Arkansas Basin Implementation Plan Draft

Prepared for

The Arkansas Basin Roundtable

By

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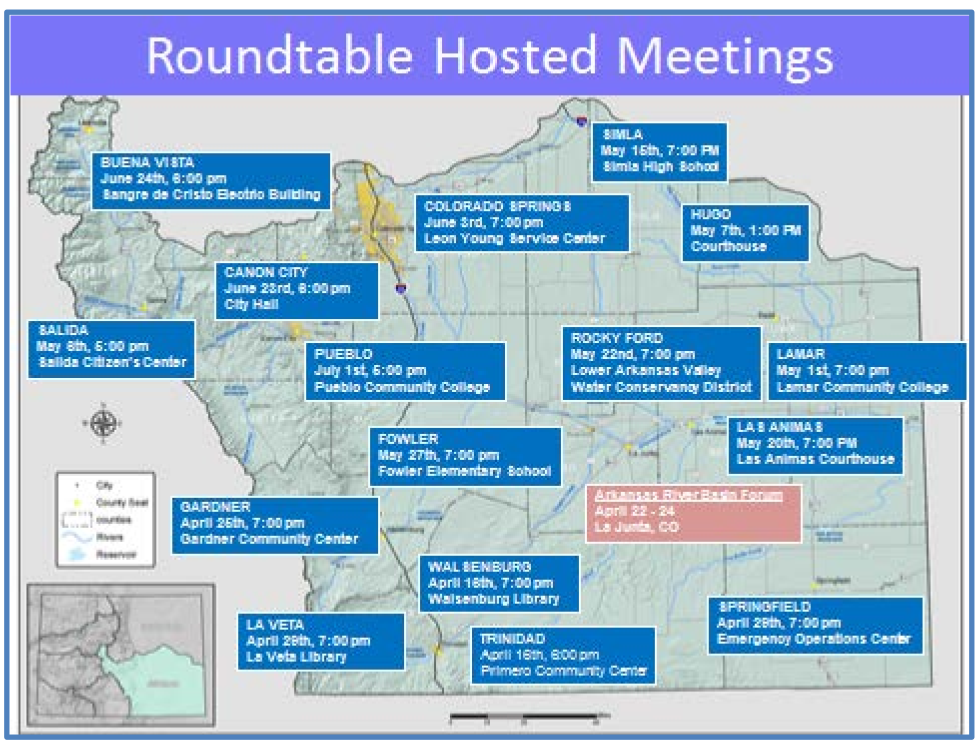
Executive Summary

Introduction

In the *Water for the 21st Century Act,* the Arkansas Roundtable was tasked with “proposing projects and methods to meet the consumptive and nonconsumptive needs of the basin.” In response, by 2012, the Executive Committee had begun a shift toward implementation, based on these conclusions:

- The seven years together studying the consumptive and nonconsumptive needs of the Arkansas Basin seemed sufficient. It was now time to put that experience into context and take action to address the multiplicity of needs;
- Recent extremes of hydrology were causing havoc in water administration; 2011 and 2012 were nearly the wettest and then driest years on record.
- The Roundtable needed to attract a broader recreational and environmental advocacy. Portions of the Basin had little or no representation.
- Agriculture is the bedrock of water usage in the Arkansas Basin, but its importance had not been well articulated.

Governor Hickenlooper’s 2013 Executive Order re-energized the Arkansas Basin Roundtable. A revitalized Roundtable embraced the charge to draft a Basin Implementation Plan, with a deadline of July 31, 2014. The Roundtable recognized the need to reach out to the citizens of the Arkansas Basin and organized a series of public meetings.



Given the recent challenges of watershed health, especially the devastating impact of fires and floods on all types of water resources, the Roundtable also organized a Watershed Health Working Group. An invitation was extended to federal and state agencies, non-profit entities with depth of experience in watershed health, and all basin roundtables. This initiative was coordinated with Colorado Water Conservation Board staff.

Following is a brief summary of what became clear through this process, along with emerging new perspectives. There are areas where further investigation is warranted and a description of the

Roundtable's focus in the near-term. There remains a commitment to continue the dialogue, both within the Arkansas Basin and within Colorado.

What became clear

What became clear was the interdependence of all water usage types, with agriculture especially important as the foundation of many other derived benefits. Augmentation and/or replacement of groundwater sources is critical in certain sub-regions. The pressure to permanently dry-up senior agricultural water rights is derived from the need to provide a reliable source for such replacements. The Arkansas Basin has gaps in all topic areas, with a need to more fully understand the dynamic between recreation, the environment, agriculture and the municipal sources of supply.

The hydrology of the Arkansas River basin, with imports from the Colorado basin and exports to the South Platte basin, when coupled with the Arkansas River Compact, is complex. The imports, with reservoir storage, underpin a robust recreational economy, support a healthy fishery and deliver water to cities and farms through a Voluntary Flow Management Agreement[1]. The interdependence of all four major areas of water usage (agriculture, environment, recreation and municipal) made it imperative that the Arkansas Basin Implementation Plan include the optional sections of Water Management & Administration and Hydrologic Modeling[2].

The mandates of the 1996 ruling in the lawsuit *Kansas v. Colorado* are primary drivers in water administration throughout the basin. Groundwater pumping, whether for greater agricultural efficiency or for community potable supply systems, requires replacement of depletions. The demand for "augmentation" is increasing while the main source of augmentation supply (fully-consumable municipal effluent) is pledged to meet municipal growth. Previous estimates of the municipal supply gap missed this double count of water: its current use for agricultural and its future use for municipal growth.

There is no "extra" water in the Arkansas basin. The current surplus of municipal return flow comes from mature municipalities, those founded in the 19th Century, which have sufficient municipal water resources for the foreseeable future. Population growth over the last 50 years has depended on groundwater, either non-renewable, hard-rock aquifers or alluvial aquifers. The alluvial aquifers known as Designated Basins are experiencing depletions that threaten the economic vitality of their respective communities. The hard-rock aquifers are non-renewing and approaching their useful life. In many rural areas, wells extended into the local alluvium are depleting groundwater rightly owed to senior water rights downstream, another need for augmentation.

Further investigation

The *Water for the 21st Century Act* divides the needs of the basin into two categories, consumptive and nonconsumptive. These terms have caused confusion, highlighting the need to better understand agriculture's current and future role. Previously, environmental and recreational uses of water were deemed nonconsumptive. Yet, as storage vessels are developed to increase the availability of

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[1] Section 4.4
[2] Sections 3.2 & 3.3

augmentation water, those same facilities may provide recreation. When wetlands are constructed to benefit the environment, improving water quality and habitat, they also consume water through evaporation. While locally beneficial, such increased evaporation will impact senior, agricultural water rights down stream

Greater clarity is also needed in the discussion about municipal conservation, or efficiency . Communities are different, have different needs and see conservation differently. "One size does not fit all." Enthusiast and advocates on the subject, many from outside the community, hold strong opinions. Is there a uniform way to measure improvements in municipal conservation? Education is essential to a productive conversation.

Where we are going next

The Public Outreach initiative generated over 100 Input Forms. The identification of needs and potential solutions will be read, processed and measured against the Arkansas Basin's goals and measureable outcomes. Additional information may be needed. The expectation is that the entity or individual generating the suggestion may be invited to present to the Roundtable for further illumination of the potential of a project or method. Since the Outreach meetings were organized by Roundtable Members, the Input Forms are sorted by sub-regions and watersheds.

Understanding regional needs and possible regional or local solutions highlights the need to disaggregate the municipal water supply gap. The 2010 edition of the Statewide Water Supply Initiative estimated the municipal supply gap in the Arkansas Basin for the Year 2050 as a range of 36,000-110,000 acre-feet. Imbedded in that range, which was established based on the probability of successful completion of the then Identified Plans and Projects (IPP's), was the assumption that water available for municipal use in 2008 would remain available in 2050. Since much of the municipal supply gap is for regions reliant on non-renewable groundwater, a more immediate understanding of local and regional supply gaps is warranted.

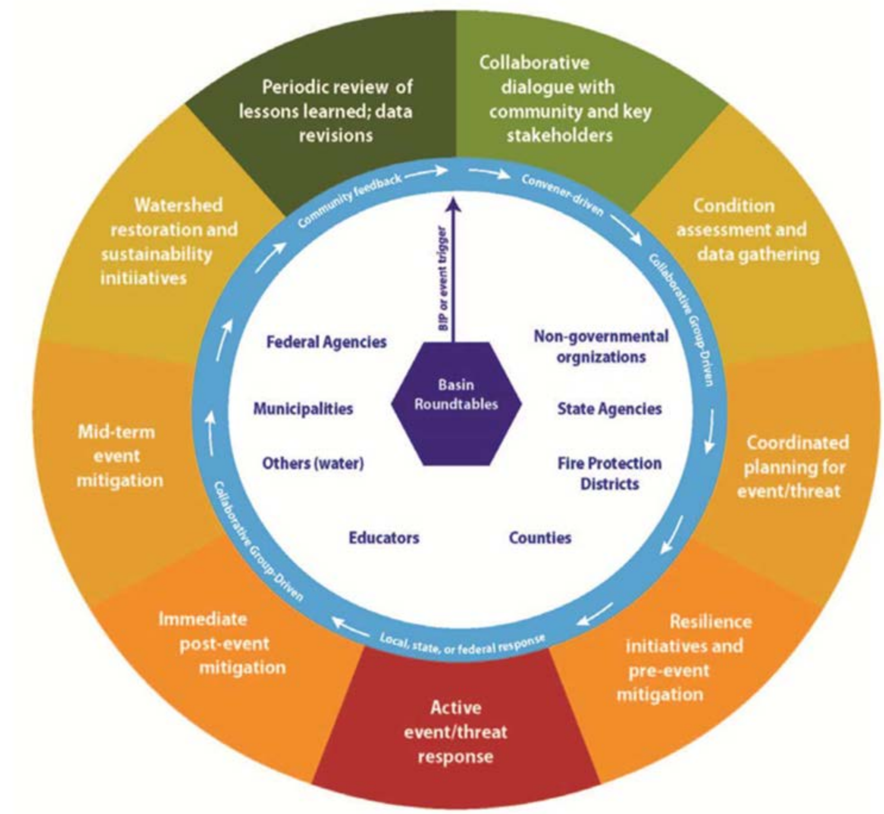
Regional solutions are emerging. A collaborative initiative began in 2009 to define the elements of rotating fallowing of agriculture. The Roundtable moved forward on three tracks simultaneously: technical studies, public policy investigations and pilot project to test these strategies. A noble effort, however, the efficacy of the outcome remains uncertain. In the meantime, regional solutions in the upper basin are emerging, the lower basin is gaining greater understanding of its challenges and the Pikes Peak region is investigating cooperative infrastructure configurations.

