from and goes can help promote understanding and conservation of resources.

Reason Selected

Some communities or water management districts, such as Santa Fe or the Irvine Ranch Water District, have been pioneers in the development of community water budgets. Such water budgets can often target larger user bases as well as involve substantial expenses associated with technology and monitoring. Much of the information to create a simpler version of a community water budget is already available to the Town and would not require major upfront costs. Assembling the inputs and outputs and discussing them with the public could be a good early engagement tool. To be a robust tool for both education and reaching water management goals and targets, however, a community water budget should go beyond accounting for supply and demand. Establishing a community water budget was suggested by a number of participants during the Expert Forum and the need to educate the public on the carrying capacity of water sources and conservation was discussed at the Small Town Forum. At the Expert Forum, most of the discussions of community water budgets actually revolved around household-scale water budgets implemented across the community. This recommendation includes a discussion of community water budgets, demand-offset programs and household water budgets.

A more complex community water budget uses data on water supply and demand as part of a conversation about where and how much water should be used in a community. In this type of budget, the amount of water used by Clarkdale would be broken into different categories such as: business, industrial, parks, schools, indoor residential use and outdoor residential use. Each of these categories would be displayed and described and then serve as the foundation for a conversation about priorities for community water use. In Clarkdale, this conversation could also include an opportunity for discussing the impacts of the Town's water use on the Verde River. For example, residents could examine the benefits of using available water resources to irrigate turf and decide to limit that type of use to leave more water in the aquifer or to support additional water use by local businesses. In this context, a community water budget is a way for the citizens to come together to discuss priorities for water use and development. One framework for these discussions could be scenario planning.

In Santa Fe, New Mexico a community water budget approach was used to cap water use for new development. The Santa Fe "Development Water Budget" sets a cap on current use and guides its demand-offset program. A demand-offset program is where new water demands must be offset, either through conservation by existing users or with new water supplies. In Santa Fe, offsets range from water conservation credits to requiring new developments to secure their own water rights. In this case, water conservation credits are obtained by the new user paying for the existing user to conserve water (e.g., low-flow showerhead and toilets).

The small size of Clarkdale, its already low GPCD, and a paucity of other water rights that could be acquired, would make it difficult to implement a water budget and total demand-offset program like that of Santa Fe. A full-scale demand-offset program could, however, conceivably work at the regional scale where there would be more opportunities for conservation and the possibility that development could acquire additional water rights. To implement this type of program there would first need to be increased coordination and cooperation of regional land use and water management.

At the Clarkdale scale, the Town could also decide to essentially require the partial offset of new demands by requiring onsite stormwater recharge or implementing an impact development fee that would cover the expense of developing water resources for the new use, such as extension of reclaimed water to the site. Impact fees are common and are charges assessed by local governments against new development projects that attempt to recover the cost incurred by government in providing the public facilities required to serve the new development. Impact fees are only used to fund facilities, such as roads, schools, and parks, that are directly associated with the new development. Impact fees cannot be used to correct existing deficiencies in public facilities. The Town currently charges capacity fees for new hook-ups to sewer and water; this would be the place to start to see if additional fees could be levied to bring in renewable water supplies, namely reclaimed water or recharged stormwater, to offset the new demand. Challenges associated with a partial offset program would include concern about the Town discouraging new business or development because of the impact fees or requirements for low-water-use fixtures. Setting fee schedules for impact fees is a complex process typically involving rate studies. Furthermore, an impact fee to provide an alternative water source could be prohibitively high depending on the current infrastructure. At this time, further research is needed to determine the economic feasibility of an option like reclaimed water delivery. Such an approach may be more financially viable when directed toward public parks or as part of a long-term contract with a local industry, compared with the large infrastructure costs associated with decentralized residential deliveries, for example. A more immediate option would be to require all new business operations to have WaterSense approved fixtures and operate according to WaterSense guidelines or to require all outdoor water use be through rainwater harvesting.

Another type of water budget specifically discussed at the expert forum was the household water budget. Household water budgets allow community members to examine their current water use as compared their historic use, others in the community, and the amount of water they should be using, often based on the number of people in the household and outdoor landscaping. These household water budgets could be tied to utility billing structures or be purely informational. If tied to a billing structure, where the customers are charged more when they exceed their water budget, it would be important to have an appeals process in place so that citizens have a way to dispute budget overages or the target water use set for their household budget.

Household water budgets could also be implemented without billing fees by using available web-based tools and educational platforms such as the Conserve2Enhance Water Use Dashboard or WaterSmart software. Conserve2Enhance (C2E) is a voluntary water conservation program developed by the WRRC, and available to communities at no cost. C2E participants monitor their water savings through the online Dashboard, which enables them to clearly and visibly track their water usage, learn where they have the most potential to save water and money, and how to invest those savings in community-identified C2E environmental enhancement projects. C2E program managers have the ability to message participants, track their water savings, and easily integrate water utility data into participant accounts. WaterSmart software is fee for service system where water utilities can contract with WaterSmart to incorporate home water reports into their billing and as well as an online web portal. This system also includes monitoring features, such as a Water Efficiency Dashboard and customer messaging options.

Examples of household water budgets can be found across the southwest. For example, in Boulder, Colorado each house has an outdoor water budget of 15 gallons per square foot per irrigable outdoor area. Another example is in the newer development at Oshara Village, New Mexico where all water use is subject to a water budget. In Oshara Village, there are water budgets for each residential property type, ranging from 0.115 AFY of potable water for smaller town homes to 0.131 AFY for larger estate homes. Each household also has an outdoor water budget for reclaimed water as no potable connections exist outside the home. In this case each lot has a specific water budget based on property size and all landscapes must be approved by the “village ecologist” to ensure that they can survive on the approximately 14 inches per year of irrigation by non-potable water (Western Resource Advocates, 2009). To implement a landscape water budget, the Town would need to know the landscape area and the water requirements of the plants on the landscape. These data can be attained using GIS, tax assessor records, physical measurement, or statistical sampling.

Challenges
Challenges in implementing a community water budget into conversations about water supply and demand include obtaining sufficient resources to bring people together for the discussion and, if water management decisions will be made based on the budget, the difficulties of building a consensus on how water should be used. These challenges are the same as those for the implementation of the WRMP in general, and are discussed in more detail in recommendation 4.2.2. For example, a full-scale demand-offset program would be very difficult to implement in Clarkdale alone. Smaller scale, or partial offset, is possible especially if done through water conservation requirements for new development. Challenges to household water budgets could include insufficient data to determine a household budget (e.g., measurement of outdoor space and home square-footage) and the time needed to implement and manage a household water budget program. If implemented through a C2E program, the challenges would be identifying and bringing people to the table to initiate a program. Challenges to WaterSmart are similar; however, WaterSmart has the additional challenge of paying to implement the program.

Action Plan
Community Water Budget

- Determine the purpose for the community water budget activity. Is it to create awareness, get feedback on how the community thinks water supplies should be used, or to actually set a plan for future priorities for where water is used (e.g., encouraging new hotels but not areas of turf)?
- Regardless of the purpose, creating a community water budget should first be considered as an initial engagement exercise with the Citizen Advisory Group suggested in section 4.2.2.
    - To complete a community water budget exercise, the Town will need to have recent data on water demands and supplies. The Town may wish to wait on this exercise until they have more certainty regarding its non-revenue water.
- If the small-scale community water budget exercise is successful with the Citizen Advisory Group, it could then be scaled up to a workshop or series of workshops. These workshops could be led by each of the Citizen Advisory Group member's constituencies or as a larger meeting. Holding a series of community water budget meetings would make gathering a diverse set of perspectives easier, however, it could make it more difficult to have a "single" water budget for the Town. The approach to expanding the budget beyond the Citizen Advisory Group should be informed by what the Town intends to do with the information.

Partial Demand-Offset

- In conjunction with other management actions associated with linking land and water use, the Town should explore ordinances requiring special water conservation measures for new development.

Household Water Budgets

- To implement a residential outdoor landscape water budget, the Town will need to collect information on the size of the landscape and the water requirement of the plants on the landscape. These data can be attainted through GIS, tax assessor records, physical measurement, or statistical sampling.
- To implement a C2E program, the first step is to download the C2E toolbox and hold a scoping meeting. As of October 2014, the WRRC has resources to help the Town initiate this effort.

Additional Resources:
Overview of the Santa Fe Water Budget and Water Demand-Offset Program
http://www.santafenm.gov/development_water_budgets

Information on WaterSense for Commercial Development
http://www.epa.gov/watersense/commercial/index.html

Information on WaterSense for Homes
http://www.epa.gov/watersense/new_homes/index.html

Conserve2Enhance Water Use Dashboard
http://conserve2enhance.org

WaterSmart Software
http://www.watersmartsoftware.com

4.3 Water Management Elements Considered But Not Currently Recommended

During the course of this project, over 50 potential elements were presented for inclusion in Clarkdale's Water Resources Management Program. Many of these are already being used as water management tools in the Town and others are part of the recommendations presented here. Some potential water management solutions are not recommended at this time because of expense, feasibility, or lack of need. Table 5 provides a complete look at elements considered, states if the Town currently uses these tools, and explains why the element is or is not recommended.

Table 5: Summary of All Elements of Water Resources Management Considered for the Town of Clarkdale

Elements of Municipal Water Management	Recommended?	Implemented by Clarkdale?	Page(s) Discussed	Reason Recommended or Not Recommended at this Time	Timeframe to Revisit?
Billing and rate-setting transparency	Yes	Yes	4, 24-25	Efforts already made to make bills clearer and rate-setting process is transparent	Annually
Cloud seeding/weather modification	No	No	Table Only	At Clarkdale scale this is not economically feasible, nor is it critically necessary for supply augmentation. Seeding remains controversial and may provoke water-rights legal challenges.	10 years, to reassess if additional water supplies are needed
Conservation easements to protect sensitive lands	Yes	No	52	As part of stormwater planning and other land-use planning exercises the Town should consider this tool.	As needed
Conserve2Enhance (C2E)	Yes	No	31	Innovative tool to educate public about water supplies and their water demand. C2E program managers can use the Dashboard to message participants, track water savings, and easily integrate water utility data into participant accounts.	5 years, or sooner depending on interest from community
Consumer water audits	Yes	No	57, 59	Consumer water audits could play a role in educating customers about possible savings from water conservation (by changing devices and/or behaviors) and in setting water budgets for households. (See below.)	Ongoing implementation
Decrease water pressure	No	No	Table Only	Not recommended because lower pressure would impact fire suppression systems and would not necessarily conserve water.	Not applicable, see reason not recommended
Drought Emergency Plan	Yes	Yes	23	Clarkdale currently has a drought emergency plan that is codified in ordinance #296	As required by statute, every 5 years
Educate business, youth, council, adults, tourism, hospitality – all sectors	Yes	Yes	Table Only	Education should be an integral part of the development of the WRMP because it will help the community understand their options and the need for water management.	Annually
Grey water re-use	No	No	Table Only	Concerns expressed in expert forum, may not be cost effective, losing return flow into reclaimed system.	5 years, review as part of an evaluation of WRMP
Import water from other basins	No	No	Table Only	Generally, not currently permitted in law and not economically feasible.	10 years, to reassess if additional water supplies are needed
Landscaper trainings	No	No	66	Landscaper training at the scale of Clarkdale doesn't make sense but could be easy early regional cooperative effort	5 years, or sooner depending on regional sentiment
Leak detection and repair, management to minimize "non-revenue" water	Yes	Yes	26-32	Lost water decreases the physical resource available for use and results in lost revenue. A robust program for "non-revenue" water will ensure that Clarkdale's water utility maximizes its revenue and water resources.	Annually revisit plan, ongoing detection and repair
Lease new surface water rights or trade for effluent	No	No	Table Only	At this time any lease would also impact the river and it is likely to be expensive.	10 years, to reassess if additional water supplies are needed

Elements of Municipal Water Management	Recommended ?	Implemented by Clarkdale?	Page(s) Discussed	Reason Recommended or Not Recommended at this Time	Timeframe to Revisit?
Low Impact Development (LID) ordinances	Yes	No	42-46	LID is a stormwater and land use management strategy that strives to mimic pre-disturbance hydrologic processes by emphasizing conservation, use of on-site natural features, site planning, and distributed stormwater management practices (BMPs) that are integrated into a project design. LID BMPs emphasize pre-disturbance hydrologic process of infiltration, filtration, storage, evaporation and transpiration. Common LID BMPs include: bioretention, rain gardens, permeable pavements, minimal excavation foundations, vegetated roofs, and rainwater harvesting.	2 years, to possibly update based on new technology and innovation
Comprehensive metering & reporting of all private wells in service area (mandatory)	No	No	Table Only	At this time private wells in the service area are not enough of a water management concern to warrant attempting mandatory metering. Such a requirement, even if it were to have a legal basis, would also require significant public outreach/education about the need for this step, as well as a plan for why the Town wants to meter wells and what it intends to use the data for.	10 years, to reassess whether a comprehensive mandatory monitoring process is needed (and legally defensible)
Metering & reporting of private wells in service area (voluntary)	Yes	Partially	21	The Town has extra meters from the conversion to radio-read meters to offer to well owners interested in knowing how much water they use.	5 years, to determine effectiveness of a voluntary program
Metering, faulty meter identification and replacement	Yes	Yes	5, 20, 23-25	The Town has recently completed an upgrade of all municipal water meters. Clarkdale should continue to identify and replace faulty meters on an as-needed basis.	Ongoing implementation
Metering, meter installation at multi-family facilities	Yes	Yes	Table Only	The Town has external meters for all multi-family facilities in Town.	Complete, not applicable
Metering, radio meter installation	Yes	Yes	5, 20, 23-25	The Town has recently completed an upgrade of all municipal water meters to radio-meters.	Complete, not applicable
Modeling, surface water for stormwater resources	Yes	No	48-49	Understanding stormwater resources in Clarkdale will help the Town protect the Town against flooding and capitalize on this currently underutilized water resource.	Create modeling and plan then revisit as needed
Modeling, understanding hydrologic conditions	Yes	Yes	7-15	Through the current project the Town has begun to understand regional hydrologic conditions. Further action on this modeling should be as advised by Lacher Hydrologic Consulting (LHC) in their final project report.	Complete modeling then continue as recommended by LHC
Natural vegetation reduction (upland and riparian)	No	No	Table Only	Water supply is not in an area impacted by water demand from vegetation.	10 years, reassess if additional water supplies necessary
New sewer connections for more effluent	Partially	Partially	Table Only	Town should pursue areas already identified for new sewer connections.	Complete existing plans, review annually
New wells for additional water supply	No	No	Table Only	Current understanding of hydrology indicates new wells will not be required in the next 5 years. The Utility should develop a strategic plan for managing well production and bringing new wells online to match anticipated demand. Start identifying wells that are vulnerable and areas where new production/storage may be required in the distant future.	10 years, to reassess if additional water supplies are needed
Office of Water Conservation	Partially	No	Table Only	Not recommended at this time for the Town individually because of the resources required, could be a good regional option in the future.	5 years, or sooner depending on the interest in regional cooperation
Outdoor water restrictions	Yes	Yes	23	Currently outdoor water use restrictions are part of the drought plan. These restrictions should be reviewed along with the Drought Plan.	5 years in conjunction with Drought Plan

Elements of Municipal Water Management	Recommended?	Implemented by Clarkdale?	Page(s) Discussed	Reason Recommended or Not Recommended at this Time	Timeframe to Revisit?
Permaculture demonstration gardens	Yes	Yes	Table Only	Clarkdale currently has a permaculture garden in front of Town Hall. There does not appear to be a need for additional demonstration projects at this time.	Complete, review if additional gardens needed during review of education plans
Plumbing retrofits, incentives	No	No	Table Only	Current GPCD is low. Costs of program will likely exceed conservation benefits.	5 years, or sooner if GPCD is high
Plumbing retrofits, mandatory	No	No	Table Only	Current GPCD is low. A mandatory program would only be warranted if GPCD was very high and the Town was able to provide grants to assist low-income residents in particular with these retrofits.	10 years, only if GPCD is high
Private wells in water service area, restrict construction	No	No	Table Only	There have been instances of businesses and residences drilling their own wells in lieu of receiving water from the utility. At this time the Town does not believe that this is a significant trend. New private wells going in near Haskell Spring may impact Town's water supply. Special critical zones (where new wells are discouraged) may be needed. Unfortunately, providing potable water to these homes is problematic because some are above the elevation of existing storage tanks.	5 years, depending on impact to water resources
Project WET (Water Education for Teachers) in Classrooms	Yes	Yes	Table Only	The Town already uses Project WET in classrooms. They should continue this curriculum in the classrooms.	Ongoing implementation
Public engagement on water management	Yes	Yes	33-38	Through the current project the Town has begun to engage with the public on water management issues. The WRRC recommends Clarkdale continues this engagement as they move forward with the WRMP through at the very least creation of a water advisory committee made up of town leaders and key community interests.	Ongoing implementation
Rainwater harvesting, active & passive	Partially	Partially	44-49	The utility of rainwater harvesting as part of the WRMP is unclear. The Town should evaluate this option further and use it in the WRMP if it appears to be a cost effective way to improve water supplies or decrease water demand.	Complete evaluation and then revisit as needed
Rainwater harvesting, macro-scale	No	No	Table Only	Legality of macro-rainwater harvesting is in question. WRRC does recommend that the Town examine stormwater capture and management.	5 years, to reassess legal feasibility and need for water supply
Reclaimed water re-use, indirect potable and non-potable	Partially	No	38-44	As recommended by multiple experts, all options for reclaimed water should be considered. Indirect potable and non-potable reuse will require feasibility assessments to determine whether they are cost-effective options at this time.	10 years, to reassess if additional water supplies are needed
Reclaimed water re-use, study sites for optimal aquifer recharge	Yes	No	38-44	As recommended by multiple experts, all options for reclaimed water should be considered. Recharge to the aquifer received strong interest, if feasible. Consider the opportunity costs tied to expensive infrastructure/bond debt.	5 years, to ensure that selected options remain best use water

Elements of Municipal Water Management	Recommended?	Implemented by Clarkdale?	Page(s) Discussed	Reason Recommended or Not Recommended at this Time	Timeframe to Revisit?
Reclaimed water, build a regional municipal reclaimed water system	No	No	Table Only	Clarkdale and Cottonwood have each made recent upgrades to their WWTPs. There may not be an immediate need for a regional reclaimed water system. There could, however, be interest in/need for regional distribution of reclaimed water.	5 years, or sooner depending on interest in regional cooperation or need for additional capacity
Reclaimed water, upgrade to produce higher quality effluent	Yes	Yes	7, 20, 25	The Town completed the new WWTP in 2013.	15 years, or sooner if WWTP reaches capacity
Regional cooperation through a water advisory board or creation of local water management district	Partially	Partially	52, 65	Until 2014 the Town participated in the Yavapai County Water Advisory Council. This council no longer formally exists; however, the WRRC recommends the Town actively seek opportunities for regional cooperation. The WRRC has not prescribed in this document how to go about this cooperation because this is a decision that must be made locally.	5 years, or sooner depending on regional sentiment
Regional cooperation, joint exercise of power coalition	Partially	No	65	A JEP coalition to tackle water resource issues would be a way for multiple cities, towns or organizations in the Verde Valley to create/develop joint resources that can be applied to achieve collective goals (e.g., bolstering recharge or otherwise supporting baseflows).	5 years, or sooner depending on regional sentiment
Regional cooperation, overarching water management plan at basin scale	Partially	No	Table Only	Like the other regional cooperation options, the WRRC recommends the Town actively seek opportunities for regional cooperation, but has not prescribed how to go about this cooperation because the WRRC feels this is a decision that must be made locally.	5 years, or sooner depending on regional sentiment
Regional groundwater mitigation bank	Partially	No	Table Only	Like the other regional cooperation options, the WRRC recommends the Town actively seek opportunities for regional cooperation, but has not prescribed how to go about this cooperation because the WRRC feels this is a decision that must be made locally.	5 years
Water Demand Offset Program	Partially	No	53-54, 58	While a full water demand offset program is not feasible at this time due to limited opportunities for water conservation, due to low GPCD, and limited options for additional water supply, the Town could consider requiring conservation measures and reclaimed water infrastructure investment requirements for new development that would result in partial offsets for new demands.	5 years
Water budgets, household	Yes	No	56-57, 58-59	Innovative tool to educate public about water supplies and their water demand.	Annually, review to determine if program is helping Clarkdale meet its mission
Water Budget, community	Yes	No	52-55, 58	Establishing a community water budget was recommended by experts and could be used by the Town to set goals for the WRMP process.	5 years
Water pricing, block rate	Yes	Yes	24	The Town currently has a block rate pricing mechanism for water rates.	Annually, to ensure water rates are meeting the needs of the Town
Water pricing, seasonal	No	No	Table Only	Water use was not significantly higher in summer months.	5 years

Elements of Municipal Water Management	Recommended?	Implemented by Clarkdale?	Page(s) Discussed	Reason Recommended or Not Recommended at this Time	Timeframe to Revisit?
WaterSmart Software	Yes	No	56-57	Innovative tool to educate public about water supplies and their water demand. WaterSmart software is fee for service system where water utilities can contract with WaterSmart to incorporate home water reports into their billing to create targeted customer messaging.	5 years, or sooner depending on interest from community
Water storage, tanks and reservoirs	Yes	Yes	Table Only	The Town currently has two water storage facilities with a total capacity of 2.4 million gallons. Clarkdale may want to consider a long-term plan for adding tanks at higher elevation in order to expand service to areas not presently accessible to service area.	Annually
Water waste ordinances	Yes	Yes	Table Only	The Town currently has water wasting rules as part of its Drought Plan. Depending on drought conditions and water use Clarkdale may want to include additional water-wasting ordinances in the future.	5 years
Xeriscaping Ordinances	Yes	Partially	24	Under ordinance #270 commercial and multi-family residences are required to select plants from the native plant list. The Town should extend this requirement to new development.	5 years

5. Conclusion: Implementing the Recommendations and Regional Cooperation

Over the past 18 months, the WRRC has been impressed by the Town of Clarkdale's commitment to managing their water resources in a sustainable way. The Town has already made great strides toward sound water management, and we believe it has a tremendous capacity to continue to improve and serve as a model community. Efforts toward realizing a goal of achieving a *water resources management program that meets the needs of residents, businesses and the natural environment equitably in order to make Clarkdale a robust and resilient community* have already begun. While the order that the recommendations have been presented in this report is roughly in terms of priority, the WRRC also recognizes that the recommendations are interrelated and in some cases interdependent. We therefore suggest that these recommendations be considered as a whole, with only the first recommendation on a water- loss control program taking precedence over the others. A general idea of the flow of implementation for the recommendations is in Figure 15.

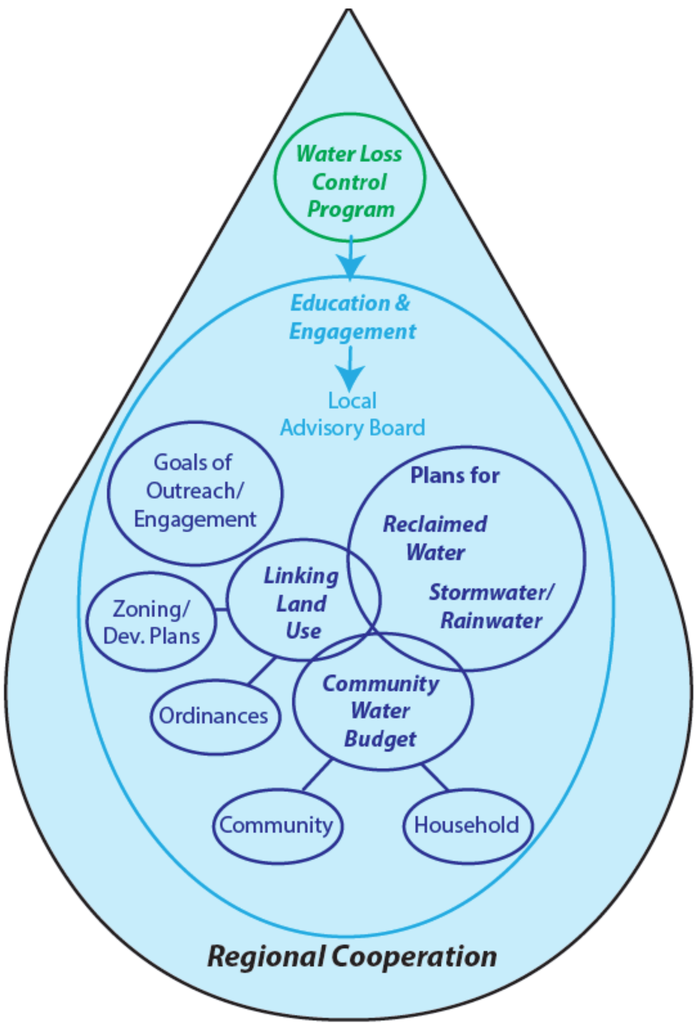


Figure 15: Implementation of Recommendations. Water drop demonstrates that all recommendations are interrelated and implementation of any one recommendation should take the others into consideration, especially when it comes to engaging with the public.

Clarkdale itself, with a population of just over 4,000 people, cannot alone shoulder the burden of improving the imbalances between water supply and demand in order to protect the region's natural environment and economy. Regional cooperation is not included in this document as a recommendation per se because the WRRC was asked to create recommendations for the *Town's* WRMP. However, in the Expert Forum, interviews, and the Small Town Forum, the need for collaboration across jurisdictions on water was one of the most common themes.

Ideas for regional cooperation are included in the summary table (Table 5) and include straightforward actions like conducting multi-jurisdictional landscaper training programs to educate local landscapers on drought tolerant plants as well as more involved actions like a water management district. Within the Small Town Water Forum, three of the top five recommendations from the exercise to determine what small towns could do to improve water management involved some form of regional cooperation. These suggestions were: regional cooperation through a water advisory board; joint-exercise-of-power coalition to tackle water issues in the Verde Valley; and an overarching management plan at a basin scale that includes information, data, conservation actions and education.

The most developed of these ideas was a joint-exercise- of-power (JEP) coalition to tackle water issues in the Verde Valley. A JEP coalition would be a way for multiple cities, towns or organizations in the Verde Valley to create/develop joint resources that can be applied to achieve collective goals (e.g., bolstering recharge or otherwise supporting baseflows). At the Forum, the group decided to focus a JEP coalition around reclaimed water and stormwater, but acknowledged it could cover other aspects of water management. The advantages of this approach would be its ability to convene otherwise disparate folks, create economies of scale, and pool resources. The disadvantages would be reduced local control, the need for consensus among groups with different goals, and concerns with equity. The people who would need to be involved at first would be those who are enthusiastic about this approach, and then the coalition could gather others based on initial successes. It would also be important to identify stakeholders who would be impacted by the coalition and keep them informed and involved.

The next steps for this idea would be to implement pilot projects, which can be good for "proof of concept" demonstrations to help others develop a more informed opinion. Interested cities and towns should also investigate where economies of scale are significant, and look for opportunities where pooling interests creates these economies of scale. Another next step would be to look at similar programs or coalitions and how they work so that the JEP coalition can borrow from their resources and experiences, as appropriate. There was also discussion that a first step could be an effort by towns and cities in the region to cooperatively change or create stormwater- or reclaimed water-use codes to provide uniformity across the Valley, which would benefit economic development. Finally, it was suggested that interested groups should not be discouraged by differing cultures within the jurisdictional boundaries because water does not care about such political lines; instead, the coalition should be based on the watershed boundary instead of jurisdictional boundaries.

The strengths for a regional approach like a JEP were also described in the Small Town Water Forum and include finding common ground, strength in numbers, reducing costs, generating new water supplies, ability to share lessons learned and seeing the big picture. Ultimately, Verde Valley residents have a tremendous challenge ahead if they are to succeed at promoting water sustainability and a healthy Verde River. The WRRC believes that while the challenges are great, so are the opportunities. We look forward to seeing the next steps the Town of Clarkdale and its neighbors take to improve water management in the Verde Valley.

References

American Water Works Association (AWWA). (2012). "Water Loss Control Terms Defined." http://www.awwa.org/Portals/0/files/resources/water%20knowledge/water%20loss%20control/water-loss-control-terms-defined-awwa.pdf Accessed June 24, 2014.

Bennett, D., & Herbold, S. (2011). *Water Conservation Plan Guidance Document for Community Water Systems*. Concord, NH: New Hampshire Department of Environmental Services Drinking Water and Groundwater Bureau.

Blasch, K.W., Hoffmann, J.P., Graser, L.F., Bryson, J.R., and Flint, A.L. (2006). Hydrogeology of the upper and middle Verde River watersheds, central Arizona: U.S. Geological Survey Scientific Investigations Report. 2005–5198,102 p., 3 plates.

Brauman, KA; Daily, GC; Duarte, TK; Mooney, HA. (2007). The nature and value of ecosystem services: An overview highlighting hydrologic services. Annual Review of Environment and Resources, Vol. 32; pp. 67-98

Cahill, R., & Lund, J. (2013). Residential Water Conservation in Australia and California. *Journal of Water Resources Planning and Management*, (139), 117–119.

Chhetri, N. B. (2011). Water-demand management: assessing impacts of climate and other changes on water usage in Central Arizona. *Journal of Water and Climate Change*, *2*(4), 288.

City of Mountain View. (2011). City of Mountain View 2010 Urban Water Mgmt Plan. City of Mountain View, CA.

Clarkdale 2012 General Plan. (2012).

Clarkdale Community Assessment. (2008).

Cogan, A., Sharp, S. and Hertzeberg, J.. (1986). "Citizen Participation." Chapter 12, The Practice of State and Regional Planning, edited by Frank S. So, Irving Hand, and Bruce D. McDowell. Chicago: APA Planners Press.

Colorado Springs Utilities. (2008). Colorado Springs Water Conservation Plan 2008-2012. Colorado Springs, CO.

Debrosky, W., (2014). Interview. Utilities Director for Town of Clarkdale.

Dooley, S. (2014). Presentation on Sierra Vista Water Management Strategies. Small Town Forum, Clarkdale, AZ.

EPRI and Tetra Tech. (2009). Sustainable Water Resources Management Volume 3: Case Studies on New Water Paradigm. Palo Alto, CA: Electric Power Research Institute.

Garfin, G., G. Franco, H. Blanco, A. Comrie, P. Gonzalez, T. Piechota, R. Smyth, and R. Waskom. (2014). Ch. 20: Southwest. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 462-486.

Garner, B.D. and Bills, D.J. (2012). Spatial and seasonal variability of base flow in the Verde Valley, central Arizona, 2007 and 2011: U.S. Geological Survey Scientific Investigations Report 2012–5192, 33 p.

Garner, B.D., Pool, D.R., Tillman, F.D., and Forbes, B.T. (2013). Human effects on the hydrologic system of the Verde Valley, central Arizona, 1910–2005 and 2005–2110, using a regional groundwater flow model: U.S. Geological Survey Scientific Investigations Report 2013–5029, 47 p.

Gautam, Acharya and Stone. (2010). *Best Management Practices for Stormwater Management in the Desert*

Southwest. Journal of Contemporary Water Research and Education, Stormwater Issue, no. 146.

Giurco, D. P., White, S. B., & Stewart, R. A. (2010). Smart Metering and Water End-Use Data: Conservation Benefits and Privacy Risks. *Water*, *2*(3), 461–467. doi:10.3390/w2030461

Lacher, L. (2014) Groundwater Modeling to Support Water Resources Planning in the Town of Clarkdale. Lacher Hydrologic Consulting.

Leake, S.A., and Pool, D.R. (2010). Simulated effects of groundwater pumping and artificial recharge on surface-water resources and riparian vegetation in the Verde Valley sub-basin, Central Arizona: U.S. Geological Survey Scientific Investigations Report 2010-5147, 18 p.

Millennium Ecosystem Assessment. (2005). Ecosystems and human well-being : synthesis. Washington, DC: Island Press.

Pima County, & City of Tucson. (2010). City / County Water & Wastewater Infrastructure, Supply and Planning Study: 2011-2015 Action Plan for Water Sustainability. Tucson, AZ: Pima County & City of Tucson.

Pool, D.R., Blasch, K.W., Callegary, J.B., Leake, S.A., and Graser, L.F. (2011). Regional groundwater-flow model of the Redwall-Muav, Coconino, and alluvial basin aquifer systems of northern and central Arizona: U.S. Geological Survey Scientific Investigations Report 2010-5180, v. 1.1, 101 p.

Reed, L. K. (2012). Capacity Building as a Policy Instrument in Water Conservation: A Case Study on Commercial, Industrial, and Institutional Consumers. Water Resources Management, 26(13), 3819–3829.

Ross & Associates Environmental Consulting, Ltd. (2012). Planning for Sustainability: A Handbook for Water and Wastewater Utilities (No. EPA-832-R-12-001). Washington, D.C.: Environmental Protection Agency.

Singleton, T. (2011). Sustainable Water Resource Management Plan for the City of Winter Haven, Florida.

Shire of Nillumbik. (2008). *Sustainable Water Management Plan*. Shire of Nillumbik, Australia.

Southwest Ground-water Consultants, Inc. (2010). Application for a Designation of Water Adequacy, Town of Clarkdale, Yavapai County, prep. for Town of Clarkdale and submitted to Arizona Dept. of Water Res., May 31, 17 pp. + figures and app.

Sustainable Cities Institute (2014). Rainwater and Stormwater Harvesting. Webpage. Accessed 10/31/2014 at: http://www.sustainablecitiesinstitute.org/topics/water-and-green-infrastructure/urban-forestry/rainwater-and-stormwater-harvesting

Tess, S. (2013). Sustainable Water Management Plan 2013-2020. City of Urbana, Illinois.

The Nature Conservancy. (2009). Verde River Watershed Conservation Plan (pp. 50–50). Tucson, AZ: The Nature Conservancy.

Thornton, J., Sturm, R., Kunkel, G., 2008. *Water Loss Control Manual (2nd Edition)*, McGraw-Hill.

Town of Manningham. (2005). *Water15 Sustainable Water Management Plan 2005 - 2015*. Manningham, Australia.

United Nations. (2010). Sustainable Water Management in Cities: Engaging Stakeholders for Effective Change and

Action. Zaragoza, Spain.

US Bureau of Reclamation, Arizona Department of Water Resources, & Yavapai County Water Advisory Council. (2011). CYHWRMS Phase II Water Resources Inventory Study Final Report. Retrieved from http://www.yavapai.us/bc-wac/files/2012/04/CYHWRMS-Phase-II-Water-Resources-Inventory-Study-Report-Final-11-15-11a.pdf

U.S. Census Bureau. (2010). American FactFinder, Community Facts. Retrieved February 8, 2014, from http://factfinder2.census.gov/faces/nav/jsf/pages/community_facts.xhtml

U.S. Environmental Protection Agency, 2010. "Control and Mitigation of Drinking Water Losses in Distribution Systems." http://water.epa.gov/type/drink/pws/smallsystems/upload/Water_Loss_Control_508_FINALDEc.pdf Accessed June 24, 2014.

U.S. Environmental Protection Agency (USEPA). (2013a). "Water Audits and Water Loss Control for Public Water Systems. http://water.epa.gov/type/drink/pws/smallsystems/upload/epa816f13002.pdf Accessed September 8, 2014.

USEPA. (2013b). Groundwater: Source Water Protection. Region 9. http://www.epa.gov/region9/water/groundwater/swp.html

Water Research Foundation, 2014. "Real Loss Component Analysis: A Tool for Economic Water Loss Control."http://www.waterrf.org/Pages/Projects.aspx?PID=4372> Accessed September 8, 2014.

Von Gausig, D., O'Banion, B., & Rooney, C. (2011a). Verde River Economic Development Study. The Verde River Economic Development Study (VREDS) Team.

Von Gausig, D., O'Banion, B., & Rooney, C. (2011b). VREDS Final Report. Verde River Economic Development Study Team. Retrieved from http://clarkdalesustainabilitypark.org/Verde%20River%20Reports%202011/VREDS%20Final%20Report-public-8-12-2011.pdf

West, P., Smith, D.H., and Auberle, W.M. (2009). Final Report for the Verde River Ecosystem Values Project. Jan. 2009. Flagstaff, AZ. http://www.emaprogram.com/emaweb/ema/site/index.asp

Western Regional Climate Center (2014) Historic climate summaries for stations at Cottonwood and Tuzigoot, updated in 2012; website accessed in Oct. 2014 (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?az8904 and http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?az2193)

Western Regional Climate Center. (2013). TUZIGOOT, ARIZONA - Climate Summary, 1977-2013. Retrieved February 19, 2014, from http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?az8904

Western Resource Advocates, 2014. *The Case for Conservation: Rainwater Harvesting, Factsheet #2.* http://www.westernresourceadvocates.org/media/pdf/CFC-Rainwater%20Harvesting.pdf

APPENDIX A: Background Materials for WRMP Recommendations

Annotated Bibliography - Reference Sources for Clarkdale WRMP Research

Bennear, L. S., Lee, J. M., & Taylor, L. O. (2013). Municipal Rebate Programs for Environmental Retrofits: An Evaluation of Additionality and Cost-Effectiveness. *Journal of Policy Analysis and Management*, *32*(2), 350–372. doi:10.1002/pam.21692

The authors partnered with a water utility in North Carolina to conduct a study of whether the rebate tied to the replacement of older toilets with high-efficiency toilets (HET) was a cost-effective incentive method of inducing consumers to participate in water conservation. The research indicated that increased water savings occurred in the over-all average of a 7% reduction in household water use; however, the results of surveys and data analysis indicated that a substantial portion of the water savings (63%) would have occurred without the rebate because households would likely have replaced the toilet without the rebate. A targeted approach, however, carefully tailored to certain segments of consumers would be most effective at encouraging HET installation by those users unlikely to replace their toilets without the incentive.

Bennett, D., & Herbold, S. (2011). *Water Conservation Plan Guidance Document for Community Water Systems*. Concord, NH: New Hampshire Department of Environmental Services Drinking Water and Groundwater Bureau.

This guide was created by state regulators in New Hampshire to offer instruction to small and large community water systems seeking to fulfill the state requirement that approval for any new water sources would require a water system to submit and receive approval for a comprehensive water conservation plan. This guide offers a detailed template on how such a plan would be structured, including components on effective water use measurements, audits, effective leak control, consumption ("demand") management, water use restrictions, and reporting requirements. The information is presented in an outline format with a methodical series of questions to address each component of the water conservation plan to ensure careful review and meaningful reporting.

Booker, J. F., Michelsen, A. M., & Ward, F. A. (2005). Economic impact of alternative policy responses to prolonged and severe drought in the Rio Grande Basin. *Water Resources Research*, *41*(2), n/a–n/a. doi:10.1029/2004WR003486

This review takes into account different local and regional actions taken to address the consequences a three-year-long drought that had resulted in substantial cutbacks on agricultural and municipal water use, threats to water supplies for the environment, and severe reservoir level impairment. The report promotes a basin-wide strategy to address future drought conditions as a way to minimize the resulting economic impact. This would require greater ease of temporary water rights transfers among water users and across jurisdictions, which is currently complicated by interstate compacts and restrictions on regional re-allocations of water.

Cahill, R., & Lund, J. (2013). Residential Water Conservation in Australia and California. *Journal of Water Resources Planning and Management*, (139), 117–119. Retrieved July 15, 2013, from http://ascelibrary.org/doi/pdf/10.1061/%28ASCE%29WR.1943-5452.0000225

Comparative reductions in per capita water use in the residential sector were analyzed for Australia and California. Similarities in population, income, and climate/precipitation allowed for a meaningful review of water conservation measures in the two target areas. Australia in particular has achieved a substantial per capita residential water use reduction, allowing for an examination of realistic efforts at conservation, as opposed to water savings based solely on projections or simulations. For the period 2000-2009, the best data available indicate that California achieved a per capita residential water reduction of approximately 10%, while in Australia, there was an approximately 35% reduction. This notable achievement was determined to be the result primarily of outdoor water use restrictions (tied to potentially substantial fines), lower-flush toilets, and water pricing adjustments.

Cai, X., McKinney, D. C., & Lasdon, L. S. (2002). A framework for sustainability analysis in water resources management and application to the Syr Darya Basin. Water Resources Research, 38(6), 21–1–21–14. doi:10.1029/2001WR000214

In many semi-arid and arid river basins, current irrigation-dependent agricultural practices have often contributed to economically inefficient and inequitable water allocation, increases in groundwater and soil salinity levels, and environmental damage. The authors propose a mathematical model for comparing different water management approaches at a multi-decadal overview in order to permit informed and efficient resource allocation. The model is demonstrated through application to the multi-national Syr Darya River Basin in Central Asia. The model seeks to account for the extended impact of intra-year, short-term decisions, and the results indicate that long-term (multiyear) sustainability criteria can be developed to guide the shorter-term actions in ways that promote a more efficient and sustainable allocation of water resources.

Chapter 4: Implementing the Sustainable Water Resource Management Plan for the Peace Creek Watershed. (2011?). Winter Haven, FL. (Appears to be part of the WRMP discussed below under *Singleton*)

The cumulative impact of land development choices since the early 1900s in the Peace Creek watershed in the Winter Haven area of Florida have resulted in several adverse consequences for the region's water supply. The community developed a Conceptual Plan to guide public and private investment in water resources to benefit water quality; water supply; the environment; flood mitigation; social, cultural, and recreational opportunities; and certain economic development options. This plan crafted six guiding principles of sustainable water resource management (p. 5) which emphasize issues like limiting dependence on outside water transfers, promoting natural instead of artificially engineered "hard" infrastructure, and recognition of the ability of every individual parcel of land to be part of the larger aggregate hydrological water budget. In addition, stormwater and wastewater are to be treated as important resources for aquifer recharge, wetland restoration, and mitigation banking efforts.

Chhetri, N. B. (2011). Water-demand management: assessing impacts of climate and other changes on water usage in Central Arizona. *Journal of Water and Climate Change, 2*(4), 288. doi:10.2166/wcc.2011.017

The author focuses on water saving opportunities in the Phoenix Active Management Area (AMA) in order to create more sustainable and resilient water management planning in the face of a continually growing human population, water stresses due to a multi-year drought, and the increasing uncertainty on water reliability due to human induced climate changes. Conserving outdoor residential/landscape water is rated as a priority. Changes in agricultural water demand management, such as through irrigation efficiency improvements, crop choices, and deficit irrigation, are also ranked highly as additional routes to increased availability of future water. The article also reviewed some impacts of urban development (such as increased water demand due to the Urban Heat Island effect) and some of the possible regional consequences of climate change (with reviews of several down-scaled Global Climate Models (GCMs)).

City of Mountain View. (2011). *City of Mountain View 2010 Urban Water Mgmt Plan*. City of Mountain View, CA.

The City of Mountain View is the urban water supplier for more than 70,000 residents with over 17,000 metered service connections, and is required by California law to revise its water management plan every five years to reflect current and future water demand and supply. No new water supply projects are under review to meet future increases in demand. New provisions address demand management measures (DMM), which are required for eligibility for certain state-authorized loans to urban water suppliers. The plan incorporates a twenty-five year horizon in its outlook. Mountain View is located in a large metropolitan region. Its water supply is highly dependent on wholesale purchases, and its wastewater disposal is also coordinated through a larger regional authority. Several programs exist or are in the works regarding conservation and DMM, such as increased use of recycled water for outdoor irrigation, plumbing retrofittings, conservation requirements on new construction, and consumer education/outreach. Active groundwater recharge initiatives are also on-going to address the historic legacy of over-pumping and subsidence, as well as recharge groundwater supplies to offset continued active pumping.

Closas, A., Schuring, M., & Rodriguez, D. (2012). *Integrated Urban Water Management - Lessons and Recommendations from Regional Experiences in Latin America, Central Asia, and Africa* (WPP Case Profile No. No. 1). Retrieved from http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2013/02/04/000425962_20130204163445/Rendered/PDF/750430WPS0Box30Africa0high00PUBLIC0.pdf

This report is a review of several Integrated Urban Water Management (IUWM) initiatives sponsored by the World Bank's Water Partnership Program in different regions throughout the world. The implementation of IUWM is being promoted as an emerging new method of managing water resources in a more holistic manner that allows for greater flexibility in the face of increasing uncertainty on water supplies due to climate change and rapid increases in urban population around the globe. IUWM seeks to connect water supply, waste management, and drainage with over-all urban planning. A strong shift toward decentralized design and infrastructure investment is a critical part of this approach, as well as a "water fit for purpose" design to reduce water treatment and transport costs. Several cases studies are briefly reviewed for lessons learned in cities of varying sizes, from Arua, Uganda (59,400 people) to Sao Paolo, Brazil (several million).

Colorado Springs Utilities. (2008). *Colorado Springs Water Conservation Plan 2008-2012*. Colorado Springs, CO.