Continued Dialogue

All of these initiatives will be measured and understood within the context of the basin's hydrologic constraints and opportunities. In particular, as competing uses and potential reallocation of resources are proposed, the concepts will be evaluated within the context of water rights administration.

Since the Arkansas basin is an importing and exporting basin, the Roundtable is a stakeholder in the future of Colorado's Compact Entitlement.[3] The impact of watershed health extends beyond the basin boundaries and intersects with the interests of other Basin Roundtables.

Figure 4.2.4-11. Watershed Health and Emergency Event Life Cycle



The Watershed Health Working Group included many government agencies, along with non-governmental advocacy groups, in the facilitated dialogue. The tools and processes generated are now available to share with other basin roundtables.[4] A highlight is the Emergency Event Life Cycle, which evolved from a sketch to a consensus model for community response to watershed values.

Summary and Challenges

The Arkansas Basin Roundtable prides itself on both the quality of its dialogue and its willingness to embrace the difficult issues facing Colorado's allocation of its most precious resource: water. Reconciling one hundred and fifty years of water resource development and administration with our 21^{st} Century values is an enormous task. The Roundtables are charged in the *Water for the 21^{st} Century Act* with "proposing projects and methods to meet the needs of the basin." This first draft of the Arkansas Basin Implementation Plan moves in that direction, with recognition that all needs may not be met to every citizens' satisfaction. Further investigation is needed in many areas, particularly with regard to sustaining agriculture as the cornerstone of environmental and recreational uses. The irreplaceable element for the future of the Arkansas River Basin is the continuation of the dialogue, predicated on the willingness by the Arkansas Basin Roundtable to solicit and then understand the voices of its residents.

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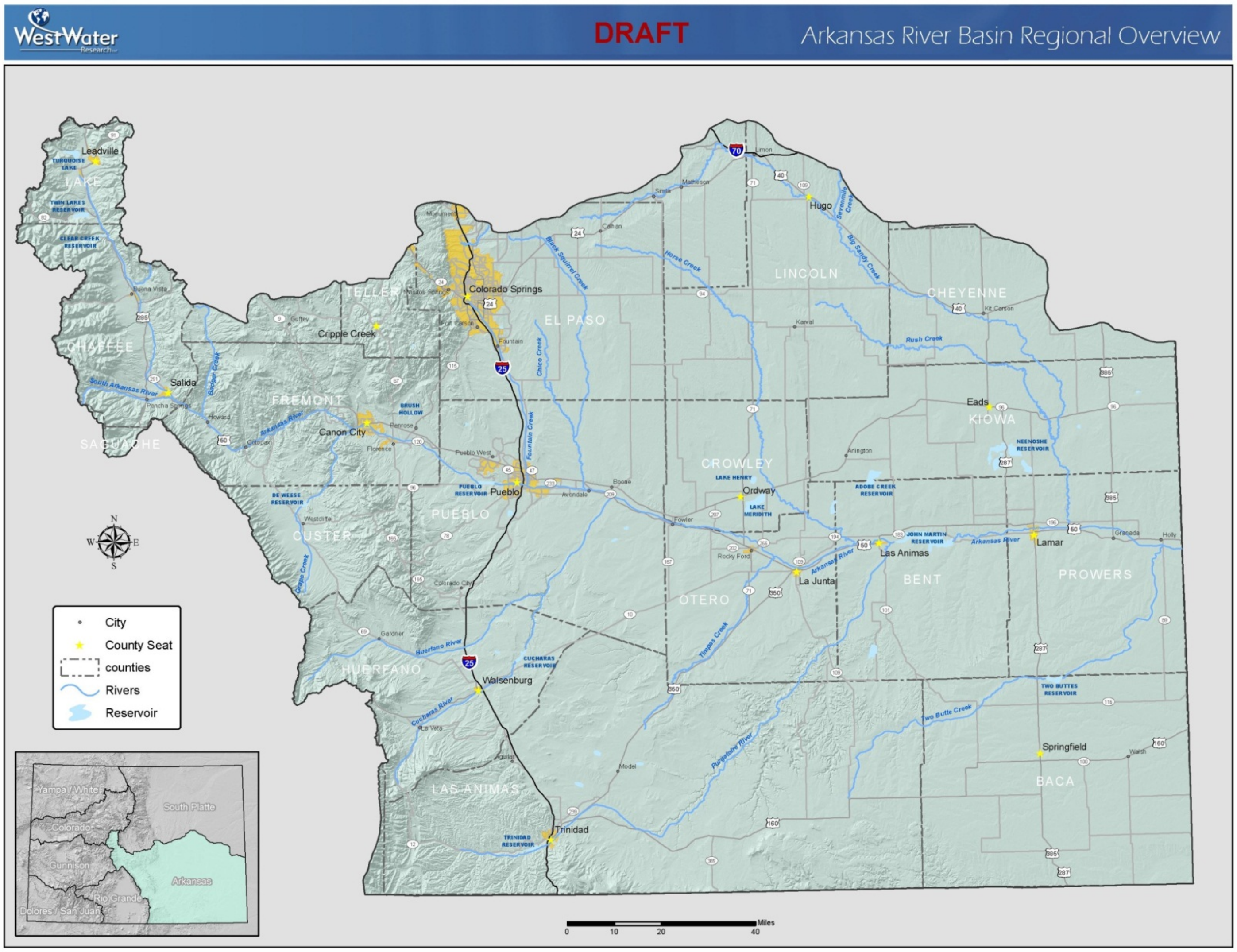
[3] The Colorado River Compact allocates depletions to the Colorado River between seven (7) States. The Intebasin Compact Committee, created by the *Water for the 21^{st} Century Act,* has completed a set of principles embodied in a Conceptual Agreement regarding future development of Colorado's share of the Compact. See Section 4.8.

[4] Special thanks to the Watershed Group of Colorado Springs Utilities, who generously supported this program with manpower and GIS mapping. See Section 4.2.

Section 1 Basin Goals and Measurable Outcomes

Figure 1.0.1 - Map of the Arkansas Basin, Source: WestWater Research, LLC



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1.0 Background and Basin Overview

The Arkansas River is a major tributary to the Mississippi River, with its headwaters in the Rocky Mountains starting at an elevation of 14,000 feet, and entering the Great Plains just past Pueblo, Colorado, continuing eastward into Kansas, at an elevation of 3,340 feet. The Upper Arkansas River (from the headwater through Big Horn Canyon) supports significant tourism and recreation. The Middle Arkansas River Valley, which includes the City of Pueblo and Pueblo County, along with the Fountain Creek Basin, the City of Colorado Springs and El Paso County, comprises the largest urban area. In the Lower Valley below Pueblo, the Arkansas River supports significant agriculture, primarily fodder crops and row crops for human consumption—pumpkins, squash and melon fruits.

In the Huerfano and Purgatory River Basins, there is a mix of agricultural, mining and tourism. A large area of the Arkansas River Valley, in the eastern portions and north and south of the valley floor, is sparsely populated. There are few if any surface supplies. These regions are dependent upon groundwater or designated groundwater to support the livestock, irrigation wells, towns and industries.

The Arkansas River Basin is the largest basin by area in Colorado, covering over 28,000 square miles across the south-east region of Colorado. Grasslands and forest dominate the lands of the Arkansas Basin; grassland covers approximately 67 percent of the basin, primarily covering the eastern portion, while forests cover the western region, which lies in the Rocky Mountains, stretching into Colorado's Front Range. In addition to agriculture, recreation, and natural landscapes, the Arkansas River Basin supports approximately 1 million people, including two large cities, Colorado Springs and Pueblo.

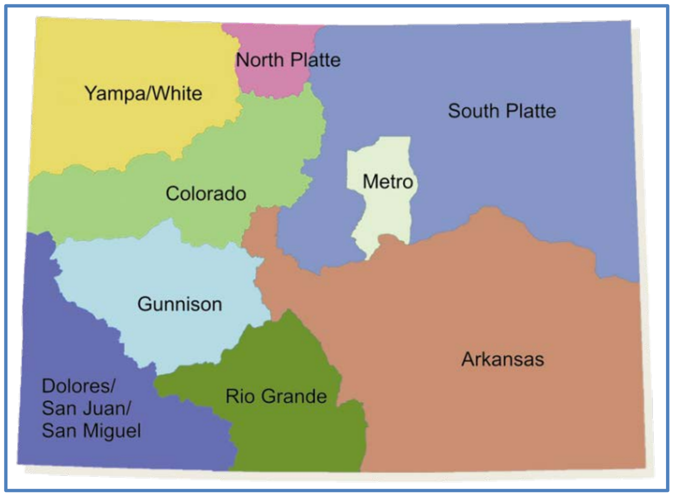
Limited water supplies in all areas of the Basin, declining groundwater levels in the nontributary Denver Basin Formations and the designated groundwater basins, extended droughts, land-use planning, growing demand, and economic changes have resulted in competing interests. Rural water users are concerned over agricultural transfers and the impact water availability has on rural communities and agricultural productivity along with declining groundwater levels and diminishing water quality. Concurrently, growth in the upper basin presents challenges to meeting municipal, industrial, and recreational demands. As a result of the current demand in the basin, there is little or no water available for new uses.