This plan was created by a community-owned, multi-service utility that provides electricity, gas, water, and wastewater services to about 417,000 people living in its service area (2006 est.). Given anticipated future growth in water demand, the utility is in negotiations to acquire an additional 76,000 acre-feet/yr. for raw water delivery capacity. With a serious drought experience still on the forefront of many minds, demand management through conservation has become a major component of long-term planning. The report offers several "Top Ten" reviews of programs based on certain criteria, such as total water savings and cost-effectiveness. Other data- and technology-driven efforts were also leading to better measurement and loss assessment. For example, the automated meter reading program was planned to be fully operational by 2010. The plan also provides a detailed explanation of a comprehensive review and assessment of the potential benefits of a long list of conservation practices and programs.

CYHWRMS Alternatives Report 051013.pdf. (n.d.).

In recognition of increasing uncertainty about future reliability of water resources, a group of communities chose to come together and work cooperatively in reviewing their options for water planning. A result of this collaboration was the Central Yavapai Highlands Water Resources Management Study (CYHWRMS). Population centers addressed in the study are situated in the Prescott Active Management Area, the Big Chino area, and the Verde Valley area. This detailed study sought to review future water supply and demands issues by projecting current trends (2006) in water demand and population growth out to 2050. Water supply alternatives were then considered, and were evaluated based on viability and community support. A technical advisory committee, which was organized by the study partners (U.S. Bureau of Reclamation, the Yavapai County Water Advisory Committee, and the Arizona Department of Water Resources), and represented roughly seventy-five participating entities/organizations involved in the over-all stakeholder process, assisted with complex scientific questions and product information assistance.

DeOreo, W., & Mayer, P. (2012). Insights into declining single family residential water demands. *Journal - American Water Works Association, 104*. doi:10.5942/jawwa.2012.104.0080

Based on special end-use measurement techniques, the authors analyze changes in water use for indoor and outdoor purposes at the residential level for the time period 1995-2008. The use of well-designed computer software in four studies over this time period allows for the chronicling of the decline in water use and the particular influences on the declines based on the specified types of water use. This review allowed for the comparison over time of water use by indoor options, including toilet, shower, dishwasher, washing machine, leaks, and “other”. The widespread installation of water-saving devices, such as toilets, contributed a great deal to the declines. Even so, the apparent improper installation of efficient toilets, or the installation of inefficient toilets, still left water use with room for improvement in these niche areas.

Dickinson, M. A., Dyballa, C., Garrity, M., & Schempp, A. (2011). *Water Efficiency for Instream Flow: Making the Link in Practice*. Washington, D.C.: Alliance for Water Efficency.

Real-world experiences regarding the application of water efficiency programs in the Colorado River basin to supplement instream flow are the focus of this report. The authors focus their assessment on individual initiatives tied to several watersheds within the basin to demonstrate how successful partnerships can be created to permit enhanced instream flows as a result of water savings within the context of existing laws and water use patterns. In particular, there is emphasis on practical experiences arising out of these initiatives in the basin states, the legal regimes regarding water transfers, the practical challenges that currently exist in relation to the creation and maintenance of these agreements, and especially promising on-the-ground opportunities that are available in the basin states. The report looks at beneficial partnerships at the local or watershed level and highlights how different groups of stakeholders (e.g., irrigation/conservation districts, environmental nonprofits, local governments) can work together to target streams with notable needs for enhanced instream flows and realistic applicability of efficiency-oriented strategies.

EPRI, & Tetra Tech. (2009). *Sustainable Water Resources Management Volume 3: Case Studies on New Water Paradigm*. Palo Alto, CA: Electric Power Research Institute.

This report grew out of efforts by the U.S. E.P.A. to increase emphasis on sustainable water infrastructure at the community and watershed levels. The two areas of Northern Kentucky and Tucson/Pima County, Arizona, were selected as case studies, and thirty-five water resource professionals were brought together to develop a broad framework based on real-world experiences. The participants set out five steps: (1) define sustainability goals, (2) draft sustainability operating principles, (3) promote integrated technological architecture, (4) develop institutional capacity, and (5) encourage a culture of adaptive management. Elements include improved accounting to include life-cycle costs, de-centralized stormwater management, bio-mimicry, municipal code revisions, use of federal infrastructure loans or grants to jump-start projects, market-based incentives, and use of social media for marketing and outreach. A list of recommended actions for various stakeholder group is also included.

Executive Office of the President. (2013). *President’s Climate Action Plan*. Washington, D.C.: The White House.

This plan for addressing climate change at the national level through the leadership of the executive branch aims to cut carbon emissions, prepare for the unavoidable and already occurring consequences of climate change, and lead at the international level to limit contributions to further climate change and anticipate the global impacts as they unfold. Especially given the strong water-energy nexus in the U.S. West, several components have direct or indirect impacts on water resources, such as promoting renewable energy, reducing carbon emissions from power plants, providing incentives for energy efficiency, encouraging shifts in transportation and transit planning, reducing wildfire risks, ensuring drought preparedness, and addressing agricultural sustainability.

Florida Department of Environmental Protection. (2002). ***Florida Water Conservation Initiative*****.**

The State of Florida's Water Conservation Initiative (WCI), created in response to the worst recorded drought in the state's history, created a series of recommendations for improving long-term water efficiency (not just during drought periods) across several sectors. Opportunities for improvement include the areas of agriculture, landscape/outdoor use, indoor residential use, and industrial/commercial sectors. Water pricing also receives strong attention as a way of discouraging "wasteful" water use. Pricing can also encourage greater appreciation and more widespread use of reclaimed water. Because of the wide-ranging nature of these recommendations, specific Work Groups were set up with a broad array of stakeholders represented for each sector, not only to reflect the diversity of views, but also to set an example of the interest in cooperation among public, private, and nonprofit sectors in implementation of these recommendations.

Fraternali, P., Castelletti, A., Soncini-Sessa, R., Vaca Ruiz, C., & Rizzoli, A. E. (2012). Putting humans in the loop: Social computing for Water Resources Management. ***Environmental Modelling & Software*****,** ***37*****, 68–77. doi:10.1016/j.envsoft.2012.03.002**

The rise of the Web has led to a remarkable increase in opportunities for interaction and cooperation as a result of the Web itself, as well as the proliferation of Web-enabled devices, mobile or otherwise. These authors analyze the application of human and social computation reliant on the Web in order to review the new ways in which this interaction among users has already been harnessed for the cooperative solving of tasks, and to posit ways in which water resource-related problems could similarly benefit from the attention and collaborative problem-solving abilities of Human Computation (HC). Insightful charts display phases of traditional versus HC problem-solving, with the specific benefits of the HC explained in some detail.

Gabe, J., Trowsdale, S., & Vale, R. (2009). Achieving integrated urban water management: planning top-down or bottom-up? ***Water Science & Technology*****,** ***59*****(10), 1999. doi:10.2166/wst.2009.196**

The relatively new approach to handling water resources known as integrated urban water management (IUWM) has been criticized for been prone to reflecting bias and inconsistency in operational evaluation, due to a lack of shared guiding principles. This paper reviewed two urban residential projects seeking to achieve a sustainable water management approach through the framework of IUWM. Each project chose different paths in the process, one with a top-down urban planning method, while the other began with more of a grassroots, community-consultation process. Developing a consistent evaluation metric for successful IUWM has proven to be elusive, and will likely require a careful consideration of socio-cultural and economic values in addition to more engineering-oriented criteria.

Garrick, D., McCoy, A., & Aylward, B. (2011). ***Market-based Responses to Arizona's Water Sustainability Challenges: The Cornerstones Report*****. Walton Family Foundation.**

The authors assess the challenges facing water use and management in Arizona and apply a variety of market-oriented strategies to resolve current and projected future competing uses for water. The report in particular points to the existing barriers to an effective market in tradable water permits in Arizona, as well as institutional weaknesses that limit reliable and effective means for measuring and enforcing any established water rights potentially subject to a trading regime. Given pressure on water uses from agricultural use, population growth, long-term drought, and climate change, water costs projected to continue to increase substantially, and current methods of water management are limited in their adaptability to deal with the anticipated water stresses. A more developed and robust water market in Arizona is proposed in order to allow for more resilience in the face of adverse conditions, as well as to best achieve principles of water sustainability that reflect the important ecosystem services provided through environmental water uses. Specific examples of more effective policy implementation are discussed in the report, with illustrations of how efforts like mitigation banking could be used in a market-based approach to promote ecosystem health and create smoother allocation of water rights.

Garrick, D., Siebentritt, M. A., Aylward, B., Bauer, C. J., & Purkey, A. (2009). Water markets and freshwater ecosystem services: Policy reform and implementation in the Columbia and Murray-Darling Basins. *Ecological Economics*, *69*(2), 366–379. doi:10.1016/j.ecolecon.2009.08.004

The elements involved in the emergence and successful establishment of water markets as a way to promote and protect environmental uses of water are reviewed in this comparison of the development of water markets in Columbia River basin (Northwest U.S.) and the Murray-Darling River basin (SE Australia). These two regions were early adopters of a market-based approach to preserving instream flows, and the experiences of these regions are analyzed in order to understand the required conditions for the creation of these markets. The authors argue that not only are certain elements of the system deemed critical for the initial formation process (e.g., legal acknowledgment of water use for the environment, system of tradable permits/rights), but a second set of issues must also be addressed so as to facilitate the successful implementation and management of such a market-based system.

Giurco, D. P., White, S. B., & Stewart, R. A. (2010). Smart Metering and Water End-Use Data: Conservation Benefits and Privacy Risks. *Water*, *2*(3), 461–467. doi:10.3390/w2030461

This paper takes cues from the Australian experience with smart meters to determine the benefits and risks associated with technology upgrade in water use monitoring in order to promote greater conservation. Three specific issues receive particular attention: the potential for conservation-based benefits for consumers and utilities due to real-time measurements (even to down to specific end-uses), the ability of utilities to adjust pricing and water management due to better understanding of use patterns, and the concerns over privacy infringement due to the manner and accessibility of data collection. Real-world experiences also indicated that certain subgroups of consumers, such as low-income users, might be negatively affected, in comparison to current pricing and use patterns, and the authors recommend that social awareness of the unintended ripple effects of smart metering be an important part of an effort to implement such a technology.

Haney, J.A., D.S. Turner, A.E. Springer, J.C. Stromberg, L.E. Stevens, P.A. Pearthree, and V. Supplee. (Feb. 2008). Ecological Implications of Verde River Flows. A report by the Arizona Water Institute, The Nature Conservancy, and the Verde River Basin Partnership. viii + 114 pages. Learn more about us. Retrieved from http://azconservation.org/dl/tncaz_verderiver_ecological_flows.pdf

This report, co-sponsored by three entities and involving experts from fifteen agencies, universities, and other organizations, focused on describing the environmental water needs of the plant and animal communities dependent on the Verde River. The report also looked at overlapping and competing water uses between the environment and human use of Verde River water, with a view toward assessing the trade-offs resulting from alternate management plans. The current body of scientific knowledge regarding the different sections of the Verde Valley is applied to determine the consequences of further reduced flows, as well as to clarify major gaps in current scientific research, so that future studies can be targeted to resolve these weak points and reduce uncertainties. Better research and modeling will be able to assist water managers in understanding the likely consequences of different management strategies on the ecology of the Valley.

Harma, K. J., Johnson, M. S., & Cohen, S. J. (2011). Future Water Supply and Demand in the Okanagan Basin, British Columbia: A Scenario-Based Analysis of Multiple, Interacting Stressors. *Water Resources Management, 26*(3), 667–689. doi:10.1007/s11269-011-9938-3

The District of Peachland in the Okanagan Basin addressed in this article is strongly dependent on surface water for its water supply, but the combination of projected demand for water and the impact of climate change result in the real likelihood of water shortages incapable of satisfying municipal and instream flow requirements by the 2050s. The severe Mountain Pine Beetle (MPB) infestation also is anticipated to contribute notably to increasing water scarcity and uncertainty in seasonal water supply within the basin. The article offers an explanation of the careful mathematical calculations and down-scaled Global Climate Model information used to create the projected diminished water flows, with a fairly brief discussion at the end regarding the possible impacts on water management.

Ison, R.L., Collins, K.B., Bos, J.J., & Iaquinto, B. (2009). *Transitioning to Water Sensitive Cities in Australia: A summary of the key findings, issues and actions arising from five national capacity building and leadership workshops*. Monash University, Clayton: NUWGP/IWC.

This report is the culmination of five workshops involving 529 participants held in Australia in 2009. Surveys helped to gather information about the participants themselves and their opinions about various water management issues. The workshops aimed to disseminate cutting-edge developments in water management as well as engage these water practitioners in discussions regarding capacity building and transitioning toward more water-sensitive cities. A major point of emphasis centered on the importance of de-centralized systems. Green technology received kudos, but was not necessarily seen as the critical primary component. Greater focus was given to addressing process and behavior, such as institutional and social components of shifting toward more water-sensitive practices. Intergovernmental cooperation and collaboration among public and private entities received especially strong importance from participants.

Jaffe, M., & Al-Jayyousi, O. (2002). Planning Models for Sustainable Water Resource Development. *Journal of Environmental Planning and Management, 45*(3), 309–322. doi:10.1080/09640560220133379

The authors categorize three types of models in addressing sustainable water management planning, with explanations of their views regarding the theoretical framework and relative benefits and shortcomings. The overriding evaluation criterion is the ability of the model to achieve a level of longer-term resource sustainability in its water management strategy. By elucidating the special strengths and weaknesses of each approach, the article aims to help water managers in determining which model would best fit the needs and conditions of their situation. Particularly in regions where water management involves a complex balancing of rights and interests among large and disparate parties, with multiple policy goals under consideration, the decision-analysis and system analysis-models posited by the authors offer a broader ability to adapt to conflicting water solutions than the economic-analysis model.

Kunz, N. C., Moran, C. J., & Kastelle, T. (2013). Implementing an integrated approach to water management by matching problem complexity with management responses: a case study of a mine site water committee. *Journal of Cleaner Production, 52*, 362–373. doi:10.1016/j.jclepro.2013.03.018

The authors argue that by designing an integrated water management approach to match the complexity of the problem, through a three-part format they offer, substantial improvement in resource management will result. They focus on mining, with the further argument that their methods should be more widely applicable in other industrial sectors, as well as in water management regimes generally. Their review of the literature suggests that a problem's level of complexity should be ascertained, and the type of strategic or tactical response and necessary limits/boundaries be set forth early in the process. Then they look to the mining industry in Australia as a place to apply this framework, with a particular mine singled out as a case study. They acknowledge that their example is simpler than other water management scenarios, but they offer it as an illustration of a framework capable of being adapted to handle greater complexity.

Lee, M., Tansel, B., & Balbin, M. (2013). Urban Sustainability Incentives for Residential Water Conservation: Adoption of Multiple High Efficiency Appliances. *Water Resources Management*, *27*(7), 2531–2540. doi:10.1007/s11269-013-0301-8

This study focused on water savings resulting from incentive programs targeting senior citizens and low income residents of Miami-Dade County, Florida. Included in the sample population were high-volume, average-volume, and low-volume water users in single-family homes, and the impact of incentives was explored in each group. The incentives included a variety of options, including exchange programs (e.g., for shower heads) and rebate programs (e.g., for high-efficiency toilets or clothes washers). The level of participation was also tracked, from households choosing to install only one water-efficient device to households installing multiple devices. As expected, the households with the most water-efficient devices conserved the most water, compared to their initial baseline consumption level, and therefore experienced the most savings in terms of decreases in their water bill. The report suggests that effective targeting of incentive programs can help a water utility to achieve the most cost effective results in promoting water conservation for demand management purposes.

Leidner, A. J., Rister, M. E., Lacewell, R. D., & Sturdivant, A. W. (2011). The Water Market for the Middle and Lower Portions of the Texas Rio Grande Basin1. *JAWRA Journal of the American Water Resources Association*, *47*(3), 597–610. doi:10.1111/j.1752-1688.2011.00527.x

A review of the operations of the water market along designated section of the Rio Grande in Texas offers some perspective into the ongoing management and governance issues facing market-oriented water transfers in this particular water-stressed region, with potential lessons applicable in similarly-situated efforts elsewhere. A particular focus on the Falcon-Amistad region offers insight into a region where the authors argue there have been relatively effective techniques for enforcement and monitoring of water rights and water use. In particular, the Watermaster has fairly strong oversight and enforcement power. The water market in the lower and middle portions of the Rio Grande has existed in some form since the early 1970s, and the increasing cost of water has led to shifts in water to uses with higher economic value. Future complications due to groundwater over pumping in the region may affect the interconnectivity of the Rio Grande with the aquifer and the economics of the surface water rights regime. The Texas Water Trust is able to accept donations of water rights specifically designated for instream flows. Instream flows have been insufficient in the past, however. In 2001, for instance, the river failed to reach the Gulf of Mexico and a sandbar developed that blocked the mouth of the river channel. In the intervening years, an agreement has been reached between the Watermaster's office and the Department of Homeland Security to ensure minimum flows, although the source of the water or the enforceability of the agreement is not discussed in the article.

Limbrunner, J., Sheer, D., Heberger, M., Cohen, M., Henderson, J., & Raucher, B. (24 June 2011). *Policy Options for Water Management in the Verde Valley, Arizona*. Flagstaff, AZ: The Nature Conservancy.

Given increasing water stresses on the Verde River watershed, both on surface water and groundwater resources, The Nature Conservancy sponsored studies regarding three related initiatives in the basin to understand alternate futures for the basin and to increase the available scientific information available to decision-makers regarding choices that affect current and future water uses. A planning level water management model was developed to estimate possible impacts on surface flows of the Verde given certain levels of sustained groundwater extraction through 2050. Reductions in surface flow resulted from the modeling, with the percentage varying based on the amount of groundwater pumping during the time period. The second initiative involved a review of the important impact of water resources on the economic activity in the Verde valley, with special emphasis given to the multi-million dollar, water-based tourism economy. Finally, case studies from other basins are reviewed for insight and potentially applicable tools. The report concludes that environmental water needs can be protected as an integral part of the regional economy, and over a dozen policy proposals are offered in the areas of water management, legal reforms, economic/market-based measures, and administrative/institutional actions to ensure long-term sustainability of the Verde.

Liner, B., & deMonsabert, S. (2011). Balancing the Triple Bottom Line in Water Supply Planning for Utilities. *Journal of Water Resources Planning and Management, 137*(4), 335–342. doi:10.1061/(ASCE)WR.1943-5452.0000128

The authors apply the triple bottom line accounting protocol for achieving sustainability, which embraces social, economic, and environmental values, in the use of "goal programming" to promote integrated water resources planning (IWRP). Goal programming, according to the authors, is "a technique that uses optimization methods to provide a means to solve a problem by striving toward multiple objectives simultaneously." A methodology is offered that can take advantage of existing water utility datasets and spreadsheet tools to generate feasible alternate water management solutions, each of which would take into account the triple bottom line conditions mentioned above. The methodology is applied to a dataset from publicly available information from a water utility in California to illustrate its efficacy. Several alternatives can be evaluated, such as aquifer recharge, water rights transfers, recycled water, new reservoirs, new wells, and desalination.

Loucks, D. P. (2000). Sustainable Water Resources Management. *Water International, 25*(1), 3–10. doi:10.1080/02508060008686793

The author reflects on the elusive contours of the concept of "sustainable water resource systems" -- defined by ASCE and UNSECO as systems that are "designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental, and hydrological integrity." This article is set forth mostly as a reflection on the competing interests, both among contemporaneous water uses, and between current and future water uses, and the difficult balancing required to weigh the various interests by both scientifically-oriented managers and policy-oriented administrators and political operators. The author argues that more research by multiple disciplines into the impacts and adaptability and trade-offs of alternate water management strategies will provide better information for decision-makers in determining how to balance these interests in order achieve greater levels of sustainability.

Maas, C. (2009). *H20 Ontario: A Blueprint for a Comprehensive Water Conservation Strategy* (No. Version 2.0). Ontario, Canada: The Polis Project on Ecological Governance.

This report addresses the importance of water conservation, even in a region with a seeming overabundance of water resources. Part I offers background information on the increasing importance of water efficiency and the many benefits of water conservation in the context of the Province of Ontario, as well as explanations regarding the creation of the Blueprint itself. Average per capita water consumption in Ontario is remarkably high, compared with similarly situated regions in other countries, and this has resulted in serious ecological decline to several watersheds which serve as sources for the large quantities of water consumed. The cost of maintaining the expansive existing water-related infrastructure is already substantial, and conservation instead of the expansion of engineered infrastructure helps to rein in future cost increases. Part II provides a summary of the vision of water conservation, along with thorough discussions of inter-related priorities and specific actions that will be integral to realizing the vision. One major element of the Blueprint endorses a "no new water" soft-path approach where new supplies (and related infrastructure) are not up for consideration. The result will be to focus attention on demand management, leak prevention, and greater exploration of recycled water usage. Decision-making should be grounded in a strong foundation of science and well-sifted data. Government actions should support a water-oriented ethic that creates positive market-based change and leads to the creation of a culture of conservation.

Marshall, R. M., Robles, M. D., Majka, D. R., & Haney, J. A. (2010). Sustainable Water Management in the Southwestern United States: Reality or Rhetoric? *PLoS ONE*, *5*(7), e11687. doi:10.1371/journal.pone.0011687

This article looks at Arizona as a case study for the U.S. Southwest and emphasizes the importance of short-term action and planning regarding determining and protecting minimum instream flows, as opposed to mitigation efforts decades into the future, regarding the protection of environmental flows in the few perennial streams still extant in the state. Using population modeling to predict future urban growth through 2050 and extrapolating municipal water demand, the study draws attention to the streams most likely to experience dewatering through increased demand under status quo water consumption and management efforts. These streams are targeted for special attention now to mediate environmental and human water demands on these watersheds before irreparable injury occurs to the plant and animal communities along these rivers.

Maryland Department of the Environment. (2003). *Developing and Implementing a Water Conservation Plan*. Annapolis, MD.

As part of the drought-inspired Maryland Water Conservation Act of 2002 (MWCA), the state Department of Environment created and distributed a guide directed at public drinking water systems for use in improving water use efficiency through the implementation of conservation plans. The guide was written especially for water systems meeting certain thresholds (such as serving a population center of more than 10,000) and were required by the MWCA to create a conservation plan; however, the principles and illustration offered by the guide would be beneficial to exempt water systems as well. In the drafting of the Maryland document, a good deal of information was drawn from the U.S E.P.A.'s 1998 Water Conservation Plan Guidelines. Three tiers of plans are offered: basic, intermediate, and advanced. The appendices provide worksheets and reference templates to assist in the tier-specific creation of a conservation plan. Elements of the planning process emphasize certain actions, such as conducting a water audit, preparing a demand forecast, identifying and selecting from a wide variety of potential water conservation methods, and final implementation of the strategy.

Massachusetts Executive Office of Energy and Environmental Affairs. (2012, November 28). Massachusetts Sustainable Water Management Initiative Framework Summary.

The Massachusetts Sustainable Water Management Initiative (SWMI) represents a multi-agency collaborative framework at the state level for developing sustainably management of water resources in ways that take into account human and environmental water needs. The SWMI was created by the Executive Office of Energy and Environmental Affairs, in cooperation with the Department of Environmental Protection, the Department of Fish and Game, and the Department of Conservation and Recreation. Further, a broad range of stakeholders were also consulted to provide broad-based input on the development of the sustainable management goals. The new framework will also be used by the Massachusetts Department of Environmental Protection to inform the permitting of water withdrawals. A Safe Yield establishes the maximum amount of allowable water withdrawals from a basin during drought conditions. Specific analyses of groundwater will be used to create baselines against which future withdrawal requests will be measured, and seasonal surface water levels will be monitored to support the magnitude and timing of natural flows.

Mathews, R. (2005). A Six-Step Framework for Ecologically Sustainable Water Management. *Journal of Contemporary Water Research & Education*, *131*(1), 60–65.

As the title of the article implies, the author puts forth a six-step, broad-based framework for use in developing plans for calculating and ensuring environmental water flows in river systems. Each step serves to outline a general objective, and a brief explanation is provided. The author then offers an example of real-world implementation of each step, drawn from efforts involving The Nature Conservancy. The cases reach across the United States, from the Southeast to the Pacific Northwest to the semi-arid Southwest. Ecologically Sustainable Water Management (ESWM) involves scientific calculation and modeling of flow regimes necessary for the environment and then working collaboratively with other stakeholders within the existing allocation regimes to develop adaptive management plans through procedural reviews like watershed planning, FERC relicensing, interstate or transboundary water commissions, species recovery plans, multi-party partnerships, and dam re-operations.

New Mexico Office of the State Engineer. (2001). *A Water Conservation Guide for Public Utilities*. Santa Fe, NM: New Mexico Office of the State Engineer.

The State Engineer's office created an easy-to-read, well-outlined guide for public utilities to use in developing and promoting their own efforts at water conservation in New Mexico. An explanation of the special importance of conservation in New Mexico begins the publication (which appears to have been drafted and mostly completed before the full-onset of the prolonged and ongoing severe drought in New Mexico). The text points out that conservation is usually the least costly water supply alternative. An analysis of current conservation practices and the potential for new ones is included, then a substantial remainder of the guide focuses on implementation and follow-through. This includes public information/outreach, in-school education, the importance of good data through well-maintained metering and record-keeping, water audits and demand analysis, leak detection and repair, pressure reduction in the water system, indoor conservation measures (such as through residential audit and retrofit programs), outdoor water use and xeriscaping (including rebate programs), landscape water efficiency training for irrigation and landscape professionals, reclaimed water for irrigation, waste water ordinance modification, and advance planning for drought and other emergency conditions. There are also several case studies of conservation initiatives by NM water utilities which serve to highlight the programs mentioned above.

Olmstead, S. M., Michael Hanemann, W., & Stavins, R. N. (2007). Water demand under alternative price structures. *Journal of Environmental Economics and Management, 54*(2), 181–198. doi:10.1016/j.jeem.2007.03.002

An often-held belief among many water managers has been that the price elasticity of water demand is fairly inelastic, in that consumers did not seem to respond strongly to price signals. As a result, the water supply was instead controlled by various types of restrictions on timing and amounts of water use during different times of the year. Basic economic theory would suggest, however, that use of pricing to influence consumer behavior regarding water use would be more efficient than top-down controls on water use. The authors investigate this approach through analysis of increasing block rates (IBR), with three main points of focus. This study offers perhaps the most broad-based review of price-diverse, residential water demand data accomplished across the U.S. at the time of publication. It also compares IBR's non-linear pricing with other common non-linear pricing structures (e.g., electricity, local/wireless telephone). Finally, it examines the relationship between household price elasticity and the utility's choice of rate structure (e.g., IBR versus uniform marginal prices).

Penn State Extension. (n.d.). *Water Conservation for Communities*. College of Agricultural Sciences Agricultural Research and Cooperative Extension.

In the wake of a new State Water Plan in Pennsylvania in 2002, the state extension service developed this guide to assist communities in developing their own water conservation efforts. Explanations are given for the benefits of conservation, including energy savings, reduced sewage flow, reduced capital costs tied to infrastructure, and water demand management in crisis and non-crisis situations. Public education and outreach programs are discussed, as well as revisions to plumbing codes/ordinances and water rate/price structures. Retrofitting programs for residential customers receive a good deal of attention as well. Water loss reduction efforts target leak detection. Finally, two short case studies look at community and institutional settings for conservation programs.

Pezzetti, T. (2011). *Guidebook to Assist Urban Water Suppliers to Prepare a 2010 Urban Water Mgmt Plan.pdf*. California Department of Water Resources.

This two-part guide has been issued by the California Department of Water Resources as part of an effort aimed at helping urban water suppliers satisfy state legal requirements; however, the recommendations offered can be beneficial to water suppliers in other states and in other contexts. The first part delves into the details of compliance with the relevant CA statutory requirements. Although non-CA urban water providers are not subject to these specific legal requirements, the helpful explanations and analytical framework can be instructive nonetheless. The second part offers a broad review of various topics related to the preparation of an urban water management plan (UWMP), and many of these topics can be applied elsewhere.

Pima County, & City of Tucson. (2010). *City / County Water & Wastewater Infrastructure, Supply and Planning Study: 2011-2015 Action Plan for Water Sustainability*. Tucson, AZ: Pima County & City of Tucson.

This joint-governmental study, sponsored by two non-consolidated city/county governments, is the culmination of a multi-year initiative involving stakeholders, advisory committees, and expert opinion. This Phase 2 report builds on an earlier sustainable resources planning framework and offers goals and recommendations for a five year effort. During this time period, elements of the study will be put into effect, including Action Areas such as more integrated planning for wastewater/stormwater resources within the larger picture of water planning, more efficient use of such renewable water resources, improvement of water quality through wastewater treatment facility upgrades, improvements in demand management, increased linkage between land use planning and water resource management, and dedicated water resources to environmental needs. The plan contributes to the larger effort to bring the Tucson Active Management Area (AMA) into compliance with the “safe yield” goal of the Groundwater Management Act by the deadline of 2025.

Pizzol, M., Scotti, M., & Thomsen, M. (2013). Network Analysis as a tool for assessing environmental sustainability: Applying the ecosystem perspective to a Danish Water Management System. *Journal of Environmental Management*, *118*, 21–31. doi:10.1016/j.jenvman.2012.12.042

This article looks at comparisons between sustainable water resource strategies and updated understandings of ecosystem functions. The growing field of Network Analysis (NA) is employed to examine a Danish municipal water management system (WMS) as a case study. The pattern of interactions among water users who are part of the WMS is studied through an “ecosystem perspective” as a network. Past conditions and projected future scenarios are reviewed. In addition, the same set of quantitative indices for comparison is used for further comparison among twenty-four other human systems and twelve ecosystems. In general, human systems have a rigidity and often a linear structure that cause them to differ from ecosystems. The Danish WMS, even though quite efficient, possesses these human system characteristics that cause it to be subject to notable stressors during extreme weather events, such as heavy rains. The authors argue that addressing the vulnerabilities of the WMS would require more ecosystem-type design elements with alternative pathways that improve structural flexibility and would promote greater sustainability for the system as a whole.

Rathwell, K. J., & Peterson, G. D. (2012). Connecting Social Networks with Ecosystem Services for Watershed Governance: a Social-Ecological Network Perspective Highlights the Critical Role of Bridging Organizations. *Ecology and Society*, *17*(2). doi:10.5751/ES-04810-170224

The authors analyze the role of social networks in promoting cooperative efforts to manage water resources, with a focus on the agricultural landscape of Monteregie near Montreal, Quebec, Canada. The authors acknowledge the challenges presented by attempts at reconciling the range of perceptions regarding the importance of water quality by different stakeholders, whether residents/leaders of different municipalities in the same watershed or groups with different interests/perspectives regarding use of a water resource (e.g., farmers and tourists/recreational water users). The research suggests that bridging organizations play a very important role in fostering cooperative efforts among different municipalities or other stakeholder groups, as opposed to direct entity-to-entity collaborative ventures. Bridging organizations can play another important role where relatively isolated farming communities are located, and the types of farming in question are thought to contribute to water quality problems. The instant study, however, shows that communities more oriented toward an ecosystem service type local economy, such as a tourism-oriented town, was more likely to be interconnected with other communities by bridging organizations, while more agriculturally-based local economies had a higher likelihood of being unconnected and isolated. By strengthening communication and cooperation through social networks, more solution-oriented, problem-solving appears to be possible.

Reed, L. K. (2012). Capacity Building as A Policy Instrument in Water Conservation: A Case Study on Commercial, Industrial, and Institutional Consumers. *Water Resources Management*, *26*(13), 3819–3829. doi:10.1007/s11269-012-0105-2

This report focuses on a case study regarding demand management in the Santa Clara Valley Water District in California, which focused on promoting capacity building among the target population as a way to encourage water saving. Compared with a similarly-situated control group, the target group achieved a net saving of 18.22% in water consumption. Capacity building is differentiated from authority tools (such as mandatory restrictions on water use) or incentives (such as rebate programs) in that capacity building tools are aimed at a target population that is lacking information or infrastructure. If these elements were made available, the population would apply the sufficient motivation to bring about the desired change. In the Santa Clara case study, Commercial, Industrial, and Institutional (CII) customers were targeted and provided with the capacity building to address their water use options, and the already reported water savings resulted. In conclusion, the authors point to the possibility of a combination of two or more tools (e.g., authority tools or incentives) to achieve in greater water conservation.

Richter, B. D., Mathews, R., Harrison, D. L., & Wigington, R. (2003). Ecologically sustainable water management: managing river flows for ecological integrity. *Ecological Applications*, *13*(1), 206–224.

The authors offer an approach for ecologically sustainable water management (ESWM) grounded in analysis of case studies from around the globe (e.g., South Africa and the southeastern U.S.) to support their argument that such a successful management regime is achievable in the great majority of river basins -- if action is taken toward implementing ESWM before the rivers become far too over-appropriated and environmental uses are under-represented or neglected entirely for much longer. A six-step process sets out the framework for calculating environmental water needs through quantitative measures, accounting for current and projected human water uses through data analysis and hydrologic simulations, taking note of apparent seasonal/annual incompatibilities in water demands, collaboratively investigating potential resolutions, operating trials and pilots to test potential solutions, and finally creating an adaptive management program to implement ESWM for the long-term time frame. The two primary examples also highlight the greatly increased difficulty of including sustainable ecological values into water demands after water supplies have already been heavily appropriated or otherwise committed. This point encourages the implementation of ESWM into watershed planning before such heavy development of water resources occur, whenever possible.

Riverside Public Utilities. (2011). *City of Riverside Final 2010 Urban Water Management Plan*. Riverside Public Works.

This Urban Water Management Plan (UWMP) for the City of Riverside, required under state law in California, offers a detailed 138-page look at a variety of water conservation strategies as employed in an urban setting in a semi-arid setting, with prescriptions for careful monitoring and re-evaluation into the future. This particular plan is designed to project out to urban water demand through 2035, as well as address the issues of water supply reliability and contingency plan in the event of shortages (such as during a severe drought). The plan lays out the categories of water demand and the sources of water supply. In particular, Section 6 of the UWMP offers fairly detailed descriptions of conservation programs as applied toward demand management efforts. This section breaks down such programs by indoor/outdoor residential use, commercial/industrial/institutional (CII) use, and other outdoor/large landscape use.

Ross & Associates Environmental Consulting, Ltd. (2012). *Planning for Sustainability: A Handbook for Water and Wastewater Utilities* (No. EPA-832-R-12-001). Washington, D.C.: Environmental Protection Agency.

This guide from the U.S. EPA grows out of extensive input and consultation from utilities, states, and other stakeholders as part of an effort to devise a handbook that promotes the use of sustainability principles in water management. There are core elements that form the crux of this guide and focus on a combination of utility and particularized community-based goals that reflect an analysis of a wide range of options considered in a local context and based on full life-cycle costs with adequate long-term financing taken into account. This guide walks utilities through a variety of sustainability-oriented planning processes that seek to incorporate both long-term financial accountability and community values. Case studies from water utilities around the country are offered to illustrate successful models of local engagement and careful planning.

Sandoval-Solis, S., McKinney, D. C., Loucks, & P., D. (2011). Sustainability Index for Water Resources Planning and Management. *JOURNAL OF WATER RESOURCES PLANNING AND MANAGEMENT*.

This paper advocates in favor of a specially designed sustainability index (SI) capable of allowing for the comparison and evaluation of different water management strategies for particular water resource systems. As proposed, this SI would take into account the needs of human water users and the environment. In is meant to incorporate performance criteria as part of the index, not replace them. As such, it is designed to reflect reliability, resilience, and vulnerability in the context of its adaptive capacity. It grows out of an earlier SI offered by Loucks in 1997, with modifications to allow for more basin-specific responsiveness. This SI model is applied to water management in the transboundary Rio Grande basin to demonstrate the ability of the model to incorporate a broad range of variables, including sustainability in the context of a heavily developed water resource involving international and other multi-jurisdictional issues.

Scotti, M., Bondavalli, C., & Bodini, A. (2009). Ecological Footprint as a tool for local sustainability: The municipality of Piacenza (Italy) as a case study. *Environmental Impact Assessment Review*, *29*(1), 39–50. doi:10.1016/j.eiar.2008.07.001

The authors examine the strengths and weaknesses of the notion of an Ecological Footprint (EF), which is defined in the scientific literature as a tool that "measures the biologically productive area needed to sustain a certain human community." A challenge identified in EF calculations arises from the difficulty in establishing appropriate weights for goods/services (e.g., electricity) created outside the local territorial jurisdiction, and accounting for economic activities generally becomes problematic. The authors argue in favor of further categories in the form of a Citizen Footprint (CF), which "includes the demand for natural capital to provide goods and services to sustain people's lifestyle", and a Territorial Footprint (TF), which "identifies and calculates the impact on natural capital of local economic activities and public services". These two indices are seen as distinct and separate. The methodology behind treating each as unique may prevent aggregation of the two, but is designed to avoid the likelihood of double counting of some impacts which are part of the formula of each.

Sharpe, W. E., & Shelton, T. B. (1989). *A guide to designing a community water conservation*

program. Publication Distribution Center, Rutgers Cooperative Extension, Cook College/Rutgers University. Retrieved from http://www.energywise.utah.gov/agency/resources/communitywater.pdf

This 1989 guide offers detailed, step-by-step advice on the creation and operation of a community water conservation program. The introduction and initial chapter discuss several benefits from water conservation, and examples are offered from four different communities across the United States to illustrate real-world approaches. Conservation options covered in this guide range from local governmental code changes to demand and supply management strategies for water utilities to consumer-oriented education programs and behavior modification. Elements of specific conservation efforts discussed in this publication include youth education/outreach, door-to-door delivery and free installation of water-saving devices, various rate structure modification options available to water utilities, water loss prevention in utility delivery systems, municipal plumbing code revisions, voluntary and mandatory plumbing retrofits, a demonstration home (the former Casa del Agua co-sponsored by Tucson Water), xeriscape plantings for outdoor plantings, graywater recycling, and rainwater harvesting.

Shire of Nillumbik. (2007?). _Sustainable Water Management Plan_. Shire of Nillumbik, Australia.

Nillumbik, a shire encompassing part of the northern suburbs of Melbourne, as well as some rural agricultural land, developed a sustainable water management plan (SWMP) to promote conservation. This two-section SWMP was created primarily to assist in improving water management in order to achieve substantial decreases in local water use. Targeted reductions in reticulated [piped system] water use by the community are set at 25%. To lead by example, the Council (local government) has also created a self-imposed reduction target of 45%. Section One sets forth the vision and framework, while Section Two provides action plans for moving toward less water use, as well as better stormwater management. The action plans are categorized as either corporate-, community-, and catchment-oriented. The SWMP generally was enacted to help the Council implement its Council Plan 2007-2011 and establish principles for the protection of the local environment so as to affect Ecologically Sustainable Development (ESD). Enactment of the Action Plans are set up as either based on a specified "Council action" or a "Council-led community action". The specific enumeration of tasks under each objective heading in the Action Plans serves as a readily accessible public document and a useful template for adaptation on the part of other local governments seeking to enact their own sustainable water management initiatives.

Singleton, T. (2011). Sustainable Water Resource Management Plan for the City of Winter Haven, Florida.
(Also, for more detail, see the entry for _Chapter 4: Implementing the SWRMP in the Peace Creek Watershed_ above.)

Wide-scale modifications to the landscape and hydrology of the Winter Haven area since the early 1900s may have created short-term, localized benefits for some landowners and residents, but the broader, longer-term consequences (and related costs) became apparent in the early 2000s. The rigidity of artificially engineered stormwater systems lack the adaptability of the region's natural system to respond to major weather events, form heavy thunderstorms to hurricanes. Declines in aquifer levels and alterations of surface flows have also undermined the future reliability of local water supplies. Substantial environmental degradation cover a broad range, including reduced baseflow in the Peace River, water quality impairment in the river from heavy nutrient loads, and habitat loss for fish and wildlife. The SWRMP is intended to restore hydrologic interconnectivity by creating a sapphire necklace of wetlands, riparian buffers, canals, and open space. The SWRMP endorses the position that rainwater capture will be essential in protecting aquifer levels, and thereby supporting existing and future growth. The report then offers details on specific actions for how to incorporate land-use modifications to achieve this hydrologic interconnectivity. In a telling declaration regarding the vision of this effort, the report states that "[u]ltimately, what is good for the lakes and the environment (storage, treatment, and recharge) is good for the community and economic growth (supply and flood protection)."

Stephens, D. B., Miller, M., Moore, S. J., Umstot, T., & Salvato, D. J. (2012). Decentralized Groundwater Recharge Systems Using Roofwater and Stormwater Runoff. *JAWRA Journal of the American Water Resources Association, 48*(1), 134–144.

Given that groundwater over pumping and aquifer depletion have been common occurrences throughout the country, efforts to capture stormwater for use in groundwater recharge have been gaining speed in recent years. Most such initiatives are conducted in relatively large-scale projects with regional scope and substantial capital outlays for water transportation and infiltration (e.g., land purchases and construction of spreading basins). This report promotes the use of decentralized water capture and infiltration at the level of the household, subdivision, or commercial development, for instance, with the application of relatively low-cost, low –impact development (LID) techniques to guide such efforts. Field studies in New Mexico suggest that upwards of 50% of rainfall may be successfully applied to groundwater recharge, without enormous public expenditures by wastewater authorities.

Survis, F. D., & Root, T. L. (2012). Evaluating the effectiveness of water restrictions: A case study from Southeast Florida. *Journal of Environmental Management*, *112*, 377–383. doi:10.1016/j.jenvman.2012.08.010

A common strategy among water managers for reducing water use levels, particularly during periods of notable water stress such as drought conditions, is to implement day-of-the-week water restrictions for outdoor water use. The authors examine the benefits and shortcomings of this approach in terms of effectiveness. Since dual metered residential use regarding indoor/outdoor water consumption is rare, and many households may have alternate, "self-supply" water sources (e.g., surface water access, private wells), direct measurement of shifts in water consumption regarding outdoor water restrictions can be difficult. Effective enforcement is often used as a proxy. The authors look specifically at a community in southeast Florida where residents used a mixture of water sources for lawn watering. In this case study, the authors fed data collected from first-hand observations into the creation of a conservation effectiveness ratio (CER). They determined that, even with regular enforcement and less than maximum lawn watering, the amount of irrigation used still led to overwatering, despite the restrictions. This study sets out to make quantitative estimates of water use, and the article's conclusion highlights some of the drawbacks of blanket water restrictions from the point-of-view of efficient water management during periods of water stress.

Tess, S. (2012). Sustainable Water Management Plan 2013-2020 City of Urbana, Illinois.

The City of Urbana developed a sustainable water management plan (SWMP) through 2020 within an internal structure comprised of five aspects, eight goals, and twenty-six actions. Concerns regarding the future reliability of the city's potable water source, the uncertain impact of climate change, additional requirements tied to revised stormwater management rules, and the economic benefits from a restored riverfront all contributed to the creation of this SWMP. The city raised its level of commitment to reducing water consumption levels in public facilities, as well as increased its efforts toward protecting the aquifer providing municipal drinking water. While some discussion involved potential future water use requirement for as-yet-unbuilt subdivisions with the city limits, or voluntary programs for water conservation, the majority of this SWMP emphasized actions to be taken by the municipality regarding public actions and modifications to public facilities.

The Nature Conservancy, AZ_VerdeRiver_Ecological_Flows.pdf. (n.d.).
(This appears to be a reference to the study cited above as: Haney, J.A., D.S. Turner, A.E. Springer, J.C. Stromberg, L.E. Stevens, P.A. Pearthree, and V. Supplee. (Feb. 2008). Ecological Implications of Verde River Flows.)

Town of Manningham. (2005). *Water15 Sustainable Water Management Plan 2005 - 2015*. Manningham, Australia.

The Town of Manningham, with a population of about 110,000, was awarded a cost-share grant to develop an integrated sustainable water management plan (SWMP), primarily to find ways of reducing water usage in public areas such as parks, gardens, swimming pools, buildings, and recreational facilities. The SWMP is meant to help target areas where greater efficiencies are possible in order to achieve better water savings. The local council has been emboldened to adopt a strategy of water consumption reduction by fifteen percent on the part of the council/local governmental operations by 2015. The report offers a fairly detailed review of water saving opportunities in the different public areas listed above, with a series of actions/tasks to enumerate the steps necessary to achieve the water savings. A system of monitoring and reporting at regular intervals (e.g., three-month, annual, five-year markers) was instituted to allow for sufficient follow-up and follow-through on the initiatives.

Tsai, Y., Cohen, S., & Vogel, R. M. (2011). The Impacts of Water Conservation Strategies on Water Use: Four Case Studies. *JAWRA Journal of the American Water Resources Association, 47*(4), 687–701. doi:10.1111/j.1752-1688.2011.00534.x

Efforts in the Ipswich watershed in Massachusetts were studied to determine effectiveness at promoting water conservation in a region with relatively high average precipitation, but increasing pressures on water supply. Further, the water resources of the Ipswich River has been so heavily developed that instream flows are diminished to the extent that there is often very minimal surface flow discharge by the river into the estuary/bay. These conservation efforts were meant to function as pilot projects in the over-all efforts to help reduce demands on the river and therefore contribute to the restoration of minimum flows in the river. The four strategies under review included: (1) the use of weather-sensitive irrigation controller switches (WSICS) in public and private settings; (2) residential rainwater harvesting; (3) outreach programs involving audits, retrofits, and/or rebates; and (4) use of moisture-retaining soil amendments in public athletic fields. All efforts resulted in notable, measurable water savings, although some proved more effective in certain circumstances than others. Further research at larger scales would expand on the datasets collected in these pilot projects.