In addition to supporting its own demands, water from the Arkansas River flows through Kansas, Oklahoma, and Arkansas before its confluence with the Mississippi River. Along its course, it irrigates millions of acres of cropland and supports significant industry and shipping. The Arkansas River Compact of 1948 apportions the waters of the Arkansas River between Colorado and Kansas, while providing for the operation of John Martin Reservoir. The Compact is "not intended to impede or prevent future beneficial development… as well as the improved or prolonged functioning of existing works: Provided, that the waters of the Arkansas River… shall not be materially

Figure 1.0.2 - Arkansas River

depleted in usable quantity or availability…" (Article IV, para. D.). The primary tool for administering the Arkansas River Compact is the 1980 Operating Principles, which provide for storage accounts in John Martin Reservoir and the release of water from those accounts for Colorado and Kansas water users, and the Hydrologic Institute, or "HI" model, which calculates and tracks compliance.

Figure 1.0.3 - Roundtable Basins of Colorado

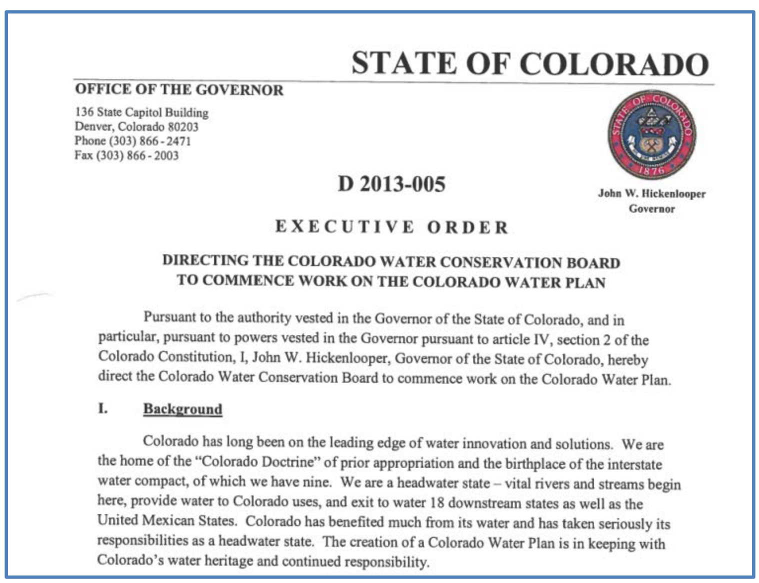


Colorado and Kansas have litigated claims concerning Arkansas River water since the early 20th century, which led to the negotiation of the Compact. In 1995, Colorado was found to have depleted stateline flows in violation of the Compact through the use of tributary groundwater. As a result, the Colorado State Engineer promulgated well administration rules to bring Colorado into compliance with the compact, and Colorado compensated Kansas for damage claims (approximately $34 million). Recently, the State Engineer also promulgated irrigation efficiency rules, which require augmentation for any upgrades to water delivery systems, such as drip irrigation or sprinkler systems.

With its varied geology and water uses, the Arkansas Basin has significant water challenges for the future. Agriculture has faced encroachment by municipal demands, while environmental and recreational water demands have increased significantly in the late 20th and early 21st centuries. Given the many competing demands for water throughout Colorado, in 2005 the Colorado General Assembly created the Arkansas Basin Roundtable, and eight other roundtables, with the passage of the Water for the 21st Century Act (House Bill 05-1177)[1]. The roundtables were charged with "proposing projects and methods to meet the needs of the basin."

The basin roundtables have become a platform for stakeholders to be heard and for future needs to be assessed in a manner consistent with the water values and culture of the region. The Arkansas Basin Implementation Plan, as an integral component of Colorado's first statewide water plan, is an initial culmination of a decade of effort by the roundtable.

Figure 1.1.1 - Governor's Executive Order



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John W. Hickenlooper
Governor

D 2013-005

EXECUTIVE ORDER

DIRECTING THE COLORADO WATER CONSERVATION BOARD TO COMMENCE WORK ON THE COLORADO WATER PLAN

Pursuant to the authority vested in the Governor of the State of Colorado, and in particular, pursuant to powers vested in the Governor pursuant to article IV, section 2 of the Colorado Constitution, I, John W. Hickenlooper, Governor of the State of Colorado, hereby direct the Colorado Water Conservation Board to commence work on the Colorado Water Plan.

I. Background

Colorado has long been on the leading edge of water innovation and solutions. We are the home of the "Colorado Doctrine" of prior appropriation and the birthplace of the interstate water compact, of which we have nine. We are a headwater state – vital rivers and streams begin here, provide water to Colorado uses, and exit to water 18 downstream states as well as the United Mexican States. Colorado has benefited much from its water and has taken seriously its responsibilities as a headwater state. The creation of a Colorado Water Plan is in keeping with Colorado's water heritage and continued responsibility.

1.1 Process Overview

The Arkansas Basin Implementation Plan was developed by the Arkansas Basin Roundtable to meet the charge given by the Governor of Colorado, directing the Colorado Water Conservation Board (CWCB) to produce a Colorado

[1] Colorado Revised Statutes 37-75-101 *et seq*.

Water Plan. In May, 2013, Governor Hickenlooper's Executive Order D2013-005, directed the CWCB to commence work on a statewide water plan (Figure 1.1.1). Colorado's Water Plan will be an aggregation of the nine roundtable basin plans, building on a decade of water planning known as the Statewide Water Supply Initiative (SWSI). The draft Arkansas Basin Implementation Plan was delivered to the Colorado Water Conservation Board on July 31, 2014, and will subsequently be incorporated into Colorado's Water Plan, a draft of which is due to be delivered by CWCB to the Governor on December 10, 2014.

The Arkansas Basin Implementation Plan provides stakeholder input into the future of water with the goal of building on previous work mandated by HB05-1177; that work was to propose projects or methods to meet the needs of the basin and utilize unappropriated waters where appropriate. However, as one of the earliest regions of Colorado to have been settled in the 19th Century the Arkansas River basin has no unappropriated water.

This work builds on the Statewide Water Supply Initiatives of 2004 and 2010 (SWSI 2010), which determined that every basin faced future gaps between supply and demand. Between SWSI 2004 and SWSI 2010[2], the Arkansas Basin Roundtable developed a report in 2009[3] which it submitted to the CWCB. An update in 2012 was followed closely by the Governor's Executive Order.

To meet the requirements of the CWCB and the Governor's order, the Arkansas Basin Roundtable, initiated an information gathering and planning process. This included:

Figure 1.1.2 - Planning Process, Source: WestWater Research, LLC

Since its inception in 2005, the Arkansas Basin Roundtable continues bringing together committee members representing water stakeholders throughout the basin to discuss and plan for a sustainable water future. Basin Roundtable priorities include:[4]

- Increase available storage;
- Maintaining agricultural viability in the lower basin;
- Providing for in-basin augmentation in the upper basin;
- Providing for adequate water quality to meet all needs;

[2] http://cwcb.state.co.us/water-management/basin-roundtables/Documents/Arkansas/ArkansasBasinNeedsAssessmentReport.pdf
[3] http://cwcbweblink.state.co.us/weblink/0/doc/138829/Electronic.aspx?searchid=a68c88fe-3cc1-4003-9974-2d9aa8046e69
[4] Colorado Water Conservation Board, Arkansas Roundtable: http://cwcb.state.co.us/water-management/basin-roundtables/Pages/ArkansasBasinRoundtable.aspx

- Ensuring adequate water for future needs, such as:
  - Municipal and Industrial (M&I);
  - Agricultural;
  - Environmental; and,
  - Recreational.

The goals and stakeholder interests informed the work undertaken by the roundtable to determine its consumptive and nonconsumptive needs, examine water supply availability, and identify projects or methods to meet those needs.

1.2 Basin Themes and Fundamentals

From its inception in 2005, the Arkansas Basin Roundtable dialogue has focused on several themes and fundamentals, which were first described in the 2009 Meeting the Needs Report , again in SWSI 2010 and in the Meeting the Needs 2012 Update. (Appendix 1-A includes a summary of the themes and fundamentals specifically addressed in each of those reports.) The 2009 Report focused on meeting the future Municipal and Industrial Supply Gap and recognized the dependence of the Arkansas River Basin on Colorado River imports (Figure 1.2.1).

SWSI 2010 highlighted the importance of storage, provided a recognition that "gaps" existed in all water use arenas—agriculture, recreation and environment—beyond just a municipal supply gap. The 2012 Update reaffirmed these themes and identified several initiatives to address these needs. In particular, the 2012 Update began an implementation effort by the Arkansas Basin Roundtable that has now been integrated into this Basin Implementation Plan.

To develop Goals and Measurable Outcomes for this section of the Basin Implementation Plan, the Arkansas Basin Roundtable meetings in October, November and December, 2013 focused on dialogue about basin goals.

Figure 1.2.1 - Excerpt from 2009 Executive Summary

> ***MEETING THE NEEDS OF THE ARKANSAS BASIN* EXECUTIVE SUMMARY, 2009**
>
> Much of the water supply "Gap" of the Arkansas basin, nearly 20,000 acre-feet, could be addressed in the near term if, and only if, the Rotating Agricultural Fallowing method is coupled with regional cooperation on new infrastructure. However, the future of sustainability for both consumptive and nonconsumptive needs in the Arkansas is tied to the future of Colorado's entitlement under the Colorado River Compact. Presentations and reports by the Roundtable's Interbasin Compact Committee Representatives make clear the interdependence of Colorado River imports, both existing and future, with the longevity of irrigated agriculture within the Arkansas basin.