U.S. Bureau of Reclamation. (2008). *Conserving Urban Water Using Landscape Irrigation Guides and Tools* (Bulletin No. No. 13). Denver, CO: U.S. Department of the Interior.

This one-page hand-out issued by the U.S. BOR addresses the use of landscape irrigation. According to the BOR, about one-third of U.S. household water use is allocated for landscape irrigation, much of which is wasted because of over-watering, evaporation, or poor irrigation system design/maintenance. Potential environmental problems related to over-watering and run-off are given brief treatment here. The BOR's Upper Colorado Regional office in Salt Lake City has created a guide on
Landscape Irrigation Simplified, with a pamphlet and video and measuring cups for determining outdoor irrigation/sprinkler rates. This guide is located at: http://www.usbr.gov/research/science-and-tech/research/results/LandscapeIrrigationSimplified.pdf

Other technical reports on smart irrigation have also been designed by the BOR. Many of these reports and further follow-up/contact information are available online via URL weblinks embedded in the hand-out. A review of the literature regarding smart controllers for use in regulating irrigation regimes is available at this link: http://www.usbr.gov/waterconservation/docs/WaterSavingsRpt.pdf

U.S. Bureau of Reclamation. (2013a, May 6). Draft CYHWRMS Executive Summary.

(Refer to the above citation of: CYHWRMS Alternatives Report 051013.pdf)

U.S. Bureau of Reclamation. (2013b, May 9). Central Yavapai Highlands Water Resources Management Study: Phase III Water Supply Alternatives.

(Refer to the above citation of: CYHWRMS Alternatives Report 051013.pdf)

Umapathi, S., Chong, M. N., & Sharma, A. K. (2013). Evaluation of plumbed rainwater tanks in households for sustainable water resource management: a real-time monitoring study. *Journal of Cleaner Production*, *42*, 204–214. doi:10.1016/j.jclepro.2012.11.006

This study focused on the use of carefully monitored rainwater harvesting efforts in twenty detached households in the South East Queensland region of Australia, with an eye toward more generalized application in urban areas worldwide. In-situ water collection and use as part of a "fit for purpose" decentralized non-potable water use strategy helps to reduce the demands on water utility infrastructure. The most common end-use applications of this water included toilets, laundry, and garden tap. Such systems generally require particularized plumbing design and basic on-site water filtration. Rainwater was able to contribute nearly thirty-one percent of household water demand. Given the early developmental stages of plumbed rainwater systems, improvements in design could further assist in collection and utilization efficiency.

United Nations. (2010). Sustainable Water Management in Cities: Engaging Stakeholders for Effective Change and Action. Zaragoza, Spain.

Given the reality that complex urban water resource management nearly always involves a broad mix of interest groups and stakeholders, and the fact that urbanization is ongoing at unprecedented scale around the planet, the United Nations co-sponsored a global meeting in Zaragoza to explore successful methods for engaging stakeholders in meaningful discussions to create cooperative efforts at achieving sustainable local/regional urban water management programs. The results of this global meeting were compiled into this report. Case studies were included from cities around the world where productive collaborations had developed as a result of careful efforts by local authorities to reach out to and involve a diverse group of stakeholders. Special emphasis was given to outreach efforts toward the urban poor, whose interests and concerns are often overlooked or discounted in water planning. Social inclusion was considered to be an especially important goal in achieving meaningful engagement. Lists of particular actions or strategies to facilitate these interactions were collected from the participants and placed in this compilation, including an insightful list of do's and don'ts for stakeholder involvement.

Vano, J. A., Udall, B., Cayan, D. R., Overpeck, J. T., Brekke, L. D., Das, T., … Lettenmaier, D. P. (2013). Understanding Uncertainties in Future Colorado River Streamflow. *Bulletin of the American Meteorological Society*, 130625085810007. doi:10.1175/BAMS-D-12-00228.1

Several modeling efforts addressing likely 21st century stream flow regimes for the Colorado River project notable decreases. These reductions in stream flow, however, include a high degree of variability, with ranges of 10 – 45% reduction by mid-century. Water managers have responded with questions regarding the level and underlying causes of this uncertainty. The authors reviewed the recent studies in response to these queries and determined four primary sources for these differences: "(1) Global Climate Models (GCMs) and emission scenarios used; (2) ability of land surface and atmospheric models to simulate properly the high elevation runoff source areas; (3) sensitivities of land surface hydrology models to precipitation and temperature changes; and (4) methods used to statistically downscale GCM scenarios". The article methodically reviews these four points and draws lessons from them to assist water managers and policymakers in understanding the relative strengths and weaknesses of various models and projections. A review of paleo-reconstructions also lends context to previous periods of climatic shift and mega-drought conditions. Potential similarities and dissimilarities to these prior periods are discussed in order to frame potential worst-case scenarios based on what is known about previous shifts in water availability. The possible uniqueness of the current change in climate in the Colorado River basin also interjects other uncertainties and makes past conditions potentially less applicable to the present situation. The report concludes with the note that perhaps the most dire outcomes would involve co-occurrence of another mega-drought (similar in severity to others documented through paleo-reconstructions) with continued warming and precipitation reductions throughout the basin as a consequence of anthropogenic climate change.

Von Gausig, D., O'Banion, B., & Rooney, C. (2011). *Verde River Economic Development Study*.

The Verde River Economic Development Study (VREDS) involved cooperation among several municipalities in the Verde River basin and interviews with ninety-eight stakeholders in the valley from a variety of backgrounds. The interviews involved eight standard and three optional questions. This report sets out to promote increased public engagement regarding the connection between sustainable economic development and the health of the river, develop increased appreciation for the value a perennial river among valley residents, determine the potential need for a river-oriented organization with a focus on public outreach/education as critical part of a successful conservation effort, and ascertain where further investment in the river would prove most effective. The findings highlighted the general lack of direct access to the river, the apparent absence of strong connections between residents and the river generally, and the under-appreciation of the river as a source of significant and sustainable economic activity. The lack of a well-staffed and well-funded organization to promote the river became a notable finding. The above points led to the conclusion that targeted investment would be best spent on access (points of entry/exit for users of the river), promotion (branding/marketing), and preservation of stream flows. A follow-up feasibility study would be of particular benefit in evaluating opportunities tied to these previously mentioned findings to determine the most financially effective initiatives to bring about the VREDS conclusions.

Ward, F. A. (2007). Decision support for water policy: a review of economic concepts and tools. *Water Policy*, *9*(1), 1. doi:10.2166/wp.2006.053

The author focuses on the use of a broad array of economic analysis tools as part of informed decision-making in the realm of water management. He offers ways in which these tools can be used to guide water allocation under *ex post* reviews based on the existing framework of laws, regulatory oversight, and population distribution, and current water use patterns. Economic tools also can be applied in *ex ante* analysis in situations involving the potential creation of variety of new institutions to guide water distribution and determine broader understanding of values of water when applied to alternate uses. Given projections for increasing scarcity and greater competition for water among a variety of existing and new uses and non-uses, the author argues that the economic value of water will likely continue to rise. Water managers and policymakers generally will be called on to make difficult allocation and re-allocation decisions for this increasingly scarce resource, with complicated negotiations across sectors and often across contested jurisdictions. New institutions will likely arise to address novel challenges, and economic analysis tools will be particularly helpful in assessing the trade-offs in policies seeking to address simultaneously questions of economic efficiency, equity, and sustainability. The article provides abroad-ranging review of how well-crafted economic analysis would be of service in addressing many of the conundrums which water managers already face or are likely to face.

Ward, F. A., & Pulido-Velazquez, M. (2012). Economic Costs of Sustaining Water Supplies: Findings from the Rio Grande. *Water Resources Management*, *26*(10), 2883–2909. doi:10.1007/s11269-012-0055-8

The authors look at the Upper Rio Grande Basin and apply an integrated basin-scale constrained optimization analysis to assess three long-term policies regarding management of the basin's reservoirs and aquifers. These options include alternate policy objectives for these water resources, including: "(1) no sustainability for water stocks, (2) sustaining water stocks, and (3) renewing water stocks." The integrated water resources management (IWRM) framework for modeling these differing policies reflects the primary basin-based hydrologic, economic, and institutional limitations regarding operational parameters. Certain tools are highlighted in this case study, such as payments for sustainability services (PSS), which can be used to retire certain surface water or groundwater use rights. Also, a cap and trade system (which would require prior adjudication of contested water rights) could be set up where a set transaction cost is tied to transfers so that a certain percentage of any water transfer is retired to support surface flows or aquifer recharge. The results of the study indicated that sustainable management of these water resources was indeed feasible, and could be accomplished over a twenty-year horizon at the cost of six to eleven percent of the Upper Rio Grande's average annual total economic value of water. The authors posited that hydroeconomic models such as this one develop reliable cost estimates related to longer-term sustainable management as a way to inform debates and determine whether the costs associated with sustainable use policies for water resources are feasible in the eyes of current heavy users of water.

Water IQ. (2010). *Developing a Water Conservation Public Awareness Program: A Guide for Utilities*. Texas Water Development Board.

This seventeen-page guide is directed at assisting utilities in improving their skillset at engaging the public in water conservation efforts. The main topics emphasize first assessing a utility's particular water portfolio to determine what information to share (although the discussion of water conservation tools is surprisingly slim), and then finding ways of working with local media to target the audience. A short section looks at internet-based outreach (e.g., blogs, podcasts, instant messaging, and email). There seem to be some missing elements (e.g., Facebook, Twitter, Youtube), even though this publication was issued in 2010. Changes in outreach methods did receive acknowledgment, however. ("Social media trends are constantly changing, and you may need to determine which current tools best fit your utility's strategy and goals."). There is much more emphasis on more traditional media outreach through newspapers, radio, TV, magazines, and trade journals. Developing media kits and creating a memorable story/pitch are addressed. Also, the guide mentions direct communication to target audience members through the use of exhibits, presentations, brochures, and billboards. Some thoughts on tracking media coverage are briefly included.

West, P., Smith, D. H., & Auberle, W. M. (2009). Final Report for the Verde River Ecosystem Values Project. Retrieved from http://arizonastateparksfoundation.org/docs/Verde_River_Eco_Values.pdf

This study was designed to be the first of several to assess ecosystem services in the Verde River basin. This valuation study included interviews with thirty-five stakeholders in the basin which led to the creation of an extensive list of watershed-related values. A short review of the literature in the area of ecosystem services was conducted, and the conclusion included particularly relevant avenues for further inquiry in future studies. The feedback indicated that a substantial number of participants valued the river, "not as a place to get things from, but as an entity that is valued for its very existence for a wide variety of reasons". (This is an interesting conclusion to compare with other Verde Valley interview feedback in other studies in this Annotated Bibliography, where the Verde was considered to be under-valued, overlooked, and viewed for its potential for recreational economic development.) The study reviewed the comments offered by participants and offered citations and context for valuation principles (e.g., non-use value) discussed in non-technical language in the interviews. The conclusion offered a list of ten additional steps for further research and study regarding more detailed valuation studies regarding the Verde Valley.

Western States Water Council. (2008). *Water Laws and Policies for a Sustainable Future: A Western States' Perspective*. Western States Water Council.

This report offers a wide-ranging review of water issues throughout eighteen western states (including Alaska, but not Hawai'i). The policy and legal implications of major water issues at the state/ interstate/federal level include: water supply augmentation, demand management, water conservation, water reuse, environmental water use/instream flows, water storage (generally), water banking, modification of agricultural practices (e.g., rotating fallow, dry year leasing), desalination, and weather modification. Preparations for the impacts of climate change are also included. The report, which includes discussion regarding growth management in the context of burgeoning urban areas, was released in 2008. Some conditions have been notably affected by the major national/international economic downturn which occurred since the release of this report. Continuing drought conditions, however, serve to underscore the importance of water planning in the face of increasing water scarcity.

Wildman, R. A., & Forde, N. A. (2012). Management of Water Shortage in the Colorado River Basin: Evaluating Current Policy and the Viability of Interstate Water Trading. *JAWRA Journal of the American Water Resources Association*. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1752-1688.2012.00665.x/full

This article was published in the wake of the release of the interim report of the Bureau of Reclamation's *Colorado River Basin Water Supply and Demand Study*. (The final report was not released until after publication of this article, although the acknowledgment of increasing water scarcity and uncertainties related to future water flows in the Colorado remain dominant themes in both versions.) The authors review some of the current legal/administrative restrictions tied to what is known as the Law of the River and examine some of the early winners and losers under these regimes in likely near-future situations where water scarcity in the Colorado River leads to substantial cutbacks on water supply. Under these conditions, different water users will feel the early pinch, including municipalities in Arizona and Nevada and farmers in Arizona. The authors argue that, while admittedly difficult to design and implement, an interstate water market among basin states could be designed to preserve the primary components of the Law of the River, which would allow decentralized market forces to facilitate water transfers from lower value to higher value uses. The effects of severe drought on the water market that had been established in the Murray-Darling basin in Australia were closely reviewed for potential parallels and learning opportunities for application in the Colorado River basin.

Clarkdale Water Resource Management Matrix

Description: This matrix is organized into three sections: 1) management options that are allowed under current law, 2) management options whose legal status are uncertain and 3) options that would require a change in law. Within each section we have organized the options into three categories: demand-based options, supply-based options and augmentation options. These categories reflect more traditional approaches to water management planning, but contain an extensive array of options. Each option indicates if it falls into the general category of policy, economics or social actions, many options can be categorized as all three. This document will serve as the foundation for developing the three expert meetings and the final report prepared by the WRRC.

(Note: This matrix includes actions already taken (see green highlights), such as implementation of block-rate pricing and a drought preparedness plan, to recognize the forward momentum already in action in Clarkdale.)

Terminology

Demand-Based Options: Management strategies that change how much water is needed or used for a specific application.

Supply-Based Options: Management strategies that change how much water is available based only on existing infrastructure.

Augmentation Options: Management strategies that involve new infrastructure or technologies to increase supply.

Policy Category: Options related to courses of action, regulatory measures, laws and funding priorities that are determined by local, state or federal governments.

Economics Category: Options involving the analysis and harnessing of market forces to effect change in the dynamic relationship between community water demand and supply.

Social Category: Options entailing concerted efforts at public education and outreach to encourage behavior modification regarding individual water use habits.

Market: A system in which buyers and sellers trade commodities. A water market entails a specific set of laws and rules that establish tradable property rights to water. The existence of a cap or limit on water use provides an incentive for trading in response to shifting values across competing uses.

Market-Based Responses: The use of tradable water rights and institutions to facilitate voluntary reallocation of water to meet environmental or human needs.

	DEMAND-BASED OPTIONS	SUPPLY-BASED OPTIONS	AUGMENTATION OPTIONS
FEASIBLE UNDER CURRENT STATE/FEDERAL LAW	Block-rate pricing (Policy, Econ)	Leakage detection and repair (Policy, Econ)	"No New Water" program (Policy, Econ)
	Seasonal pricing (Policy, Econ)	Decrease in water pressure (Policy, Econ)	Active/passive residential rainwater harvesting (Policy, Econ)
	Native/xeriscape landscaping ordinance (Policy)	Greywater reuse program (Policy)	Active/passive rainwater harvesting from commercial buildings and hardscapes (Policy, Econ)
	Retrofit programs: Plumbing Code Changes (Policy, Social)	Use of reclaimed water/municipal effluent for aquifer recharge (Policy, Econ)	Active/passive public rainwater harvesting (Policy, Econ)
	Retrofit programs: Toilets, showers, faucets, clothes washers and dishwashers (Policy, Econ)	Use of reclaimed water/municipal effluent for non-potable uses (Policy, Econ)	Natural vegetation reduction (upland & riparian) (Policy, Social)
	Retrofit programs: Pre-rinse valves, hot water recirculators, on-demand hot water (Policy, Econ)	Study of potential sites for optimal recovery of recharge/storage programs (Econ)	New well acquisition/construction (Policy)
	Water Waste ordinance (Policy)	Regional Water Cooperation: Pursue water delivery efficiency projects for economies of scale/enhance streamflow. (Policy, Econ)	Acquisition of surface water rights and use (Policy)
	Enhance outdoor water restrictions (Policy, Social)		Additional effluent from increase in population (Policy, Econ)
	Project WET-type curriculum in local schools (Social)		Conversion of septic systems for enhanced effluent collection/ treatment/reuse (Policy, Econ)
	Develop Drought Emergency Plan (Policy, Social)		
FEASIBLE UNDER CURRENT STATE/FEDERAL LAW	Revised enhanced-readability water bills (Social)		
	Faulty meter replacement/data tracking (Policy, Econ)		
	Voluntary consumer in-home water audits (Social)		
	Voluntary consumer landscape water audits (Social)		
	Training for landscapers (Social)		
	Meter installation in multi-family facilities (Econ, Social)		
	Smart-meter installation (Econ, Social)		

	DEMAND-BASED OPTIONS	SUPPLY-BASED OPTIONS	AUGMENTATION OPTIONS
	Promote transparency in rate setting/ billing/PR/ communications to allow consumers to become familiar with the “real” value of water (Econ, Social)		
	Development and promotion of a permaculture demonstration garden to encourage use of drought tolerant plants in landscaping (Social)		
	Establish an Office of Water Conservation/ Information (Policy, Econ, Social)		
UNCERTAIN	Creation of Community Water Budget and a market-based demand offset trading program for new construction (Econ, Social)	Linkage of use of sewer hook-up availability to use of municipal water system to discourage aquifer depletion by new private wells (Policy)	Construction of large reservoir(s) for stormwater/floodwater collection including “off channel” floodwater storage (Policy, Econ)
	Development of rebate structure for existing users/irrigators under a demand offset program (Econ, Social)	Centralized collection and treatment of effluent from surrounding urban/suburban areas (Policy, Econ)	Regional Water Cooperation: Strengthen long-term collaborations on groundwater mitigation banking to offset new depletions (Policy, Econ)
	Examine elasticity & structure of water rates for further beneficial consumer behavior modification (Econ, Social)		Centralized collection and treatment of effluent from surrounding low-density rural areas (Policy, Econ)
			Coordinated upland vegetation reduction/wildfire management/range management with adjacent land managers in watershed, such as USFS (Policy, Econ)
LAW CHANGE REQ.	Mandatory comprehensive retrofit of all existing residences and businesses (Policy, Econ)	Trading of effluent for surface water rights/uses w/ area rights-holders (Policy, Econ)	Groundwater importation from adjacent basins (Policy, Econ)
	No new wells in water provider service area without permit (Policy)	Use of reclaimed water/municipal effluent for landscape irrigation by residential users (Policy, Econ)	Leasing of groundwater/surface water rights from ag users (Policy, Econ)
	Mandatory metering and reporting of private wells in service area	Formation of a water mgt. district for Clarkdale to handle adequacy rule oversight and water usage taxation (Policy, Econ)	Regional Water Cooperation: Situate short- & long-term transactions in the context of basin-wide planning frameworks to meet multiple demands (Policy, Econ)

	DEMAND-BASED OPTIONS	SUPPLY-BASED OPTIONS	AUGMENTATION OPTIONS
		Leasing of groundwater/surface water rights from I&M users (Policy, Econ)	Capture & store un-appropriated main-stem Verde River surface water (Policy, Econ)
			Weather modification/Cloud-seeding (Econ, Policy)
		Regional Water Cooperation: Integrate voluntary restoration & regulatory mitigation demand into a single market (Policy, Econ)	Capture & store un-appropriated Verde River tributary surface water (Policy, Econ)

APPENDIX B: Forum on Water Management for Small Towns - Summary and Outcomes

June 26 and 27, 2014
Clarkdale, Arizona

In January 2013 the Town of Clarkdale, Arizona, began a multi-year process to create a Water Resources Management Program (WRMP) to protect the flowing Verde River while maintaining their water supply. As part of this process the Town hired the University of Arizona Water Resources Research Center to provide recommendations the Town could use to create their water management program.

In the 18 months since the project began, the Town and its project partners, WRRC and Lacher Hydrologic Consulting, executed the following tasks in support of the project:

1. Formed an advisory committee to help shape recommended strategies for the WRMP
2. Hosted public meetings and open houses to provide information on ideas for the WRMP and the hydrologic modeling process to the public and surrounding communities
3. Facilitated an expert forum to gain insight from water managers across Arizona on Clarkdale's water resource management challenges
4. Hosted a Small Town Water Forum to identify and develop strategies addressing the water management challenges unique to small towns and to review drafts of plans Clarkdale is developing for its Water Resources Management Program. Figure 1 provides an overview of the project.

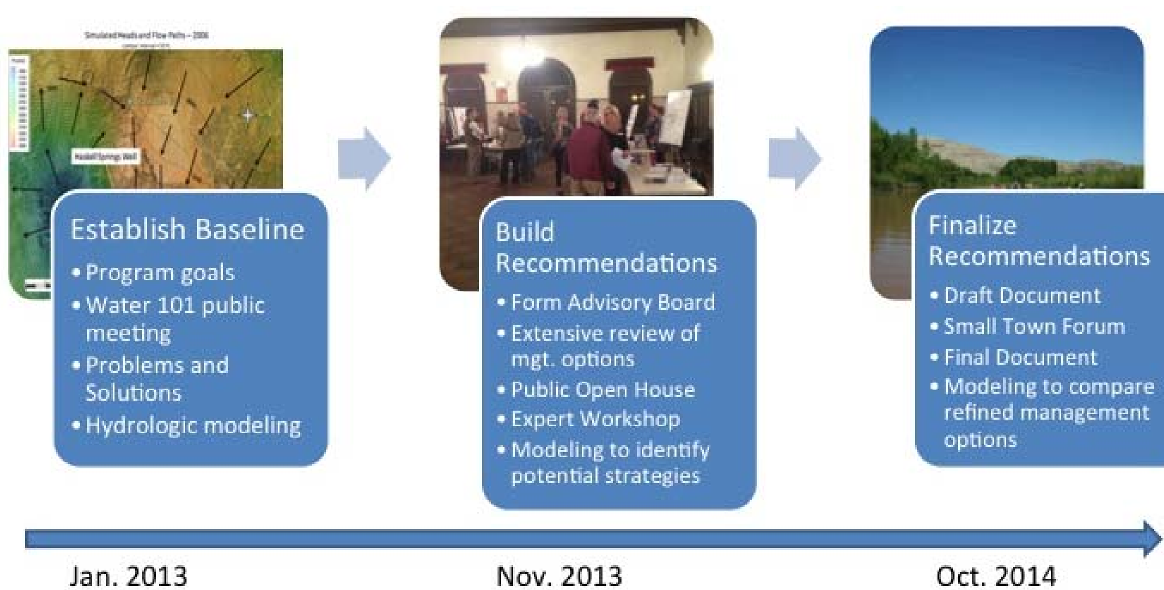


Figure 1: Timeline for Creating Recommendations for the Town of Clarkdale Water Resources Management Program

This brief report provides a summary of the insights and ideas from the two-day Small Town Water Forum, held on June 26 and 27, 2014 in Clarkdale, Arizona. The Forum was made possible by the generous support of the Walton Family Foundation and the Arizona Water Infrastructure Finance Authority. At the Forum, cities, towns and experts from Arizona and beyond (Table 1) discussed their water resource situations, water management challenges and solutions, and ideas for collective strategies to improve water management in small towns. The roster of participants was intentionally a mixture of communities with considerable experience in water management and planning, such as Payson and Sierra Vista, as well as those, like Clarkdale, that are still building their management programs. In addition to the 11 Arizona cities and towns, representatives from the Southeastern Colorado Water Conservancy District and the Orange County California Water District were invited to provide outside perspectives on water management and planning.

TABLE 1: SMALL TOWN FORUM PARTICIPANTS
City/Town or Organization Name
Town of Camp Verde
Town of Chino Valley
Town of Clarkdale
Cochise County Cooperative Extension
City of Cottonwood
Energy Policy Innovation Council
Town of Jerome
Orange County Water District (California)
Lacher Hydrological Consulting
Town of Payson
Town of Pinetop-Lakeside
City of Safford
City of Sedona
Sedona– Arizona Water Company
City of Sierra Vista
Southeastern Colorado Water Conservancy District
Town of Thatcher
Water Infrastructure Finance Authority
Western Resource Advocates
Yavapai County Water Advisory Committee

The Forum was designed to bring small towns together to share their water management challenges and successes, and to generate input and ideas for Clarkdale, in particular for the Town's WRMP. On the first day of the Forum, the WRRC, together with the Town of Clarkdale, shared the Town's water management challenges and ideas for a WRMP in order to get feedback from the other participants. The afternoon included a series of presentations on tools cities and towns can use, including financing options from the Arizona Water Infrastructure Finance Authority, techniques for conservation from the Southeastern Colorado Water Conservancy District, identification of opportunities for rainwater harvesting through the WRRC's Desert Rainwater Harvesting Assessment tool, and a database on energy policies created by the Energy Policy Innovation Council at Arizona State University. The remainder of the first day and the morning of the second were dedicated to each town or city sharing its water management story. In the afternoon of the second day, the WRRC led participants through an identification of strengths, weaknesses, opportunities, and threats (SWOT) regarding their ideas for improving water management in small towns. The SWOT exercises were first completed individually, then in groups of two, and then in facilitated groups of six. Finally, the Forum concluded with all participants together discussing action items for one of the many ideas that came out of the SWOT exercise. Details including the Forum Agenda, brief descriptions of tools and where to access them, detailed "Share Your Story" summaries, and participant evaluations of the Forum are included as supplemental information to this summary. This summary provides highlights from the Share Your Story portion of the Forum and ideas for improved water resources management from the Forum's SWOT analysis and discussion of ideas to improve water management in small towns.

Share Your Story

An important part of the Forum was the opportunity for each city or town to share its water management story. Before the Forum all participants were provided with a questionnaire to encourage each city or town to gather relevant information and present on similar topics. The presentations were very informal and designed to allow the group to offer suggestions to the water management questions of the presenter or to learn from the experiences of the presenter. The following are highlights from these presentations. The Share Your Story questionnaire and a more complete summary for each participating town, city or organization are included in the supplemental materials.

Town of Camp Verde (Presenter: Stan Bullard, private water company owner)

Camp Verde relies on four private water companies in the town. Coordination between the town and the companies in regard to land-use planning is being investigated as a method for effectively managing the impacts of growth on groundwater supplies. This approach would also moderate the stresses imposed by new services on the existing older infrastructure and limited budgets of these small private companies. Currently, the town requires development costs to be paid up front by the developer, then repaid by water companies over time.

Town of Chino Valley (Presenter: Mayor Chris Marley)

Chino Valley is 100% dependent on groundwater and is exploring cost-effective options for groundwater recharge. Injection wells would be important in assuring recharge occurs in the targeted aquifer, which is situated beneath a layer of impervious clay. Both effluent and clarified stormwater could be applied toward recharge efforts.

Town of Clarkdale (Presenters: Mayor Doug Von Gausig, Ellen Yates and Kelly Mott Lacroix, WRRC)

Clarkdale has embarked on a far-reaching water management initiative to promote sustainable groundwater use and also to protect the flows of the Verde River. Following the 2006 purchase of the private water company in collaboration with Cottonwood, Clarkdale has created a public water utility to take over management of the potable water supply. The Town's Utilities Department works with the Town Council to develop and implement conservation policies using tools such as

Arizona's Water Adequacy Program, landscape ordinances, increasing block rate pricing structures, and infrastructure repairs. In 2008 the Town adopted the Adequate Water Supply Requirement (SB1525). These combined measures have led to substantial water savings. A grant from the Walton Family Foundation allowed the Town to explore additional actions to promote sustainable water use, in part through partnering with groups like Lacher Hydrological Consulting and the UA's Water Resources Research Center to better understand groundwater hydrology, explore effluent reuse options and to develop a water resources management program.

Town of Jerome (Presenter: Former Mayor Jane Moore)

The water supply for Jerome is completely dependent on local springs that fluctuate depending on climate conditions. Land use ordinances are being researched to encourage sustainable development and better water management. Jerome has an upgraded wastewater treatment plant that generates about 56 acre-feet per year (af/yr) of effluent. The downhill location of the plant in relation to the town complicates the prospect of effluent reuse in Jerome because the water would have to be pumped back uphill, significantly increasing the cost. Alternative uses include groundwater recharge, small-scale agriculture, instream flow augmentation of the Verde River, or leasing of the water to downstream users.

Town of La Junta, CO (Presenter: Tracy Bouvette / Southeastern Colorado Water Conservancy District)

Several small private water companies around La Junta are facing increasing maintenance costs, but customer bases are small (sometimes a few as 26 as connections) and funding options are extremely limited. The public utility, which has the power to tax or issue bonds, has been entering into partnerships and installing system interconnects with these private companies. The private companies still manage the operations and account billing, but have more reliable systems supported by the public utility. Through a larger customer base and more revenue, the public utility can provide the small private companies with better access to funding for targeted investments such as reductions in nonrevenue water, improved data collection, or increased water conservation that private water companies couldn't fund alone.

Orange County Water District/OCWD (Presenter: Adam Hutchinson, Recharge Planning Manager)

The OCWD offers a regional groundwater management approach. It supports the reliability of local supplies by providing the planning and oversight structure for recharge operations via the efficient capture of stream baseflows and stormwater flow. Very high-quality reverse osmosis (RO)-treated recycled water is also currently used for recharge, and may be eligible for other uses in the future. An incentive-based pricing system using an annually adjusted basin production percentage gives water providers flexibility in balancing their water supply portfolios while supporting costs for meeting the District's regional groundwater management targets.

Town of Payson (Presenter: Buzz Walker, Water Superintendent/Asst. Public Works Manager)

Groundwater recharge has been a critical component to Payson's water management efforts. The town currently operates 42 groundwater production wells. Payson also entered into a cooperative agreement with the sanitary district to build and operate the 40-acre Green Valley Park and lakes, which offers recreational opportunities to the community and provides an infiltration basin for aquifer recharge to help in sustaining the town's wells. Through a complex agreement with SRP, Payson is eligible to utilize water from the CC Cragin Reservoir that will also generate hydropower in the water-transfer pipeline; this water will feed into the new water treatment plant and contribute to the town's water supply for current use and groundwater storage for future use.

Town of Pinetop-Lakeside (Presenter: Andy Romance, Director of Engineering and Public Works)
Pinetop-Lakeside currently manages no public utilities. The largest water provider in the town is Arizona Water Company. The town is currently weighing the benefits and costs of establishing a public water utility versus collaboration with private water providers. Pinetop-Lakeside is seeking to achieve improved outcomes regarding per capita water usage, implementation of its land-use plan, and fire suppression preparedness.

City of Safford (Presenters: Mayor Chris Gibbs and Utilities Manager Eric Buckley)
Safford has been successful in developing relationships with other institutional partners in the region. Data collection and technological adaptation efforts have been improved due to assistance from the mining company Freeport-McMoRan (FMI), which has supported the drilling of several piezometer wells and experiments with a siphon system to augment the gallery infiltration system on Bonita Creek. Land owned by the University of Arizona has been developed for two supplemental wells to broaden the water supply portfolio, but the town is still unable to meet demand outside its service area.

Town of Thatcher (Presenter: Mayor Bob Rivera)
Thatcher recently upgraded its wastewater treatment from a basic lagoon system to a wetland treatment system. The higher quality Class B effluent has additional allowable uses, but cannot be used on food crops. Thatcher has secured approval from ADOT, Graham County, and the railroad for the construction of a 4-inch line (uphill) through a ditch beneath the state highway, county roads, and the railway. The recycled water will be substituted for potable water and used to irrigate the recreational fields of a public park and the cemetery.

City of Sedona (Presenters: Charles Mosley, Director of Wastewater Department, and Keith Self, Division Manager at Arizona Water Company)
Sedona is moving forward with the use of recycled water for groundwater recharge through injection wells. Community members initially expressed reservations regarding contaminants of emerging concern (CECs). Effluent testing revealed that most CECs were filtered out at levels approaching 95-99% removal, and these test results have helped build public support for the recharge efforts. Monitoring of the injected effluent will continue, using tracers like sucralose (the main ingredient in sugar substitutes like Splenda) as indicators of the spread of the injected water plume. Arizona Water Company has effectively implemented a tiered water rate structure and water use has decreased. As a private water company regulated by the Arizona Corporation

Commission, it has successfully raised rates to keep up with the cost of water supply delivery and infrastructure maintenance.

City of Sierra Vista (Presenter: Scott Dooley, Public Works Director)

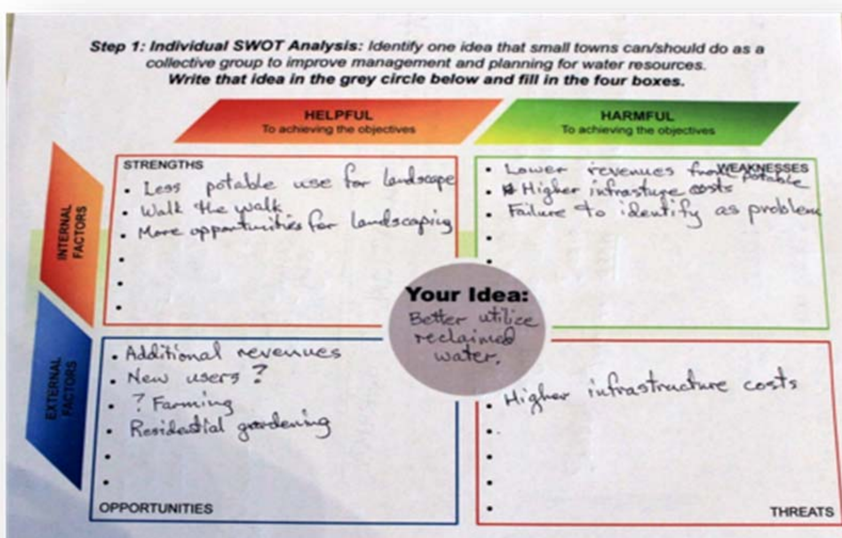
Sierra Vista has developed several initiatives to counteract the effects of a groundwater deficit from sustained pumping activity. Its Environmental Operations Plant generates and recharges Class A+ effluent via wetlands and infiltration basins to support baseflow in the San Pedro River, accrue recharge credits, and mitigate the impacts of the cone of depression in Sierra Vista. The San Pedro Recharge Program is in the process of designing a network of near-stream recharge basins to collect and recharge stormwater and other available sources of water in order to sustain base flows in the San Pedro River.

Ideas for Improving Water Management for Small Towns

Individual SWOT Analysis

To generate ideas for improving water management for small towns, the participants completed a SWOT exercise to identify opportunities to work collaboratively at a regional scale (see image on the right). Each participant was asked to come up with his/her idea or recommendation to improve management and planning for water resources, specific to small towns, and then think about the strengths, weaknesses, opportunities, and threats around implementation of that idea. As with a traditional SWOT analysis, strengths and weaknesses were considered internal factors from the perspective of a single town or water provider and opportunities and threats were considered external factors, from the perspectives of both the public and from a statewide stakeholder group focused on water issues (similar to the group convened for this Forum). Responses indicate that there may have been confusion about the difference between internal an external factors, but certain themes persisted throughout the SWOT exercise.

There were 22 forum participants who completed the SWOT exercise and as a result, 13 unique ideas were identified to improve small town water management and planning. These 22 SWOT analyses resulted in identification of 100 strengths and opportunities and 129 weaknesses and



Sample individual SWOT worksheet

threats. Many times the same theme would be noted as both a strength and an opportunity or as a weakness and a threat.

The overarching theme presented at the beginning of the SWOT exercise was "collaborative work at a regional scale" and participants developed their main SWOT ideas with this regional collaboration in mind. Participants identified that collaboration could be used to broadly:

1. Develop and manage effluent resources;
2. Increase collaboration between private water companies and cities and towns, in general, and to overcome water shortages;
3. Identify common water management goals or a unifying problem on which to focus collaboration;
4. Develop a regional management plan;
5. Have a presence at the statewide level to improve services and financial stability;
6. Create and rely on a set of best practices in water management, including ordinances that promote water conservation, and have local communities all adopt/use similar practices and ordinances.

Other, more specific ideas included:

7. Implementing rainwater harvesting and stormwater recharge;
8. Better utilization of reclaimed water;
9. Creating a basin-wide groundwater management agency;
10. Concern that EPA and ADEQ prioritize the needs of the environment over the needs of human populations;
11. Educating the public on the carrying capacity of water sources, cost of importation alternatives, water shortages, and conservation measures;
12. Standardizing rate structure to a similar tiered system among small towns;
13. Explore mechanism to tie sewer rates to water use when the town does not own the water utility.

Among the 13 different ideas, many of the 100 strengths and opportunities were similar. The most frequently cited strengths and opportunities were: a) creating common ground among small towns, and b) the value of collective strength as it is engendered through that common ground. Participants also thought pooling resources to reduce costs and creating awareness were important strengths or opportunities for many of their ideas. Figure 2 lists all of the themes recorded more than once from the strengths or opportunities and how many times that theme was mentioned. There were an additional seven themes only mentioned once in the strengths and opportunities, including quality of life, decreasing lawsuits and increasing transparency.

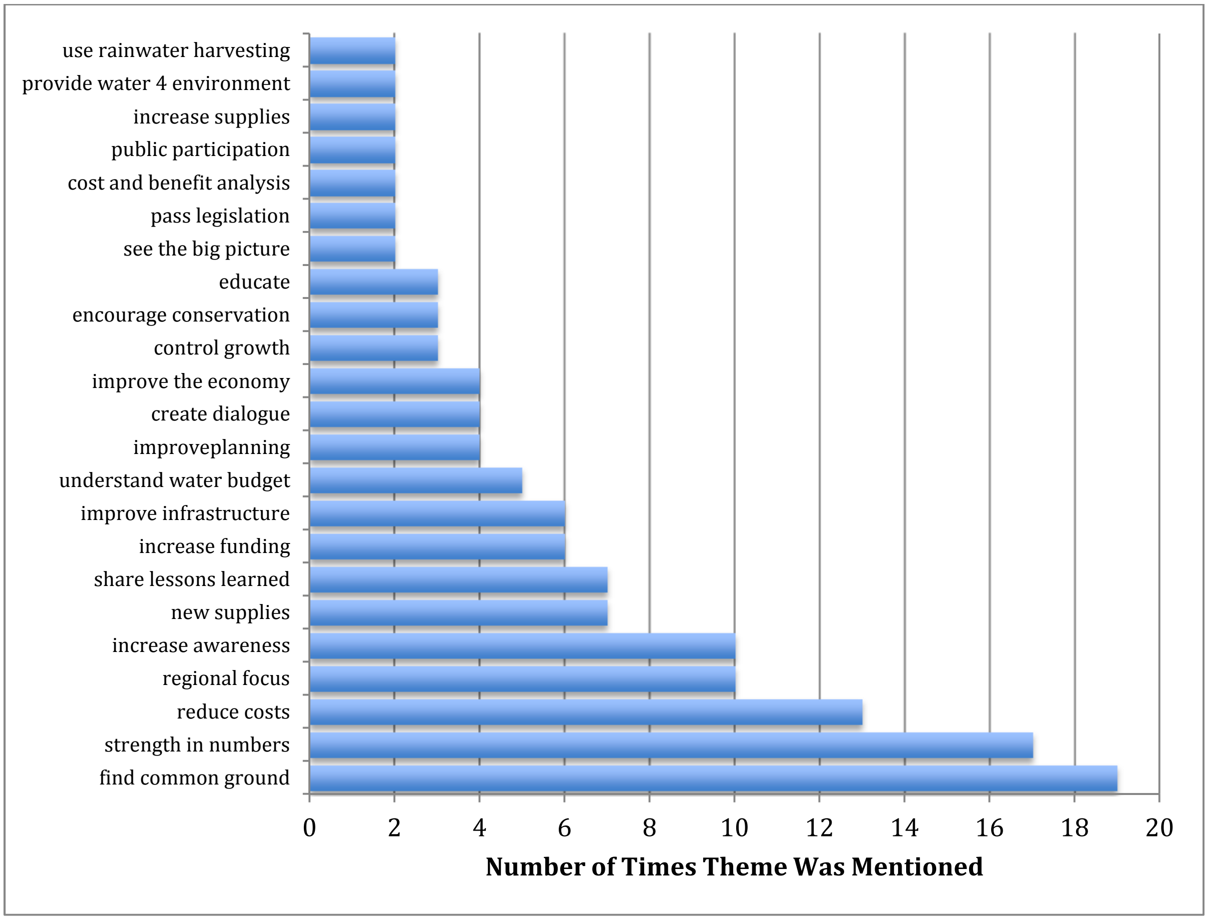


Figure 2: Recurrent Themes from a Review of Strengths and Opportunities

There were 129 weaknesses or threats suggested for the 13 unique ideas for improving small town water management. For weaknesses and threats, there was less agreement across the different ideas and much more diversity in the themes. Although noted less than half as frequently as the most common strengths and opportunities themes, the most common weakness and threats themes were unwillingness to participate and distrust. Unwillingness to participate and distrust were noted in 11% (17 of the 129) of the total number of weakness or threats and in 25% of the ideas. Other more common themes cited that could prevent new approaches to management were: concerns with water quality, additional expenses, politics, and the strength of the status quo. Figure 3 shows only those themes indicated more than once in the weaknesses and threats. There were an additional 21 other weaknesses and threats themes including threats to the local economy, conflict with existing regulations, changes in climate and limiting creativity.

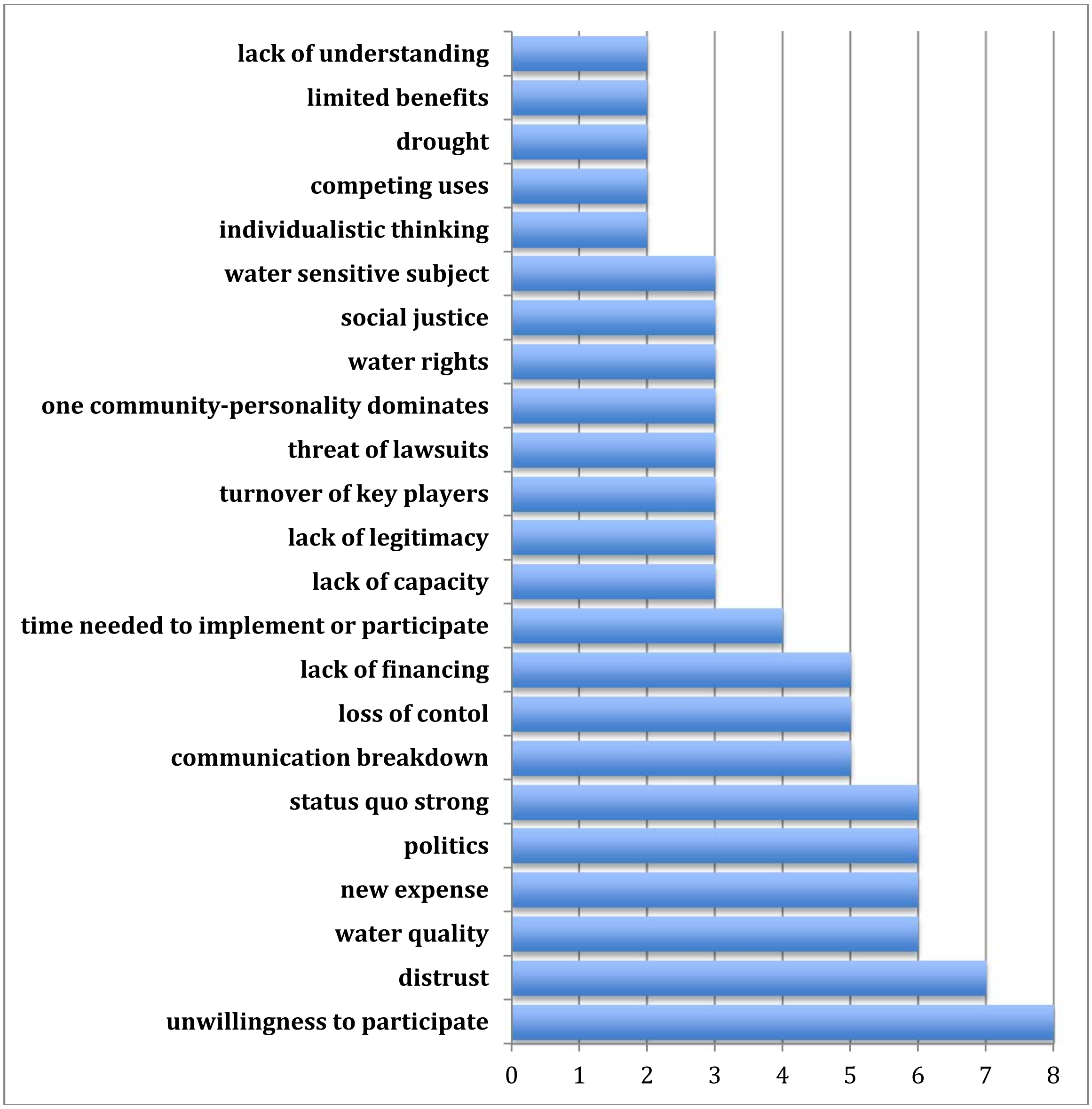


Figure 3: Recurrent Themes from a Review of Weaknesses and Threats

Group SWOT Analysis

The responses here are based on the individual and small group SWOT discussions. The format of the SWOT exercise was designed to gather a large number of ideas, develop those ideas further through discussion, and then narrow the many ideas down to just a few. At the conclusion of the three facilitated discussions conducted in groups of six, the top ideas from each group were:

1. Regional cooperation through a water advisory board;
2. Water authority that combines public and private systems;
3. Determining the best use of our reclaimed water;
4. Joint-exercise-of-power coalition to tackle water issues in the Verde Valley;

5. Overarching management plan at a basin scale (includes information, data, conservation actions and education).

Participants then used anonymous keypad polling to vote on the one idea for which the entire Forum would build action items. Based on the poll, the Forum closed with a discussion of a joint-exercise- of-power (JEP) coalition to tackle water issues in the Verde Valley (36% of votes). The overarching management plan idea received 26% of the votes and the regional cooperation idea received 16%. The selection of the joint exercise of power coalition idea was reflective of the fact that the majority of the small towns in the room were from the Verde Valley.