1.2.1 Basin Themes

The three broad themes identified by the Roundtable are:

1. Increased water storage is critical to all solutions;
2. The Arkansas Basin, as an importing and exporting basin with significant interbasin and interstate obligations, must meet its present and future water supply gaps by maximizing the use of native and imported water; and,

3. Stakeholders should take all actions required to maintain current water supplies and prevent future water supply gaps from increasing.

These basin themes reflect the values of the Arkansas Basin and provide broad goals for engagement across many stakeholders' areas of interest. They are also in accord with Section III, Declaration and Directives, of the Governor's May, 2013 Executive Order:

> *Colorado's water policy must reflect its water values. The Basin Roundtables have discussed and developed statewide and basin-specific water values and the Colorado Water Plan must incorporate the following:*
> - *A productive economy that supports vibrant and sustainable cities, viable and productive agriculture, and a robust skiing, recreation, and tourism industry;*
> - *Efficient and effective water infrastructure promoting smart land use; and,*
> - *A strong environment that includes healthy watersheds, rivers and streams, and wildlife.*

The Governor's executive order frames the dialogue in economic terms. Colorado's economic and environmental health is directly tied to its water resources, which support abundant recreation in addition to supporting vibrant ecosystems and habitats.

1.2.2 Basin Fundamentals

In order to acknowledge all of the stakeholders, their goals, and their needs, the Arkansas Basin Roundtable developed the following basin fundamentals to guide the Implementation Plan:

- Water supply gaps include all of the potential consumptive and nonconsumptive use categories: environmental, agricultural, municipal, industrial, and recreational;
- The Colorado-Kansas Compact[5] places unique constraints on water resource management within the Arkansas Basin;
- Regional extremes in hydrologic conditions require collaborative solutions from all stakeholders.

These basin fundamentals were agreed upon by the Arkansas Basin Roundtable in order to ensure that all stakeholders are included in the planning process, that all gaps are addressed, and that constituents acknowledge potential constraints to finding a sustainable water future. Water is critical to the economy of the Arkansas Basin: it provides for significant municipal populations, industry, agriculture, recreation, and tourism.

[5] Colorado Revised Statues 37-69-101 *et seq.*

1.3 Report Organization

This report is organized according to the requirements of the Basin Implementation Plan Guidance document, issued by the Colorado Water Conservation Board, with additional sections for background and basin specific needs. The report provides summaries of previously conducted studies and reports, details the current conditions in the basin, and provides information regarding identified projects and processes (IPPs) and methods to meet the Basin's needs moving forward.

Figure 1.3.1 - Report Organization

Executive Summary

Section 1	Basin Goals and Measurable Outcomes
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	1.3 Report Organization
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	1.5 Basin Implementation Planning, 2014
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	1.7 Summary and Challenges
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	4.8 Interbasin Projects and Methods (Optional)
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Section 6	How the plan meets the Roundtable's Goals and Measurable Outcomes

1.4 Basin Overview by Water Sectors

The Arkansas Basin Roundtable was purposefully organized by the Colorado General Assembly to reflect equal representation of the basin geography while providing specific voices for the sectors of water uses. Municipal representatives from throughout the basin, including a specific "small water provider" representative, are joined by multiple agricultural members, specific environmental, recreational and industrial representatives and seats for the water conservancy districts. Following is an overview of the main water sectors of interest within the Arkansas River Basin.

Municipal

In 2013, the Arkansas Basin, including Colorado Springs, Pueblo, and many smaller rural communities, was estimated to have a population of 1.03 million.[6] By 2035, the population is expected to increase by almost 41 percent, to 1.45 million. In 2005, municipal water use in the basin accounted for 5.84 percent of water withdrawals, over 106 million gallons per day. The Colorado Water Conservation Board estimates that by 2050 demand for residents and industry in urban counties (El Paso and Pueblo Counties) will be approximately 314,000 acre-feet per year;[7] by 2050, total municipal and industrial demand throughout the Arkansas Basin is estimated to be between 298,000 and 352,000 acre-feet per year.[8] The top five industries by economic activity in the Arkansas Basin include:

- Federal Government (military);
- Food services and drinking establishments;
- Public education (state and local);
- State and local governments (non-education);
- Real estate.

These industries continue to attract urban population growth and drive municipal development, the second largest consumptive use of water in the Arkansas Basin.

Industry

Industrial users (manufacturing, construction, etc…) withdraw approximately 74 million gallons per day, 4 percent of Arkansas Basin withdrawals; thermoelectric power generation withdrawals almost 37 million gallons per day, or 2 percent of the total; and, mining withdraws 2.8 million gallons per day, or 0.15 percent of total basin withdrawals.[9]

Agriculture

The Basin also supports a diverse agricultural economy, including crops and animal husbandry, which had total output over $1.5 billion in 2010; it was estimated[10] that irrigated crops accounted for over $1 billion of

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[6] Estimated using Colorado State Demographer's Office and SWSI 2010 data.
[7] Western Resource Advocates, (2012). *Filling the Gap: Meeting Future Urban Water Needs in the Arkansas Basin*.
[8] SWSI 2010 estimates, provided by CDM.
[9] Ivahnenko, Tamara, and Flynn, J.L., (2010). *Estimated Withdrawals and Use of Water in Colorado*, 2005: U.S. Geological Survey Scientific Investigations Report 2010-5002.
[10] Jake Salcone and James Pritchett, *Value of Water Used in Agriculture for the Arkansas River Basin,* February 4, 2014.

economic activity. Agriculture accounts for over 87 percent of water withdrawals in the Arkansas Basin, amounting to over 1.56 billion gallons per day,[11] and for 80 percent of withdrawals from the Arkansas River, primarily in the Eastern Arkansas Basin where agriculture is concentrated. There are over 428,000 acres of irrigated cropland in the basin, in which much of the land is unsuitable for dryland farming. Removing water from irrigated acres generally results in decrementing total cropland as a switch to dryland farming is frequently inhibited by climactic conditions.[12] Without secure water for the future, many agricultural stakeholders fear the dry-up of irrigated land.

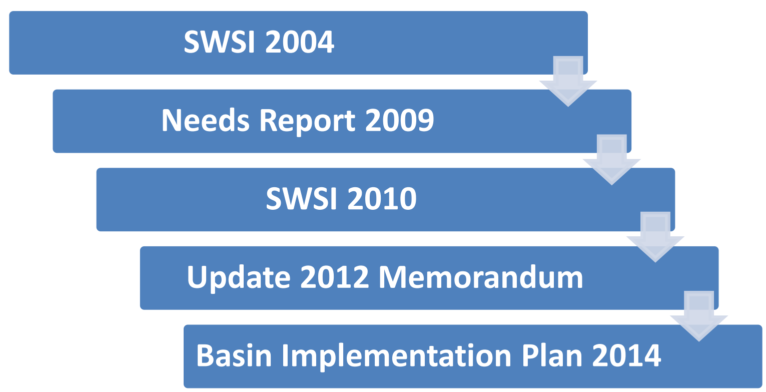
Recreation and Tourism

Recreation and tourism account for over $1 billion in income per year and add significant depth to the economy. Nonconsumptive users benefit from the Arkansas Basin's many water based activities including white-water rafting, flat-water recreation, fishing, and scenic tours. In three specific regions, Headwaters Recreation Area, Pueblo Reservoir, and John Martin Reservoir, annual recreation economic activity is estimated at $349 million,[13] with over 2.6 million visitors per year.[14] Reductions in nonconsumptive water levels in rivers and reservoirs observationally correlate with reduced recreational visits and expenditures.

1.5 Basin Implementation Planning, 2014

Each of the previous studies built upon the earlier ones and incorporated new knowledge and findings as they progressed. The 2012 Update represented the culmination of many years of work by the Basin Roundtable and its many supporters and constituents.

Figure 1.5.1 - Build up to Basin Implementation Plan



Subsequent to the 2012 Update, the Basin Roundtable began moving forward on its recommendations. Shortly thereafter, the Governor of Colorado issued the Executive Order (D 2013-005), calling for each basin to develop a Basin Implementation Plan. In response to the Governor's order, in the Fall of 2013 the Arkansas Basin Roundtable integrated those implementation strategies into the Implementation Plan process.

In 2014, the Arkansas Basin Roundtable began work on the Arkansas Basin Implementation Plan, to be incorporated into Colorado's Water Plan. The Basin Roundtable's knowledge and experience have increased significantly through the previous planning processes, and are reflected in the basin's updated goals for the future. The following section details Arkansas Basin goals for consumptive and nonconsumptive water uses, including actions, measurable outcomes, and anticipated challenges or constraints.

[11] US Geological Survey, Ivahnenko and Flynn, 2010 (see above for full citation).
[12] Estimates by Salcone and Pritchett (2013, Colorado State University) indicate that approximately one-third of irrigated cropland may be used in dryland farming.
[13] Includes direct, indirect, and induced effects.
[14] 2007-2011 averages by Colorado Department of Parks and Wildlife.

1.6 Goals of the Arkansas Basin

Water use throughout Colorado enhances and maintains the quality of life of its residents. The economy of the state is underpinned by its historic water resources, which support tourism, recreation, agriculture, industry and municipalities. Rapid growth, combined with frequent drought conditions, has renewed focus on constrained water resources. To meet the challenges of the future, the Water for the 21st Century Act seeks to assess the needs of the state. Through a collaborative process, the Arkansas Bain Roundtable identified the goals of its membership. This section details the goals and their associated actions, outcomes, and challenges.

Identifying and articulating Basin wide goals are critical to developing projects and methods to meet the future needs of the Basin. The goals of the Arkansas Basin are derived from the primary stakeholders in the region and are categorized as follows:

- Storage Goals;
- Consumptive;
    - Municipal Goals;
    - Agricultural Goals;
- Nonconsumptive Goals;

Through these goals, IPPs and methods can be developed and implemented to meet the future needs of the Arkansas Basin. For each goal, the Roundtable articulated:

- Actions – What is to be done to meet the goal;
- Measurable Outcomes – What specific measurements or mileposts denote accomplishment or progress;
- Challenges – What are the constraints faced in achieving the goal.

The following sections provide detailed tables and information outlining each category and goal.

1.6.1 Storage

Storage is acknowledged by the Roundtable as being critical to the future of the Arkansas Basin. Several IPPs have been proposed to expand storage, and they remain high priorities to the Arkansas Basin in order to meet consumptive and nonconsumptive needs in the future.

Four goals are identified for storage in the Arkansas Basin:

1. Increase surface storage available within the Basin by 70,000 acre-feet by the year 2020;
2. Develop alluvial and designated basin storage in gap areas within the Basin;
3. Support multiple uses at existing and new storage facilities; and,
4. Identify storage facilities that can be renovated, restored, or enhanced for additional storage.

Each of the goals has actions, including implementing specific IPPs, quantifying storage opportunities, and working with stakeholders to assess the feasibility of additional storage. Significant challenges exist to achieving the storage goals of the Arkansas Basin, including government permitting, regulation, competing stakeholder interests, and reluctance of storage site owners to take on further responsibility. While the challenges are significant, they are surmountable through coordinated efforts, IPPs, and Roundtable engagement.

The following table provides the goals and associated actions, measurable outcomes, and challenges.

Table 1.6.1 - Storage Goals

Goals	1. Increase surface storage available within the Basin by 70,000 AF by the Year 2020.	2. Develop alluvial and designated basin storage in gap areas within the Basin.	3. Support multiple uses at existing and new storage facilities.	4. Identify storage facilities that can be renovated, restored or enhanced for additional storage.
Actions	1. Implement the IPP called Preferred Storage Option Plan (PSOP). 2. Work with the State Engineers Office of Dam Safety to identify storage projects for restoration, rehabilitation and increased capacity. 3. Support funding, including grant contributions where appropriate, for storage restoration and expansion projects.	1. Quantify alluvial storage opportunities in the sub-regions of the Basin, Upper Ark, Huerfano/Purgatoire, Fountain Creek and Lower Ark. 2. Develop a feasibility study and action plan for storage in designated basins.	1. Support rehabilitation efforts with WSRA funds if the project includes environmental and recreational attributes. 2. Engage Colorado Parks and Wildlife and other stakeholders in project discussions.	1. Conduct an inventory assessment and map candidate facilities in collaboration with the SEO and DWR offices. 2. Support feasibility studies, permitting and construction at these locations with WSRA grant/loan funding in collaboration with CWCB.
Measurable Outcomes	1. Storage capacity and percentage of stored water annually from 2015 to 2020. 2. Annual reporting of projects that have been permitted and/or constructed.	1. Quantify potentially available alluvial storage and cost by Dec, 2015. 2. Annual reporting of projects that have been permitted and/or constructed.	1. Approved WSRA grant requests that incorporate multi-use attributes. 2. Direct feedback from CPW and stakeholders that participation is on-going.	1. Complete an inventory of prospective facilities with an estimate of recoverable storage volume by Dec, 2015. 2. Annual reporting of projects that have been permitted and/or constructed.
Challenges	Federal, state and local permitting requirements; Funding for design and permitting; financing sources.	Regulatory regime, permitting, financing, legal challenges by patent holders.	Complexity of competing stakeholder interests, permitting challenges.	Reluctant ownership, permitting challenges, spillway requirements.

1.6.2 Consumptive Goals

The Arkansas Basin supports significant consumptive users throughout its varied geography. Urban growth continues to increase municipal and industrial water demand, while concurrently the agricultural economy is dependent on water to maintain its economic contributions to the basin. Agricultural to municipal transfers may continue to remove water from irrigation, and many stakeholders seek to find alternatives to permanent dry-up of Arkansas Basin cropland. There are two broad categories of consumptive use in the Arkansas Basin:

- Municipal and Industrial; and,
- Agricultural.

Consumptive goals identify the future needs and potential gaps that exist in municipal and agricultural demands. Recent sustained drought conditions in the Arkansas Basin have led to immediate or near immediate gaps for consumptive users. The Basin Roundtable, in conjunction with constituents and stakeholders throughout the Basin, engaged in a process to identify the main concerns and goals for consumptive users going forward.

1.6.2.1 Municipal and Industrial

Population growth in the Arkansas Basin is expected to average 1.6 percent annually through 2035, when the population is expected to reach approximately 1.45 million[15] from its 2013 estimate of 1.03 million.[16] Projections for 2050 indicate that the population of the Arkansas Basin will be between 1.58 and 1.84 million,[17] implying an increase of between 53 and 79 percent between 2013 and 2050. The municipal and industrial (M&I) supply gap is projected to exceed 20,000 acre-feet by 2020 and continue increasing through 2050.[18] Continued dependence on non-renewable groundwater is exacerbating the gap in water supply and demand. This places significant pressure to secure future municipal water supplies. According to SWSI 2010, by 2050, Municipal and Industrial water use is expected to be between 298,000 and 352,000 acre-feet per year, compared with a 2008 estimated annual water use of 196,000 acre-feet for Municipal and Industrial users.

The following four goals for meeting municipal water needs were identified by the Roundtable:

1. Meet the municipal supply gap in each county within the Basin;
2. Support regional infrastructure development for cost-effective solutions to local water supply gaps;
3. Reduce or eliminate Denver Basin groundwater dependence for municipal users; and,
4. Develop collaborative solutions between municipal and agricultural users of water, particularly in drought conditions.

The goals are paired with clear measurable outcomes, including developing and implementing storage capacity projects and developing alluvial storage before 2020. The goals and outcomes clearly emphasize the importance storage will play in meeting the future needs of the Arkansas Basin.

[15] SWSI 2010 projections, estimated using data and methodology from the Colorado State Demographer's Office.
[16] Estimated with data from Colorado State Demographer's Office.
[17] SWSI 2010, estimated using data and methodology from the Colorado State Demographer's Office.
[18] 2012 Update, *Meeting the Needs of the Arkansas Basin*.

Table 1.6.2 - Municipal Goals

Goals	1. Meet the Municipal Supply Gap in each county within the Basin.	2. Support regional infrastructure development for cost-effective solutions to local water supply gaps.	3. Reduce or eliminate Denver Basin groundwater dependence for municipal users.	4. Develop collaborative solutions between municipal and agricultural users of water, particularly in drought conditions.
Actions	1. Determine surplus and deficit sub-regions within each county for collaboration. 2. Project annual supply and demand for water providers who choose to participate in addressing the gap.	1. Complete current regional infrastructure studies. 2. Identify and support new regional studies in gap areas. 3. Support construction of the Arkansas Valley Conduit.	1. Support regional solutions to water supply availability. 2. Identify interim water supply options. 3. Support funding, including grant contributions where appropriate, for collaborative solutions.	1. Continue ATM process of engineering, public policy and pilot projects. 2. Support with WSRA grant/loan funding in collaboration with CWCB.
Measurable Outcomes	1. Generate a study by December, 2015 determining surpluses and deficits within sub-regions/counties. 2. Funds provided in support of collaborative efforts reported annually.	1. Agreements to regional use of identified IPP's such as Southern Delivery System. 2. New WSRA grant request for regional infrastructure studies. 3. Agreements for off-take of Conduit water; Funding of Conduit processes and construction.	1. Presentations by groundwater dependent entities on solutions that have been implemented. 2. Presentations on interim solutions and funding requests to support those solutions. 3. Funds provided in support of collaborative efforts reported annually.	1. Pilot project implemented as reported annually. 2. Engineering template implemented by the Division of Water Resources to expedite temporary transfers at reduced cost.
Challenges	Federal, state and local permitting requirements. Funding for design and permitting; financing sources.	Regulatory regime, permitting, financing, informed decision makers at participating entities.	Complexity of regional agreements, competing stakeholder interests, education, conservation.	Administration of temporary transfers, institutional barriers, permitting, legal challenges.

1.6.2.2 Agricultural

Agricultural economic activity is significant in the Arkansas Basin, contributing an estimated $1.5 billion annually to the economy. Agriculture has always been critical to the culture and economy of Colorado, and the agricultural goals of the Arkansas Basin reflect a desire to protect existing water supplies while making water available for growing demands. Urban growth has led to competing water interests within the basin.

"Coloradans find that the current rate of purchase and transfer of water rights from irrigated agriculture is unacceptable."[19] Agricultural producers are the largest owners of water resources in the state. As new or growing users, particularly municipalities, require additional water resources, they often purchase it from agricultural users. To many stakeholders, the resulting drying of agricultural land represents a permanent loss to

[19] Governor's Executive Order 2003-005.

the basin. This multi-base constituency is reflected in the goals outlined for agricultural water within the Arkansas Basin. The four articulated goals are:

1. Sustain an annual $1.5 billion agricultural economy in the basin;
2. Provide increasing quantities of augmentation water for increased farm efficiencies;
3. Develop a viable rotational fallow and/or leasing program between agriculture and municipal interests to address drought and provide risk management for agriculture; and,
4. Sustain recreation and environmental activities that depend on habitat and open space associated with farm and ranch land.

The goals are paired with associated actions, outcomes, and challenges, including establishing long-term augmentation water sources, constructing recharge facilities, minimizing permanent dry-up of agricultural land, and protecting habitats. Significant challenges include commodity crop prices, storage availability, legal challenges, and changing climactic conditions.

The following table provides details of the agricultural goals.