A JEP coalition to tackle water resource issues would be a way for multiple cities, towns or organizations in the Verde Valley to create/develop joint resources that can be applied to achieve collective goals (e.g., bolstering recharge or otherwise supporting baseflows). The group decided to focus on a JEP coalition focused on reclaimed water and stormwater, but acknowledged it could cover other aspects of water management. The advantages to this approach would be its ability to convene otherwise disparate folks, create economies of scale, and pool resources. The disadvantages would be reduced local control, the need for consensus among groups with different goals and concerns with equity. The people who would need to be involved at first would be those who are enthusiastic for this approach and then the coalition could gather others based on initial successes. It would also be important to identify stakeholders who would be impacted by the coalition and keep them informed and involved. The next steps for this idea would be to implement pilot projects, which can be good for "proof of concept" in that seeing the efforts in action on the ground might help others develop a more informed opinion. Interested cities and towns should also investigate where economies of scale are significant, and look for opportunities where pooling interests creates these economies of scale. Another next step would be to look at similar programs or coalitions and how they work so that the JEP coalition is not reinventing the wheel. There was also discussion that a first step could be an effort by towns and cities in the region to cooperatively change or create stormwater- or reclaimed water-use codes to provide uniformity across the Valley, which would benefit economic development. Finally, it was suggested that interested groups should not be discouraged by differing cultures within the jurisdictional boundaries because water does not care about such political lines; instead, the coalition should be based on the watershed boundary instead of jurisdictional boundaries.

The Value of Bringing Small Towns Together

The Small Town Water Forum was an opportunity to bring Arizona's small towns and cities together to discuss water management and was an important event in the context of the Clarkdale WRMP project and the WRRC's program mission to help communities create a secure water future. To gauge whether this Forum was useful, as well as if another one should be held, the WRRC provided the participants with an online survey after the event. Overall, attendees who responded to the survey (18 responses out of 25 participants) found the Forum very useful, with an average rating of 8.5 on a 1 to 10 scale. In addition, all 18 respondents indicated another forum would be beneficial. One participant noted that it was "[v]ery useful to get all the organizations represented at such a high level. Story telling is critical to chang[ing] management and preparing for the future." This sentiment reflects the importance of the Share Your Story presentations as the single most valuable exercise of the Forum (average rating of 9.125). When asked what was the most valuable thing they learned at the Forum, participants discussed the value of understanding that each community is not in it alone, and that while they each face specific challenges, there are lessons to be learned from other approaches.

Participants who answered the survey also offered a number of ideas for the next forum. These proposals include a discussion of water supply development; legislative changes needed for better water management; what initiatives communities can enact even with the restrictions of Proposition 207[4]; and discussions of what communities have done since the 2014 Forum.

The feedback offered by the participants indicates that there is an unmet need in Arizona among small towns for a venue in which to discuss water management challenges and innovative practices. Unfortunately, neither the Town of Clarkdale nor the WRRC currently has funding to host a second forum. Financial assistance for attendees is particularly critical at a time when municipal budgets are generally strained and limit a town's ability to participate in such a Forum and benefit from the creative exchange of ideas and practices. The support of the Walton Family Foundation and the Arizona Water Infrastructure Finance Authority were, therefore, crucial to the success of this event, covering planning and logistics and coordinating travel and accommodations for the participants. The WRRC's mission necessarily focuses on providing assistance to Arizona communities in water planning and policy. Because of the strong responses from the participants regarding the value of this event, the WRRC is now committed to seek additional funding for a second forum.

Those interested in learning more about a future forum should contact the WRRC directly:

Kelly Mott Lacroix
Research Analyst
klacroix@email.arizona.edu
(520) 621-3826

[4] Arizona Proposition 207, officially titled the "Private Property Rights Protection Act" was approved by voters in 2006, requiring the government to reimburse land owners when enacted regulations decrease the property's value and also prevents government from exercising eminent domain. (ARS 12-1134)

Forum on Water Management for Small Towns: Appendix I – Agenda

Thursday, June 26th – Day 1, 10 am – 5 pm

10:00 am – 10:30 am	Welcome to the Forum (Town of Clarkdale & WRRC)
10:30 am – 11:30 am	An Innovative Approach to Local Water Challenges *Presentation of Clarkdale Primer & Draft Recommendations* Document (WRRC)
11:30 am – 12:00 pm	Lunch
12:00 pm – 1:00 pm	Continue Lunch and Discussion/Feedback on Clarkdale Water Resources Management Program Recommendations and Q&A
1:00 pm – 2:30 pm	Tools/Funding Opportunities • AZ Water Infrastructure Finance Authority (WIFA) • Southeastern Colorado Water Conservancy District • Energy Policy Innovation Council (EPIC) Database • DWHI Rainwater Harvesting Toolkit
2:30 pm – 2:45 pm	Break
2:45 pm – 5:00 pm	Share Your Story (20 minutes per Town) *What are your sources and uses of water?* *What are your top 3 water challenges?* *What innovative water management techniques have you used/plan to use?*
5:00 pm – 6:00 pm	Wine Tasting at Four Eight Wine Works
6:15 pm – 7:30 pm	Dinner at Su Casa

Friday, June 27th – Day 2, 8 am – 3:30 pm

8:00 am – 9:30 am	Share Your Story Continued (20 minutes per Town)
9:30 am – 9:45 am	Break
9:45 am – 10:45 am	Toolkit Cafés with Experts: • Reclaimed Water Use • Rainwater Harvesting • Financing • Water Districts • Conservation BMPs
10:45 am – 12:30 pm	SWOT (Strengths, Weaknesses, Opportunities and Threats) for Small-Town Water Management *What can/should small-towns do as a collective group to improve legislation, funding, information sharing etc. to improve management and planning for water resources?*
12:30 pm – 1:30 pm	Lunch (networking to meet new people)
1:30 pm – 2:45 pm	Create action items based on group SWOT analysis
2:45 pm – 3:15 pm	Concluding Remarks & Toolbox Takeaways

Forum on Water Management for Small Towns: Appendix II –Tools

1. Arizona Water Infrastructure Finance Authority (WIFA)
   http://www.azwifa.gov
   WIFA is an independent agency of the state of Arizona and is authorized to finance the construction, rehabilitation and/or improvement of drinking water, wastewater, wastewater reclamation, and other water quality facilities/projects. Generally, WIFA offers borrowers below market interest rates on loans.

   WIFA also awards Planning and Design Assistance grants. These grants provide funding for water infrastructure planning or design projects and prepare communities for necessary capital improvement projects.

2. Southeastern Colorado Water Conservancy District (SECWCD) BMP Tool Box
   www.secwcd.org/BMPToolbox
   The SECWCD is about 200 miles long, incorporating virtually all of the Arkansas River and its dependent communities. The District has integrated planning efforts among the communities served by the Fryingpan-Arkansas Project, a transmountain diversion that supplies southeastern Colorado with improved water supply for multiple uses.

   As a part of this effort, a conservation tool box has been created to address demand management issues throughout the basin. This tool box emphasizes the collection and use of data, which has also helped promote water conservation and evidence-based planning as a way to reduce demand.

3. Energy Policy Innovation Council (EPIC) Database
   www.energypolicy.asu.edu
   Energy policies made at the local level are difficult to find and monitor, but EPIC has created an online database of local energy policies that allows consumers and policy makers to explore trends and innovative approaches to energy policy across Arizona. This database holds to include ways that cities and towns are recognizing the water-energy nexus.

   On a separate matter, a municipality (or perhaps private developers) could partner with EPIC at ASU as part of a fee-for-use project to investigate its current policies and determine opportunities for improvements.

4. Desert Water Harvesting Initiative (DWHI) Toolkit
   www.wrrc.arizona.edu/dwhi
   The DWHI Toolkit is available online through the WRRC. It can be used to structure a facilitated assessment of a community's local resources and water harvesting opportunities and to determine how or whether certain water harvesting options could work in that community.

Orange County Water District/OCWD (Presenter: Adam Hutchinson, Recharge Planning Manager)

The OCWD was formed in 1933 to protect the region's groundwater basin, which had begun to experience stresses such as notable depletion, subsidence issues, and saltwater intrusion. California water law supports this innovative system by requiring all well owners to pay to pump groundwater. This regional management approach supports the reliability of local supplies by providing the planning and oversight structure for the efficient capture and recharge of local flows (i.e., the Santa Ana River base flow as well as storm flow), as well as the strategic use of recycled water.

The OCWD employs several recharge facilities spread out over 1,590 acres (instream and off-stream locations), with infiltration rates that can average 10-12 feet/day. Over 100,000 af/yr of highly treated recycled water is stored through a complex groundwater replenishment system that first began in 1975. Currently, there is no direct potable reuse (DPR). Given the very high quality of the RO-treated recycled water, the DPR conversation may move forward within the next 10 years if conditions (e.g., climate, drought, public sentiment) allow.

The OCWD serves as a wholesale water broker for 33 water providers. These providers are assigned a basin production percentage (BPP), which represents how much water providers can pump from aquifer before the price increases/equalizes with the cost of imported water (supplied by the Metropolitan Water District). The BPP, which currently hovers around 70%, provides an incentive for providers to switch to imported water as a way of decreasing their maintenance costs on groundwater pumping infrastructure. This incentive structure is used to protect groundwater levels. Thanks to managed aquifer recharge (MAR) planning, the OCWD can store 334,000 af/yr into the aquifer, which is three times the natural recharge rate. This allows for greatly enhanced resilience in regional water planning.

Town of Camp Verde (Presenter: Stan Bullard, private water company owner)

Camp Verde has four water companies in town. One of these private water systems dates to 1865 and the establishment of the original military facility of Fort Verde. The largest company currently serves about 1,600 customers. As private water companies, rate change cases must go before the Arizona Corporation Commission (ACC). Such reviews are generally expensive, particularly for smaller companies. The last review cost $50,000, and the cost of such a rate change case itself cannot be recovered through the rate change.

The oldest water system currently has two wells online, which cumulatively produce about 376 af/yr. There have been water quality challenges, particularly with arsenic exceedance. A WIFA loan of $1 million allowed for the acquisition of surface water rights through the CAP, but there were restrictions on surface water withdrawal by the U.S. Fish & Wildlife Service because of concerns regarding aquatic species in the river. As a result, a seven-mile line was built into town from the Mongini Well site, in part through an exchange of the CAP water with Scottsdale. There are two wells there in operation at present, with 4 million gallon storage and 4 pressure tanks. The new wells have experienced some fluctuating water levels; water levels were at roughly 374 feet in 1999, then dropped around 25 feet in the 2000s, and then have more recently gone up again. Water loss is also an issue. There are approximately 45 miles of water lines underground. The current estimated water loss is around 14%. Until May 2014, however, the level was 25%. The discovery and repair of a leak has led to a notable improvement.

In terms of demand management, an increasing block rate was established in the last rate case (16 years ago), based on the requirements of the ACC, so users of over 50,000 gallons now pay a premium. There is currently no conservation tariff, but it will likely be required by the ACC the next time there is a rate change case. There is the possibility that coordination of water planning and local zoning rules would address the issuance of building permits and therefore how water companies would handle requirements to serve water to new developments. If the Town of Camp Verde were to pass a water adequacy ordinance, for example, a developer with a proposal for a new site would have to submit to the Town a certificate of water adequacy (as issued by ADWR), with indirect impacts on the private water utility. Water infrastructure development costs are generally paid up front by the developer, but the water company is supposed to pay back the costs, amortized over time.

Town of Chino Valley (Presenter: Mayor Chris Marley)
Chino Valley's water supply is 100% groundwater. There are two wells, but only one is currently in operation. The other well is sanded out, and there is no secondary supply. It produces about 500,000 gal/day at its peak in June. It serves about 700-800 customers *(rough estimates).* There are some arsenic hotspots in the Chino Valley area, necessitating regular water quality monitoring. Water use is about 90% residential. Most agriculture has left the area. The Town of Chino Valley is about 10,000, and the surrounding annexed area is equally as large. All surrounding residents are on private wells.

A notable water supply issue is tied to sheet flooding and inadequate stormwater collection systems. Finding ways of collecting that water, then allowing it to settle and clarify, could augment future injection projects. Injection wells would be very important, due to the presence of an impervious clay layer about 250 feet below ground, which prevents aquifer recharge via infiltration basins. Recharge projects would mitigate the ongoing depletion of the area's small aquifer (dropping at roughly one foot/year). Recharge would be helpful to mitigate this effect. In terms of wastewater, there are about 300,000 gal/day of polished effluent released into recharge ponds. Increased effluent recapture could also be helpful, but is challenging because of large areas of low density, with residents dispersed across of 5 and 10 acre lots. Much of the area grew, and then incorporated later. It is generally not cost effective to attempt to put in sewer system infrastructure or purple pipes for recycled water in these areas. There are efforts to expand the wastewater system to the high-density pockets and plan for future effluent reuse (likely through injection wells). Monitoring of wastewater for injection would likely be necessary, however, since some residents connected to the sewer system are on private wells, and there could arsenic exceedance issues.

Town of Clarkdale – A full summary is prepared in the *Water Primer for the Town of* Clarkdale (available at: http://www.wrrc.arizona.edu/sites/wrrc.arizona.edu/files/clarkdale_primer_forweb.pdf)

Town of Jerome (Presenter: Former Mayor Jane Moore)
Jerome is a small former mining town with a local economy based largely on the arts and tourism. There is a year-round population of 500, but perhaps 2,000-3,000 visitors/day. The water supply for Jerome comes from eight springs. The spring water is collected into two lines and then chlorinated where the two lines meet. Annual water use is estimated at around 450 af/yr. The fire chief estimates a 20% rate of lost/unaccounted for water. There are a few commercial establishments (restaurants/bars/hotels) as well as some B&Bs with higher water uses. An estimated 2/3 to 3/4 of water use is residential. With the exception of a couple of small vineyards, there is little agriculture. Water rates are separated by residential and commercial use. The current water rates, based on the number of people per household, are: \$25.36/month/1st occupant, then \$33.20/month/2 occupants, and ~\$41/month/3 occupants. Tiered water rates have been discussed, but not enacted as of yet. Commercial water rates are established at different levels. For a small business, the charge is currently \$38.99/month. For restaurants/bars, the bill is based on number of seats. Bills are set up to read per 1,000 gallons. Very few customers use more than 10,000 gal/month.

Water challenges include fluctuating spring flows (strongly influenced by snowpack and major rain events), water line maintenance, and complications from a gravity-feed system. The water infrastructure was built well over 100 years ago by the United Verde Copper Company (succeeded by Phelps Dodge). The Town took over the water system around 1964, and maintenance has been an ongoing chore. The leaks were fairly severe in the 1970s, and the system was sometimes held together with baling wire. There was an occasional need for trucked-in water. Also, the area's acidic soils eat away at the early cast iron pipes. In the mid-1970s, there was a bond to repair 14 miles of main water lines into town. The gravity-feed system relieves the town of operating a pump, but the fluctuating pressures in the system require vigilant valve and regulator maintenance.

Increasing water storage capacity (now at ~600,000 gal) is another goal. Storage is currently for fire suppression, but it can serve as a back-up supply during drought conditions. The town's hilly topography complicates the placement of additional 200,000 gal storage tanks. Large commercial structures in town are now required to install sprinkler systems, in recognition of limited water supplies for firefighting and a local history of significant town fires.
In terms of innovative techniques, Jerome's small size allows for effective public outreach through word-of-mouth and postings in commercial spaces. Conservation incentives have been discussed, but are difficult to fund. In-town rainwater harvesting is being investigated, especially in regard to

outdoor water use. Land use controls are also being researched as a way of encouraging sustainable growth patterns over time and managing the amount of water usage allowable for different commercial activities. Because of the small sizes of yards, and the general lack of lawns, outdoor water conservation is thought to be of limited opportunity. As for effluent management, Jerome has an upgraded WWTP that generates about 56 af/yr. Effluent reuse is also complicated by topography, since the plant is downhill from the rest of the Town. The treated effluent, which is regularly tested, is currently released into Bitter Creek. It percolates completely into the ground before it reaches the Verde. Other options include using the effluent to support small-scale agriculture or as a new water source for downstream water users.

Town of Payson (Presenter: Buzz Walker, Water Superintendent/Asst. Public Works Manager)
Payson's unofficial Town Motto: "If it's wet, we drink it!" The major components of the Payson Water Supply portfolio include: the wastewater treatment plant, groundwater, Blue Ridge/Cragin Reservoir (at a cost of $50 million for access/infrastructure), groundwater recharge, and a groundwater remediation site (to treat contaminated water, such as from residual dry cleaning chemicals). Current water use is about 1,600 af/yr, with about 8,000 connections and safe yield is 2,500 af/yr.

Water challenges include: 42 drought-sensitive in-town groundwater wells, growth pressures on a limited water supply, state laws not conducive to growth management *vis a vis* limited water supplies, restrictions on the expansion of the water system due to the presence of Tonto National Forest surrounding Payson on all sides, and limited funding opportunities.

Groundwater recharge will be a critical component to Payson's water management efforts. Payson will operate 12 aquifer storage and recovery (ASR) wells utilizing excess CC Cragin reservoir surface water. An example of effluent reuse for recharge efforts would be Green Valley Park, jointed paid for by the Town of Payson and the sanitary district. The Town owns the "bowl" of the reservoir and parkland, and the sanitary district provides enough water to take care of a 40-acre park/reservoir. The water percolates into ground and recharges the aquifer, which supports the town's wells. Excess treated effluent is used throughout Payson for golf course and sport field irrigation thus saving local groundwater for potable uses.

A central groundwater remediation treatment facility has been built in central Payson for treating contaminated water from seven central Payson wells contaminated by the improper disposal of dry cleaning chemicals and leaking underground gas station storage tanks. A cone of depression is also maintained to keep the contaminated water from flowing downstream. This system has been in operation for about 13 years and has reduced contaminant levels from 13,000 ppb to 5 ppb. (The federal standard is 5 ppb.)

Payson has also secured surface water rights in the Cragin (formerly Blue Ridge) Reservoir. The town filed for water rights in the Little Colorado River in 1994. As part of the transfer of the Blue Ridge Reservoir from Phelps Dodge to the Salt River Project in the early 2000s, Congress authorized Payson to utilize up to 3,500 af/yr from the renamed Cragin Reservoir. The water from Cragin Reservoir would be pumped over the Mogollon Rim, then gravity would carry the water downhill to a 3 MW hydropower station. The power generated could then be carried back over the mountain to power the pumps that empty the reservoir. The water is fed into a new Payson raw water pipeline near the head of the East Verde River. From there Payson's pipeline transports water 12.5 miles to a new hydroelectric generator and membrane filtration water treatment plant then an additional two miles into town to use for the public supply and excess water will be used for ASR work. The water's use is restricted, in that it cannot be severed and transferred to other users. Acquiring and planning for the use of these water rights so far has required four acts of Congress, with additional funding still needed. WIFA has been an instrumental partner in assisting with funding opportunities.

Town of Pinetop-Lakeside (Andy Romance, Director of Engineering and Public Works)

Pinetop-Lakeside has a year-round population of 4,200, but the arrival of summertime residents expands the Town to 21,000. There are no public utilities in the town. Arizona Water Co. is the largest water provider. Sanitary sewer is provided through the Pinetop-Lakeside Sanitary District, but it is not directly affiliated with the Town. In terms of local conditions, the Town receives roughly 24 inches of rainfall annually. Elevation ranges from roughly 6,800-7,800 ft. There is a local irrigation water right dating to 1903 – predating the creation of SRP.

The lack of a public utility creates limits on what the Town can do to shape water usage, as well as in the implementation of land use plans and in fire suppression efforts. The current council is considering becoming directly involved in the water supply/management business. The alternate approach of collaboration and facilitation instead of outright ownership of a public utility is also being reviewed.

Town of La Junta, CO (Presenter: Tracy Bouvette / Southeastern Colorado Water Conservancy District)

La Junta was founded in 1892. The upstream Town of Pueblo has a water right going to 1865, and Pueblo relies on its rights for severe drought, which is problematic for downstream users. The Arkansas River is "too thick to drink, too thin to plow," and it tends to have low flows even in average years, yet its basin covers close to 25% of the state. Low flows negatively impact the local farming economy. The Town has experienced a decrease in population, due to the closure of a sugar beet factory and water exchanges with the Denver area that undercut the local agricultural economy. The Town currently has about 7,000 residents. There are 14 groundwater wells that provide 100% of the potable water. Reverse osmosis units are required to filter the groundwater. About 30% of the initial water is released as brine into the Arkansas River. Credits are given for this water flow.

Funding options are often limited. Small private water utilities have almost no opportunities. The public utilities do have access to state revolving funds. Construction loans are also available from the Colorado Water Conservation Board. There are some grant programs (federal and/or state) for conservation implementation as well.