Table 1.6.3 - Agricultural Goals

Goals	1. Sustain an annual $1.5 billion agricultural economy in the Basin.	2. Provide increasing quantities of augmentation water for increased farm efficiencies.	3. Develop a viable rotating fallow and/or leasing program between agriculture and municipal interests to address drought and provide risk management for agriculture.	4. Sustain recreation and environmental activities that depend on habitat and open space associated with farm and ranch land.
Actions	1. Establish the Colorado State University economic study as the baseline for agriculture production at $1.5 Billion.	1. Establish long-term sources of augmentation water through leasing, water banks or interruptible supply agreements. 2. Construct recharge facilities to capture and retime fully consumable water supplies.	1. Complete the on-going technical studies and engineering to facilitate temporary transfers. 2. Define and quantify potential third-party impacts to shareholders within a ditch system engaged in a fallow program by providing funding in support of an economic study. 3. Minimize permanent dry-up.	1. Conservation easements to protect habitat values. 2. Financial support for economic development of tourism in historic agricultural communities.
Measurable Outcomes	1. Increase in measured economic productivity by update of CSU Study in 2020.	1. Document the baseline of current augmentation available. 2. Track available storage facilities for augmentation sources.	1. Report on pilot projects underway as of Dec, 2015. 2. Completion and presentation of the report by Dec, 2015. 3. Survey of permanently retired acreage as of the Year 2020.	1. Measure the economic contribution of tourism to the basin economy within the CSU 2020 update. 2. Change of status for "protected" attributes as measured by nonconsumptive projects and methods in SWSI 2016 report.
Challenges	Farm commodity prices; climate and weather.	Storage availability, legal challenges, administration of new decrees or substitute water supply plans.	Legal challenges, modifications of the statute by the Colorado General Assembly, disputes over application of the technical platform.	Climate and weather, impacts of reduced irrigation if rotating fallowing is successful, dust control, economic development funding availability.

1.6.3 Nonconsumptive Goals

In addition to assessing consumptive needs, the Basin Roundtable was asked to assess nonconsumptive needs, specifically environmental and recreation based demands. Environmental goals are to protect resident fish species and riparian habitats critical to supporting biodiversity and animal health. Environmental goals frequently align with recreational goals, which seek to maintain fishing opportunities and environmental health, while improving opportunities for water recreation.

While it is challenging to ascribe an economic value to a healthy environment, tourism and recreation play significant roles in the Arkansas Basin economy. A Colorado State University study[20] estimates that recreation contributes approximately $1 billion to the Arkansas Basin economy, including its direct, indirect, and induced economic multipliers. Three specific water recreation areas, Headwaters Recreation Area, Pueblo Reservoir, and John Martin Reservoir, contribute an estimated $349 million to the Arkansas Basin each year. Coloradans place significant cultural and economic value on their environment, and nonconsumptive water plays a critical role in maintaining a "productive economy that supports… a robust skiing, recreation, and tourism industry."[21]

The eight goals articulated by the Basin Roundtable and its constituents for nonconsumptive water uses in the Arkansas Basin are:

1. Maintain or improve native fish populations;
2. Maintain, improve, or restore habitat for fish species;
3. Maintain or improve recreational fishing opportunities;
4. Maintain or improve boating opportunities, including rafting, kayaking, and other non-motorized and motorized boating;
5. Maintain or improve areas of avian (including waterfowl) breeding, migration, and wintering;
6. Maintain or improve riparian habitat, and restore riparian habitat that would support environmental features and recreational opportunities;
7. Maintain or improve wetlands, and restore wetlands that would support environmental features and recreational opportunities; and
8. Improve water quality as it relates to the environment and/ or recreation.

The following table provides details of nonconsumptive goals in the Arkansas Basin, including their associated measurable outcomes and challenges:

[20] Jake Salcone and James Pritchett, *Value of Water Used in Agriculture for the Arkansas River Basin,* February 4, 2014.
[21] Governor's Executive Order 2013-005.

Table 1.6.4 - Nonconsumptive Goals

Goals	1.Maintain or improve native fish populations.	2. Maintain, improve or restore habitat for fish species.	3. Maintain or improve recreational fishing opportunities.	4. Maintain, or improve boating oppor-tunities, including rafting kayaking and other non-motorized and motorized boating.	5. Maintain or improve areas of avian (including waterfowl) breeding, migration and wintering.	6. Maintain or improve riparian habitat, and restore riparian habitat that would support environ-mental features and recreational oppor-tunities	7. Maintain or improve wetlands, and restore wetlands that would support environ-mental features and recreational oppor-tunities	8. Improve water quality as it relates to the environ-ment and/ or recreation.
Actions	This section to be completed between Aug, '14 and Dec, '14.							
Measurable Outcomes	This section to be completed between Aug, '14 and Dec, '14.							
Challenges	This section to be completed between Aug, '14 and Dec, '14.							

1.7 Summary and Challenges

The Governor of Colorado issued an executive order calling for the CWCB to work with the Basin roundtables, Interbasin Compact Committee (IBCC), and other stakeholders to develop the Colorado Water Plan (CWP). Each of the nine Basin Implementation Plans are grassroots efforts critical to the Colorado Water Plan as guides for each basin to meet their unique challenges and future demand growth for municipal, agricultural, industrial, recreational, and environmental water uses. The plan calls forward stakeholders to engage in the process and provide local knowledge and support.

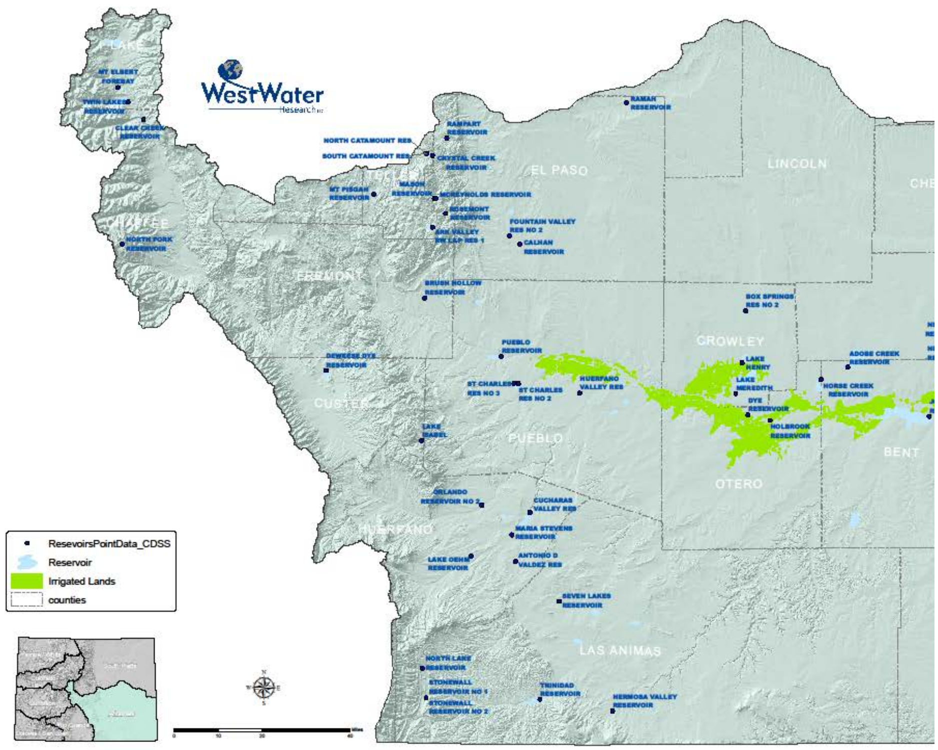
SWSI 2010 clearly determined that the Arkansas Basin faces a significant supply gap across a broad spectrum of water uses. The Arkansas Basin Implementation Plan identifies projects and methods to meet basin specific goals to address consumptive and nonconsumptive demands.

Section 2 Evaluate Consumptive & Nonconsumptive Needs

Evaluation of Consumptive and Nonconsumptive Needs

The decade of basin roundtable dialogue, starting in 2003 with the Statewide Water Supply Initiative, has brought clarity to the interdependence of water needs in the Arkansas Basin. The conversations between roundtable members revealed that the municipal, agricultural, and industrial consumptive uses of water are inextricably linked to environmental and recreational nonconsumptive uses. Furthermore, all water uses depend on water storage systems, from the headwaters where water is diverted from the Colorado River basin, to the federally funded storage reservoirs of Lake Turquoise, Lake Pueblo, Trinidad Reservoir and John Martin Reservoir.

Figure 2.0.1 - Basin Storage Facilities



The capacity to store water at an altitude of 10,000 feet in Turquoise Reservoir at the top of the Basin, and then manage flows to Pueblo Reservoir, provides renewable energy, recreation and environmental support for a Gold Medal trout fishery, capturing benefits from water resources specifically developed for agricultural and municipal demands. Although the consumptive and nonconsumptive needs are presented as separate sections, they are deeply connected. From the agricultural development of the 19th century, the urban growth of the 20th century, and the booming recreation industry of the 21st century, consumptive and nonconsumptive users share the same basin and a common water future. Sections 2.1 and 2.2 detail the nonconsumptive and consumptive needs of the Arkansas Basin. The sections provide background and information from previous reports, contextualize the adaptive economics of water, and demonstrate the interconnectedness of water resources within the Basin.

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2.1 Nonconsumptive Needs

This section provides information on environmental and recreational attributes that have nonconsumptive water demands. Statewide Water Supply Initiative (SWSI) 2010 and preceding efforts have defined environmental and recreational features that are important to the individual basins, and identified existing and planned projects and methods that provide various levels of protection to those features.

The Colorado Water Plan will integrate the work of the Basin Roundtables (BRTs), Interbasin Compact Committee (IBCC), and Colorado Water Conservation Board (CWCB) to determine how to implement water supply planning solutions that meet Colorado's future water needs. For the Arkansas Basin Implementation Plan (BIP), information gathered by these groups will continue to be expanded upon to develop a strategy for implementing future projects and methods to meet the nonconsumptive needs of the basin.

To be effective, Colorado's water policy needs to reflect the state's water values. BRTs have developed statewide values to incorporate into the Colorado Water Plan that will also be reflected in the BIPs. These values, as stated in *Executive Order D 2013-005*, include:

- A productive economy that supports vibrant and sustainable cities, viable and productive agriculture, and a robust skiing, recreation, and tourism industry;
- Efficient and effective water infrastructure promoting smart land use; and
- A strong environment that includes healthy watersheds, rivers and streams, and wildlife.

2.1.1 Arkansas Basin Nonconsumptive Goals

In addition to statewide values, each basin has distinct values and goals based on its unique nonconsumptive uses and needs. For example, Browns Canyon along the Arkansas River is the most popular whitewater rafting destination in the United States. Therefore, maintaining water flows for rafting and other recreational opportunities may be a more significant goal for the Arkansas Basin than it for other basins in the state. Additionally, more than 100 miles of streams along the upper Arkansas River were recently added to the statewide list of Gold Medal Waters Gold Medal listings are a reflection of a healthy trout population accompanied by strong numbers of larger fish, and Gold Medal Waters serve a dual purpose of supporting both recreation (fishing) and our native fish species. There are numerous other attractions including Pueblo State Park, the Royal Gorge Bridge, and FIBArk, the nation's oldest whitewater rafting festival.

Through the process of assessing the Arkansas Basin's consumptive and nonconsumptive needs, the Arkansas BRT identified the following priorities:

- Maintain agricultural viability in the lower basin;
- Provide for in-basin augmentation in the upper basin;
- Provide for adequate water quality to meet all needs; and

- Ensure adequate water for future needs including municipal and industrial (M&I), agricultural, recreational, and environmental purposes.

The Arkansas BRT has three major subcommittees: Transfer Guidelines, Consumptive, and Nonconsumptive. While working together with the BRT as a whole, the Nonconsumptive Needs Subcommittee focuses on identifying and meeting the Basin's nonconsumptive needs. The subcommittee is comprised of members from the following organizations:

Arkansas Valley Audubon Society – SeEtta Moss
Arkansas Basin Roundtable Recreation Representative – Reed Dils
Colorado Parks and Wildlife – John Tunko, Rob White, Dave Lovell
Bureau of Land Management – John Smeins
U.S. Forest Service – Misty Desalvo
Colorado Springs Utilities – Pat Wells
Aurora Water – Tom Simpson
Purgatoire Watershed Partnership – Karen Wolf
Other – Karen Salapich, non-member/interested citizen-rancher

An important first step for the BIP is identifying basin-specific goals, and as part of that effort, the Arkansas Basin Nonconsumptive Needs Subcommittee has defined the following nonconsumptive goals for the basin:

- Maintain or improve native fish populations;
- Maintain, improve, or restore habitat for fish species;
- Maintain or improve recreational fishing opportunities;
- Maintain or improve boating opportunities, including rafting, kayaking, and other non-motorized and motorized boating;
- Maintain or improve areas of avian (including waterfowl) breeding, migration, and wintering;
- Maintain or improve riparian habitat, and restore riparian habitat that would support environmental features and recreational opportunities;
- Maintain or improve wetlands, and restore wetlands that would support environmental features and recreational opportunities; and
- Improve water quality as it relates to the environment and/ or recreation.

2.1.2 Nonconsumptive Needs and Attributes

An increased awareness and desire to balance nonconsumptive needs with other water uses has evolved in recent years due to numerous factors, including:

- Public desire for environmental protection;
- Public's interest in nonconsumptive needs and uses;
- Economic importance;
- Regulations (e.g., Endangered Species Act [ESA] compliance); and

- New and better ways of conducting business through partnerships and common goals (e.g., Arkansas River Voluntary Flow Management Program).

Nonconsumptive needs, commonly referred to as environmental and recreational needs, are those resources or activities that require water, but may or may not consume water. For example, improvement of a diversion structure in a stream does not consume water, nor does bank stabilization that decreases erosion and sedimentation. However, creation of new wetlands would consume some water, and an increase of flows for recreation could have increased transit loss. Specifically, a nonconsumptive need is the physical and chemical demand needed to sustain a nonconsumptive attribute in a specific location defined by the BRT as being important. This could include flow, channel morphology, reduction in harmful chemical constituents, or temperature levels. A nonconsumptive attribute is defined as an environmental or recreational value, such as a species, community of species, or other value deemed as important to the BRT. Examples include Colorado cutthroat trout, important fishing areas, rare wetland plant communities, and significant boating areas. Through previous planning efforts, nonconsumptive attributes and needs have been identified, evaluated, and prioritized within each basin.

Nonconsumptive needs are often associated with recreational activities and environmental features, but can also include other categories. These features are commonly very important to the general public and play a key economic role for the state.

Examples of nonconsumptive attributes with nonconsumptive water needs include:

- Rafting, whitewater play parks, and flatwater boating;
- Fishing;
- Threatened and endangered species; and
- Wildlife habitat.

2.1.3 Importance of Nonconsumptive Needs

Since 2010, Colorado has ranked as the nation's fourth fastest-growing state, with a population increase of 4.76 percent during the period from April 1, 2010, to July 1, 2013,[1] and Colorado's population is expected to nearly double within the next 40 years. The Arkansas River Basin population is projected to increase by approximately 78 percent between 2008 and 2050 under mid-range economic development assumptions.

Although various factors draw new residents to Colorado, there is no doubt the natural environment and the many diverse recreational opportunities of the Rocky Mountains and plains play a significant role in attracting people to the state. These features also support tourism, a major economic driver in many parts of Colorado. In several headwaters counties, recreation and tourism are the largest

[1] "Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2013." *2013 Population Estimates,* United States Census Bureau, Population Division. December 30, 2013.

industries. Outdoor recreation contributes more than $34.5 billion statewide in annual economic output. In the Southeast Region, which encompasses much of the Arkansas Basin but does not include the Arkansas Headwaters Recreation Area (AHRA), recreational output is approximately $1.0 billion.[2]

As Colorado's population continues to grow, there will be increasing and competing demands for water. The state's individual BIPs and the larger Colorado Water Plan will strive to find a balance for Colorado's consumptive and nonconsumptive water needs.

2.1.4 Previous Reports and Mapping

The documents listed below are prior efforts and phases of the Colorado Water Plan and are summarized in the following sections, with a particular focus on the nonconsumptive information contained in each document:

- Statewide Water Supply Initiative (CWCB, November 2004);
- Colorado's Water Supply Future: Statewide Water Supply Initiative – Phase 2 (CWCB, November 2007);
- Colorado's Water Supply Future: Watershed Flow Evaluation Tool Pilot Study for Roaring Fork and Fountain Creek Watersheds and Site-Specific Quantification Pilot Study for Roaring Fork Watershed, Draft (CWCB, June 2009);
- Colorado Water Conservation Board: Nonconsumptive Needs Assessment Focus Mapping (CWCB, July 2010);
- Colorado's Water Supply Future: Colorado Water Conservation Board – SWSI 2010 Arkansas Basin Report Basinwide Consumptive and Nonconsumptive Water Supply Needs Assessments (CWCB, June 2011);
- Colorado's Water Supply Future: Colorado Water Conservation Board Statewide Water Supply Initiative 2010 (CWCB, January 2011); and
- Nonconsumptive Toolbox (CWCB, July 2013).

Statewide Water Supply Initiative (CWCB, November 2004) and Statewide Water Supply Initiative – Phase 2 (CWCB, November 2007)

In 2003, the Colorado General Assembly authorized the Colorado Water Conservation Board (CWCB) to implement the Statewide Water Supply Initiative (SWSI). Overall, the stated mission of SWSI is to "…help Colorado maintain adequate water supplies for its citizens, agriculture, and the environment through a mix of solutions, all of which should be pursued concurrently." SWSI reports are intended to be used as living documents and the CWCB will continue to develop and incorporate the best information available.

The SWSI was initially accomplished in two phases. SWSI 1, approved by the Board in 2004, was a comprehensive identification of Colorado's current and future water needs, and it examined a variety of

[2] Colorado Parks and Wildlife. 2014. *The Economic Contributions of Outdoor Recreation in Colorado: A regional and county-level analysis*. Southwick Associates. Available online at: http://cpw.state.co.us/Documents/Commission/2014/May/ITEM21-2013COEconImpactReport.pdf

approaches Colorado could take to meet those needs. SWSI 1 implemented a collaborative approach to water resource issues by establishing the BRTs, which were further institutionalized in 2005 with passage of the *Colorado Water for the 21st Century Act* (HB 05-1177). The BRTs were tasked with developing basinwide water needs assessments, the results of which were published in the *Basinwide Consumptive and Nonconsumptive Water Supply Needs Assessments* report for the Arkansas Basin.

This was followed by SWSI 2, which established four technical committees: Conservation, Alternative Agricultural Water Transfers, Environmental and Recreational Needs, and Addressing the Water Supply Gap. The overall goal of SWSI 2 was to develop a range of potential solutions that would help water providers, policymakers, and stakeholders gain a deeper understanding of the relative role that water efficiency, agricultural transfers, and new water development can play in meeting future needs, as well as the tradeoffs associated with these solutions.

2.1.4.1 Watershed Flow Evaluation Tool Pilot Study for Roaring Fork and Fountain Creek Watersheds (June 2009)

Many of the BRTs requested that CWCB provide technical assistance in quantifying flow needs for the environmental and recreational priority areas that they identified in the Nonconsumptive Needs Assessment Focus Mapping (Section 2.1.4.3). In response, the Watershed Flow Evaluation Tool (WFET) framework was developed and a pilot study was conducted.

WFET provides a framework for examining ecological risk related to flow conditions at a watershed or regional level. Although many site-specific flow quantifications have been completed around the United States, the geographic extent of rivers and streams with site-specific quantification is still quite small. For this reason, recent research efforts have focused on regional assessments of flow conditions. WFET was derived from the Ecological Limits of Hydrologic Alteration (ELOHA) framework that was developed from research by an international collaboration of researchers and water resource professionals at universities, government agencies, and non-governmental organizations (NGOs).