Water quality issues are also a recurrent challenge in many areas. There are 18 private water companies under orders to cease operation in Colorado because of naturally occurring radionuclides. Treatment would cost millions of dollars. There are currently efforts to address these concerns in hopes of finding sustainable solutions.
In terms of innovative practices, water conservation efforts have paid large dividends. The Town realized that a reduction in its peak summer demand could reduce a third of its $6 million capital loan. There was subsequently a coordinated effort to remove most grass lawns in town to achieve these savings.

The public utility, which has the power to tax or issue bonds for maintaining/improving systems, has been entering into partnerships with small private water companies. The private water companies remain autonomous and still manage the operations and billing, but have a more reliable supply due to new interconnects with the public utility. Several local water companies have roots in a water truck route in the 1930s, which were later expanded to well service and 2-inch pipes in the 1950s through governmental grants/loans. Several of these small systems are failing (some with as few as 26 connections). The private companies still are faced with challenges, such as the lack of extensive maps and detailed infrastructure inventory. Board members are often older in age as well, and it is becoming increasingly difficult to find replacements for board members. These negotiations have resulted in three interconnections, with the possibility of five more in the coming years. Most of the expansion has been in the area of gravity-fed systems. There is the possibility of including some with booster pumps, if the cost-benefit analysis works out.

Another innovative water management solution being pursued in the Arkansas River Basin is the creation of water authorities. Through an action at the County level, private water companies join forces to create a water authority, which then gives the private companies opportunities to pursue public funding and float bonds.

City of Safford (Presenters: Mayor Chris Gibbs and Eric Buckley, Utilities Manager)
Safford is one of only two Arizona municipalities that manages four public utilities (water, sewer, gas, and electric), although the service areas for the different utilities can vary substantially. Safford's water system has a service area that covers about 90 sq. miles. The water utility has 7,895 water connections serving 25,000 people. The WWTP, however, serves only the 10,000 residents within city limits. Over 1.2 billion gallons of effluent were produced in 2013 (~3,500 af). In past years, upwards of 4,400 af/yr have been produced (pre-drought). In terms of customer base, the system is about 90% residential. There are some large local users with limited conservation options. The state prison, for instance, used 4 million gal in the month of May 2014. The commercial customers have a flat fee for the WWTP sewer services. The sewer fee varies for households.

The Safford municipal system's primary water source is an infiltration gallery on perennial Bonita Creek. The land is mostly managed by the BLM. There are some endangered aquatic species in the creek. About three miles of aboveground pipes run through the canyon before exiting the canyon. The system is set up as a gravity feed system all the way to Safford. The system dates to the 1930s, and there are ongoing maintenance requirements. From about October to March, Bonita Creek can provide 100% of the water supply for Safford. Overall, Bonita Creek provides about 2/3 of Safford's water most of the year. After 19 years of drought, production has decreased about 20%. There is a difference in elevation of only 300 ft. in the gravity-fed Bonita Creek system, which is not quite enough head to create an opportunity for small-scale hydroelectric power. The galleries are buried about 25 feet deep in the stream bed. Several tests are conducted regularly, the results of which are sufficient to preclude a designation of the sources by ADEQ as "under the influence of surface water". The water quality is much better than from well production. Only chlorine is needed for treatment.

The Town has 10 wells to supplement the water supply. Submersible pumps are typically operated in the wells. There are four active pressure zones. Booster zones are scattered around to help with water lift and pressurization. The reliability of individual wells has fluctuated over the course of the drought. Safford is located in a major agricultural area. Cotton is the main crop, with some hay and other crops.

Water rights play an especially crucial factor in the Upper Gila River Valley, given the allocation regime set forth in the Arizona Water Settlements Act of 2004. There is some surface flow in the Gila at present (June 2014), but a person could just about walk across and stay dry. Senior water rights holders downstream around Coolidge have to be satisfied before Upper Gila Valley users. Safford only uses subflow per the settlement agreement. The farmers have surface water rights, but they must also abide by the settlement agreement (which affects their total water allotment – a combination of surface water and groundwater). City of Safford is allocated about 9,704 af/yr under the current settlement within the zone from Bonita Creek to the San Carlos Apache Reservation. About half of that is currently being used, so there is still room to grow within the allotment.

The farmers are forced to switch to groundwater pumping when there is low flow in the Gila, and Safford's wells can feel the impact. Overall, perhaps 30-40% of the wells in the valley are currently either dry or sucking sand. There are about 22,000 acres of farmland lying fallow because of the drought, the water settlement restrictions, and pump problems. Agricultural water conservation can be a double-edged sword. If farmers conserve more than 10% of their water rights, then the reliability of their water rights may be called into question. There is the added complication of retired farmlands. FMI's predecessor Phelps Dodge bought several farms in past years to gain access to water rights. At present, FMI has not actively used the rights.

The Water Reclamation Plant takes on about 900,000 gal/day. It could handle up to 2 million gal/day. It produces grade A+ effluent, most of which is pumped to a local golf course. Some has been made available for an adjacent hayfield for agricultural education.

The water utility has dealt with a range of challenges. The Safford Valley is rich in archaeological resources, so the installation of water mains can involve a fair amount of supervised digs – and potential delays. Water quality issues arise as well, especially regarding nitrates tied to the region's agricultural practices.

There have been significant expenses tied to storage tank construction/refurbishment, system maintenance, and the search for new water sources. The newer storage tanks cost about $6 million. There was an additional $3 million in debt for well field and transmission line improvements. WIFA has been a crucial partner in these projects. Because of careful management over time, communities tied to the public water utility have continued to enjoy high quality, lost-cost water for many years. Last year, however, a rate change was proposed and adopted. In some cases, rates went up at 300%. In the last few years, the drought has forced water restrictions and conservation-oriented rate increases. The rates now run from $1.44/gal up to $4.30/gal. This may still be cheap at the state level, but it was a cause of great discontent locally.

In search of water security and reliability, Safford has had success in applying several initiatives to improve its water management planning. The city utility has worked hard to develop a secure water storage system. There are 19.5 million gallons of storage in the system. These include steel welded tanks and concrete tanks. The largest component is an underground storage tank with a 10 million gallon storage capacity (dating to the 1970s). There were failures in the liner, and there was a substantial water loss. The lost water didn't appear for a long time, and then it resurfaced with little notice near the utility shed at Discovery Park. A tattletale drainage system was installed during the refitting in order to catch future leaks.

The search for new water sources is ongoing and has required cooperative efforts and the clearing of a variety of regulatory hurdles. Some sites for new wells were located on UA land, located 1.2 miles from the City. Permission was finally granted for transmission lines to cross BLM land and to follow a state highway. This expedited approval took 18 months. These two new wells will not have high water production levels (perhaps 700 gal/min), so they will only serve as supplemental water sources.

Data collection and technical adaptation are increasingly important for Safford's water system. The mining company Freeport-McMoRan (FMI) has assisted in the drilling of several piezometer wells. As the data collection process continues, more information will allow for better water management. FMI has also helped in other projects, such as experimentation with a siphon system to augment the gallery infiltration system on Bonita Creek.

Water conservation has improved in response to the drought. Two years ago, the Mayor issued an emergency declaration for water restrictions. The ordinance was then reworded and categories of restrictions were created. This has led to a 16-17% reduction in water use. Perhaps a 30% reduction would be better. Even with the rate increases, about 20% of the revenues were cut by the conservation. Projects have been delayed, and in-house work becomes more common (as opposed independent contractor work).

Enforcement is a tricky subject. The ordinance, as currently written, allows for warning letters before a citation is issued. Only one citation has been issued to a major water user at present. Explanations of the water restrictions were sent out twice in the water utility bill. By way of comparison: Gayle Maberry (Clarkdale) described the signage placed all over town to alert neighbors to water alert levels. Ellen Yates (Clarkdale) mentioned that many warnings have been issued. Two citations have been issued in seven years.

Safford has developed an acute appreciation for the problems of water scarcity in times of extended drought. Being mindful of an old African proverb: "When the watering hole dries up, the animals look at each other differently," Safford hopes to build resilient partnerships with its neighbors in the future to help maintain mutually beneficial relationships during times of drought.

Town of Thatcher (Presenter: Mayor Bob Rivera)

Thatcher has 4,965 residents (2010 census). The Town does not currently have its own public water utility. Several hundred water connections are part of the Safford water utility, particularly in the older parts of the Town. Outside of Old Thatcher, there are a substantial number of private wells. The Town is in the process of consolidating local electric utility management for its residents from the local Co-op.

Thatcher recently upgraded its wastewater treatment from a basic lagoon system to a wetland treatment system, partly due to the encouragement of a cease and desist order. The effluent, produced at the rate of about 400,000 gal/day, is in the range of Class B, and cannot be used on food crops. ADOT, Graham County, and the railroad have agreed to allow a 4-inch line (uphill) through a ditch beneath the state highway, county roads, and the rail line to transport the recycled water for use as irrigation on certain publicly owned properties. Potable water would no longer be needed for these recreational fields or the cemetery. The goal is to have this improvement up and running within a year.

Water conservation is regularly promoted, especially through the reduction in outdoor water use. Convincing residents to switch to xeriscape landscaping is an ongoing challenge, however. Public outreach and education remain very important in alerting residents to the issue of water scarcity and in encouraging water conservation. Mayor Rivera pointed out how he seeks to communicate the same message five times in five different ways. Reaching out to the school system has been especially effective in sharing the message with schoolchildren, who then can encourage water conservation at home.

City of Sedona (Presenters: Charles Mosley, Director of Wastewater Department, and Keith Self, Division Manager at Arizona Water Company)

Sedona has two private water providers – Oak Creek Water Company (serving about 1 sq. mi.) and the Arizona Water Company (AWC). (The issues facing the operation of AWC are explained after the discussion on effluent management.) The City of Sedona operates a wastewater treatment plant, which is located along Hwy 89A. At present, the effluent management plan envisions the continuation of about 100 acres of spraying, maintenance of the current 27 acres of wetlands, and development of up to 6 injection wells. The injection wells don't need much of a footprint – perhaps one acre/well, compared to other options.

Effluent disposal/reuse efforts have been dealt with quantity and quality issues in recent years. At the time of construction, ADEQ required as part of the permitting process that the water not leave the site. Production was initially about 600,000 gal/day. Once effluent production reached about 1.4 million gal/day, ADEQ required modifications to the effluent management plans to supplement the use of spray irrigation. Three options were reviewed: utilizing continuous spraying, utilizing wetlands, utilizing injection. Percolation rates were decreasing in the area being sprayed, due to chemical reactions in the soil. After a meeting with council, the decision was made to create 27 acres of constructed wetlands. It eventually became Sedona Wetlands Park. This was initially established as an effluent disposal project through evaporation and transpiration. There were impermeable soil layers beneath which prevented full infiltration. The CSAMT method was used to find suitable locations for test injection wells (at 30 to 60 day tests). As a result of the tests, there was evidence that up to 400 gal/minute could be injected.

Effluent quality issues went beyond questions of regulatory compliance, as there was notable concern in the community about contaminants of emerging concern (CECs). Testing of the effluent revealed that CECs were filtered out at levels approaching 95-99% removal. The pathogens would be more of a concern than the CECs. These results will be an important component of public education and outreach going forward. Monitoring of the injected effluent will continue into the future. Since sucralose (the main ingredient in sugar substitutes like Splenda) apparently was not showing much degradation in the treatment process, it could be used as an indicator of the spread of injected water.

Effluent treatment capacity has also been in flux. The initial plan contemplated the ability to achieve two million gal/day of treatment capacity. Tests indicated that only 1.4 million gal/day could be adequately treated due to changes in the strength of the wastewater entering the plant. Discussions with Prescott revealed that a similar challenge had been experienced there, and the response there served as a helpful model for Sedona.

Restaurant sewer charges have been revisited. Previously, restaurants had been charged based on their number of seats. Some restaurants found this approach problematic, since they might only serve breakfast, or lunch and dinner, or just dinner. Under the revised wastewater rate, sewer charges for restaurants are adjusted based on water usage. Alternately, if there is no water meter, there is the option of setting a sewer rate based on the square footage of the restaurant. Using water usage as a guide for setting rates has been explored; however, the bulk of the costs to the sanitary system is based on fixed costs, not just on the water usage. The charges are intended to reflect some of this cost structure.

A regional water credit program might spur on additional efficiencies and conservation initiatives. Sedona and other Verde Valley communities are not currently in an Active Management Area (AMA) or any other regional groundwater management district. If such a regional effort were to be created, other communities might point out that Sedona's gpcd averages are high compared to their own. In such a system, water credits might be a useful tool to motivate additional water conservation.

Background on the Arizona Water Company (Keith Self)
The Arizona Water Company (AWC) was originally incorporated in 1955 in Bisbee when the Town of Bisbee got out of the water business. Since then, AWC has expanded throughout the state. AWC has 10,700 connections in the north-central region and serves most of Sedona and portions of other communities, including Oak Creek. In the early stages of the development of Sedona, each subdivision would have its own tank and well system. AWC began to purchase and consolidate these systems, with a focus on improving infrastructure. The current system utilizes 100% groundwater for its water supply. There are 22 wells with a daily demand of 3.5 million gal (about 3,500 af/yr). There are about 3,600 connections in Sedona. About 16% of the customer base is commercial in nature, mostly in Sedona.

Challenges for this system are similar to those already mentioned today. Maintaining aging infrastructure ranks high on the list, particularly given the complex interconnections among combined systems in the Sedona area. New regulations, such as those governing water quality, can be very demanding. Addressing revisions to the acceptable levels of arsenic is a case in point. Toward Rim Rock, arsenic levels approach 44 ppb in the groundwater. Closer to Sedona, the level is ~9 ppb. Also problematic is the effort to expand the system to meet new demands. A new gravity tank has been in discussion, but finding a location acceptable to the community has been very difficult. As a result, the alternative of using a buried tank with a booster pump is being explored.

In terms of innovative approaches, a range of tools is being used to promote water conservation. In recent years, a tiered water conservation rate was introduced. Since then, there has been an 8% decrease in water as a result. All of the different communities tied to the AWC system are now on the same rates. Investing in conservation and leak detection can be costly. The Sedona system received a particularly notable rate increase during its last rate case hearing before the ACC, which helps to defray such expenses. Additional conservation efforts could create further benefits, especially since the water consumption level in Sedona is currently at 345 gpcd (inclusive of commercial and residential users). A Best Management Practices guide (BMP) has been adopted to encourage conservation in landscape management and outdoor water use. Water waste rules are in effect, and investigations have been carried out. New homeowner programs have been implemented. Customer high water use notifications have been used as well. Leak detection has also been an ongoing project. "Nonrevenue water" losses were at 9-10% on average. So far, the conservation rates seem to have had the most impact on decreasing per capita water usage. (Terminology: Instead of a category such as "nonrevenue water" or "lost/unaccounted for water", AWC has three categories of water: sold, unsold, and unsold/accounted for.)

The AWC is also exploring ways of tying sewer rates to water use. Part of the complication involves the integration of potable water accounts and sewer accounts (currently set at a flat monthly rate of ~$13/mo.), which have been managed separately. A successful connection of the two could result in notable conservation dividends, since it could allow for a clear demonstration to customers of their water use. Understanding their comparable water use over time (including seasonally adjusted patterns) would lead to more informed customers, and potentially lower per capita water usage.

Getting approval from the ACC has been critical to allow for funds to maintain/improve infrastructure. In a sense, AWC can't afford not to submit a rate case to the ACC. In 2013, the ACC adopted a policy that would allow systems to make infrastructure improvements without having to move forward with a rate change case. The Residential Utility Consumer Office (RUCO) has just filed a lawsuit challenging this policy out of the concern that it would result in the double billing of consumers, and the case is still working its way through the court system. This case is being watched with a great deal of interest.

A final note on the public/private water system discussion: A private water supplier can offer the benefit of a specialization in water provision (no distractions from other utility services) and experience/expertise. Cooperation with other entities remains crucial in planning and cost management. Negotiations over public rights-of-way are important, and good planning is critical to reduce failure of equipment and in the coordination of road replacement with utility maintenance/replacement.

City of Sierra Vista (Presenter: Scott Dooley, Public Works Director)
The U.S. Army installation of Fort Huachuca was established in 1875, and it remains a major employer in the area. The City of Sierra Vista grew up around the military base, and now has a population of 43,888 (2010 Census). In 1988, Congress created the San Pedro Riparian National Conservation Area (SPRNCA) in recognition of the unique attributes of the San Pedro River. Addressing the groundwater deficit has been crucial in assuring the continued operations of Fort Huachuca and the City's economy. Water management efforts take a variety of forms. Groundwater recharge has been a major component of the WWTP program, which is responsible for about 2,500 af/yr of recharge. Cochise County has a water adequacy requirement, like Clarkdale and Yuma County. Regional cooperation has led to the establishment of regional recharge projects. Sierra Vista has participated in the Upper San Pedro Partnership (involving 21 different organizations) as a way of engaging with other local governments, agencies, and organizations in the watershed.

There have been a large number of studies funded by federal authorities, among others. It took quite a while to understand the components of the local hydrology and the effects of human consumption patterns. The resulting data have informed the development of action plans and the creation of numerous initiatives in targeting the most effective and efficient methods to address the cone of depression. The studies are available on the Upper San Pedro Partnership website (www.usppartnership.com).

Sierra Vista has implemented a variety of innovative approaches in its water management planning. New developments which create new stormwater volumes are required to find ways of shifting this stormwater into recharge areas, such as nearby washes. Building code changes have also been made in order to promote conservation. These include the establishment of low impact developments (LID) with landscape restrictions as well as the use of low flow toilets and other water-efficient fixtures. Sierra Vista was the first community in the state to adopt WaterSense standards. (Nearby Bisbee was second.) Sierra Vista probably has the largest municipal compost operation in the state. Biosolids from the wastewater treatment process are incorporated into the composting operations.

The Cochise Water Project has helped to promote voluntary water conservation, with special efforts to reach out to residents on well water who live in or near water-sensitive areas. A public-private partnership (supported in part through Walton Family Foundation support) has allowed a network of recharge basins to be constructed near the river to collect and capture stormwater/surface flow and allow it to percolate in order to support the groundwater levels and sustain base flows in the San Pedro. There is also a new toilet replacement effort to change out 1.8 gal/flush toilets with 0.95 gal/flush toilets, for instance. Rainwater harvesting rebates and demonstration projects are also serving to increase awareness and promote conservation.
By way of comparison, Fort Huachuca can dictate a variety of compulsory conservation standards regarding on-base activities. The base has incorporated LID standards, applied reclaimed water to public recreation areas, and mandated water-efficient fixtures. The conservation efforts have been so successful that there are currently some problems with achieving sufficient sewer system flows for adequate sewer operations.

The City has made headway in addressing groundwater deficit issues, and other methods continue to be explored as ways of managing/recharging groundwater. The Environmental Operations Plant (a.k.a., the wastewater treatment plant) lies between the river and Sierra Vista's cone of depression created by groundwater pumping. The recharge basins there have very high infiltration rates. Their location helps to buffer the river from the effects of the cone of depression. This was the first recharge facility outside of an AMA that began accruing credits for future use.

The most critical local water management challenge remains how to address the impacts of the cone of depression created by groundwater pumping. The USGS modeling has helped to determine that recharge directly into the cone of depression might not have the intended effect, especially in the short- to medium-term. The use of the near-stream infiltration basins managed by the EOP has demonstrated that recharge could have dual benefits of protecting the river flows and addressing the cone of depression.

Other outstanding issues include the "Tribute Development" court case and the SPRNCA reserved water rights. A decision was recently handed down by a Maricopa County Superior Court, and an appeal is likely. There are also questions regarding the implications of the Gila River Adjudication on the San Pedro watershed.

Responses Received: 18
Number of Attendees (not including Clarkdale Team): 25
Response rate: 72%
Overall, attendees who responded to the survey found the Forum very useful (an average rating of 8.5 on a 1 to 10 scale) and all indicated that another Forum would be useful. One participant noted that it was "Very useful to get all the organizations represented at such a high level. Story telling is critical to change management and preparing for the future." This sentiment is reflected in the single most valuable element of the forum being the Share Your Story presentations (average rating of 9.125). When asked what their favorite aspect of the Forum was over half of the respondents to the survey indicated the opportunity to hear about other town's challenges and solutions. The remaining elements of the Forum, presentation on Clarkdale's water management issues and recommendations; tools and funding opportunities; evening social hour and SWOT exercise, all received an average score of about 7.5.
When asked what was the most valuable thing they learned at the Forum, participants discussed the value of understanding that each community is not in it alone, and that while they each face specific challenges there are lessons to be learned from other approaches. Specific responses included:

- Hearing about the similarities in each town's issues, and the governance issues each faces and how they address them.
- That private, small water providers do not always have their community's best interests in mind.
- Some different ideas we will have to look harder at.
- I gained an understanding of the differences and similarities of issues small systems face. All are unique, but some common threads
- Financing options; growing recognition of effluent as a critical resource; innovation/efforts to address local issues
- How the various towns have dealt with the drought in regards to rate structures, restrictions and media.
- What is being done, what is available, the hurdles of regulation that is likely to be encountered as one proceeds. The huge expense involved.
- Coming together, working together, sharing. That was a take-away from the SWOT priorities and that is a difficult thing to do but critical for water management.
- The need for collaboration and open lines of communication between all stakeholders.

Suggested improvements to a subsequent Forum included broadening the scope beyond the Verde Valley more, as the first part of the meeting was very focused on Clarkdale and the SWOT exercise ended up being about collaboration in the Verde Valley. Three participants thought that nothing should be changed. Other suggested improvements include:

- Limit comments from non-water providers.
- A matrix listing available actions municipalities can take to improve water management.
- More framing at the front end would help to manage participant expectations and help to guide participants in their role in the forum.
- I would add a legal component. Someone that can address the legal avenues to managing water in Arizona, the various legal structures that could be put in place, etc.
- More round robin discussions from the towns. I was very interested in hearing from them as to how they have been working through the water shortages.

As indicated above all participants who answered the survey thought another Forum should be held. Most survey respondents thought that a second forum should be 2-days long. The most common suggestion for topics at a second Forum was more share your story sessions, but including additional towns. Other ideas for topics to learn about or discuss at a second forum include:

- A list of water saving strategies, their effectiveness, cost to implement and if they are measurable
- Geology, forest issues and water
- More topics about water supply development and less about individual water system operations.
- More ideas on better use of reclaiming water and funding sources
- Legislative changes needed for better water management. Legal options to better manage groundwater, water use, zoning, etc.
- How legislation moves? Perspective on perseverance: Histories of major water projects.
- ACC impediments; land use/water use-what can communities do even with Prop. 207; resource planning; more on innovative strategies
- What did the communities do since the last forum? Did they use the tools? What happened?
- Randomly selected hypothetical situations and possible solutions. (brainstorming)