The pilot study examined two watersheds in Colorado: the Roaring Fork Watershed (Colorado River Basin) and the Fountain Creek Watershed (Arkansas River Basin). These two watersheds were selected because they offered contrasting scenarios of water management and data availability, and taken together, they served as useful test cases for application of the WFET framework.[3]

Although the pilot study produced useful results for the Roaring Fork Watershed, outcomes from the Fountain Creek Watershed were not as constructive. The Roaring Fork Watershed effort was more successful due to the availability of essential technical components, including an existing hydrologic model used to calculate a record of natural and developed daily flows, and available data describing relationships between flows and the river ecosystem. The Fountain Creek Watershed effort was hindered by inadequate data, primarily the lack of flow data and the absence of a hydrologic model to

[3] Sanderson, J. S., Rowan, N., Wilding, T., Bledsoe, B. P., Miller, W. J., and Poff, N. L. 2012. "Getting to Scale with Environmental Flow Assessment: The Watershed Flow Evaluation Tool." *River Research Applications*, 28: 1369–1377. DOI: 10.1002/rra.1542 (http://onlinelibrary.wiley.com/doi/10.1002/ rra.1542/abstract).

extend the spatial coverage of that deficient data. Additionally, little data were found on the ecological response to flow augmentation, the primary flow impact in Fountain Creek.

The results of the pilot study yielded conclusions regarding the capabilities and limitations of the WFET, a few of which are listed below. More information can be found in the Watershed Flow Evaluation Tool Pilot Study (draft report, June 2009).

- The WFET could be used to build upon the Nonconsumptive Needs Assessment Focus Mapping by examining which focus areas have attributes with ecological risk, and help identify the projects and methods required to meet nonconsumptive needs in these areas.
- The WFET can provide a regional assessment of ecological risks related to flow, identifying locations with minimal to high risk based on flow conditions for specific stream attributes without in-depth or detailed site-specific information, and can help to target areas that need further site-specific studies.
- The WFET is best utilized in areas with a detailed understanding of baseline and existing hydrologic conditions or areas with models for pre- and post-water management conditions (i.e., areas where CWCB has developed a Decision Support System [DSS] model).
- In areas where CWCB's DSS models are not available, WFET could be used in a predictive capacity to examine potential future water management using conditions today as a baseline.
- WFET will not identify areas that are at ecological risk for factors not directly associated with flow conditions.

Given the above considerations, the Arkansas BRT has decided not to use WFET at this time for analysis of nonconsumptive needs and identification of projects and methods.

2.1.4.2 Nonconsumptive Needs Assessment Focus Mapping (July 2010)

In order to assess the nonconsumptive needs of the basins, an extensive inventory, analysis, and mapping effort of environmental and recreational features was conducted that built upon the SWSI 2 mapping efforts. The new maps that were produced identified and illustrated the nonconsumptive focus areas for each basin.

Focus Mapping Process

Maps and data layers produced during SWSI 2 were used as a starting point for the focus maps. The SWSI 2 mapping efforts produced a set of geographic information system (GIS) data layers, or shapefiles, which mapped areas representing the geographic coverage of an environmental or recreational feature. The data layers were selected by the Environmental and Recreational Technical Roundtable, and were intended to be used to determine areas of focus for nonconsumptive water needs. The list of SWSI 2 GIS data layers is shown in Table 2.1.1. Attributes in bold are data layers used for the Arkansas Basin mapping.

Table 2.1.1 - SWSI 2 Environmental and Recreational Data Layers, Source: CWCB, 2010

Environmental and Recreational Data Layers	
Arkansas Darter	**Trout Lakes**
Audubon Important Bird and Biodiversity Areas	**Trout Streams**
Bluehead Sucker	Greenback Cutthroat Trout
Bonytail Chub	Humpback Chub
Boreal Toad Critical Habitat	**Rafting and Kayak Reaches**
Colorado Department of Public Health and Environment Water Quality Control Division 303(D) Listed Segments	Rare Riparian Wetland Vascular Plants
Colorado Pikeminnow	Razorback Sucker
Colorado River Cutthroat Trout	**Recreational In-Channel Diversions**
CWCB Instream Flow (ISF) Rights	Rio Grande Cutthroat Trout
CWCB Natural Lake Levels	Rio Grande Sucker
CWCB Water Rights Where Water Availability had a Role in Appropriation	Roundtail Chub
Flannelmouth Sucker	**Significant Riparian/Wetland Communities**

As part of the focus mapping for the nonconsumptive needs assessment, BRTs reviewed the SWSI 2 data layers and compiled a list of additional features. Some of the additional GIS data were received directly from state and federal agencies, NGOs, and municipalities, or downloaded from their official websites. Other additional GIS data were digitized from available information, lists, or maps provided by BRTs, specialists (biologists, recreation guides), and other stakeholders. Table 2.1.2 contains a list of additional environmental and recreational data layers that were collected on a statewide basis from BRT Nonconsumptive Needs Subcommittee input. Attributes in bold are data layers used for the Arkansas Basin mapping.

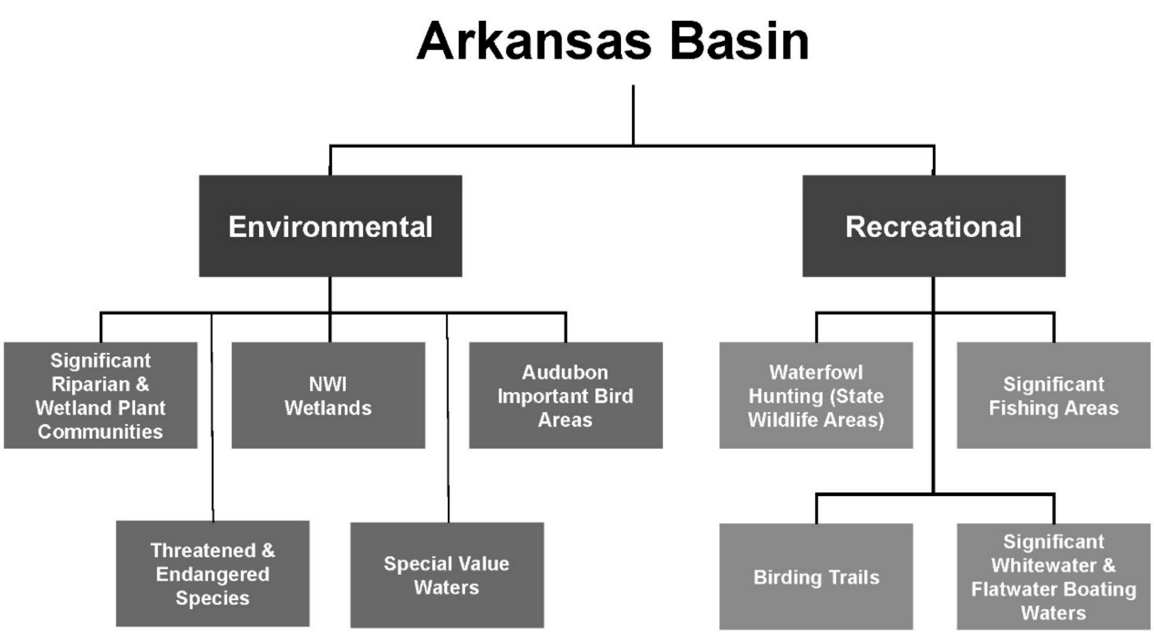
Table 2.1.2 - Additional Statewide Environmental and Recreational Data Layers Used for Mapping Focus Areas, Source: CWCB, 2010

Additional Environmental and Recreational Data Layers	
Additional Fishing	**National Wetlands Inventory (NWI)**
Additional Greenback Cutthroat Trout Waters	Northern Leopard Frog Locations
Additional Paddling/Rafting/Kayaking/Flatwater Boating	Northern Redbelly Dace
Additional Rio Grande Sucker and Chub Streams	Osprey Nest Sites and Foraging Areas
Bald Eagle Winter Concentration	**Piping Plover**
Bald Eagle Active Nest Sites	Plains Minnow
Bald Eagle Summer Forage	Plains Orangethroat Darter
Bald Eagle Winter Forage	Preble's Meadow Jumping Mouse
Brassy Minnow	River Otter Confirmed Sightings
Colorado Birding Trails	River Otter Overall Range
Colorado Outstanding Waters	Rocky Mountain Biological Laboratory (scientific and educational reaches)
Common Garter Snake	Sandhill Crane Staging Areas
Common Shiner	Southwestern Willow Flycatcher
Ducks Unlimited Project Areas	Stonecat
Educational Segments	**Waterfowl Hunting Areas**

Additional Environmental and Recreational Data Layers	
Eligible/Suitable Wild and Scenic	Wild and Scenic Study Rivers
Grand Mesa, Uncompahgre, and Gunnison Wilderness Waters/Areas	Wildlife Viewing
High Recreation Areas	Yellow Mud Turtle
Least Tern	

Basin-specific lists of environmental and recreational data layers were compiled by selecting appropriate data layers from those shown in Table 2.1.1 and Table 2.1.2. These data layers were then grouped into subcategories representing a collective environmental or recreational category. This method had two advantages: 1) it reduced redundancy among comparable, geographically overlapping individual data layers; and 2) it allowed for a more comprehensible presentation of the GIS data. The Arkansas BRT identified nine subcategories, including five environmental and four recreational, as shown below in Figure 2.1.1. Arkansas Basin subcategories and environmental and recreational attributes are further discussed in Section 2.1.6.

Figure 2.1.1 - Focus Mapping Subcategories for Arkansas Basin, Source: CWCB 2010



<u>Arkansas Basin Mapping Results</u>

The Arkansas BRT chose to use 12-digit Hydrologic Unit Code (HUC) watersheds as the basis for its GIS mapping development. Hydrologic units are subdivisions of watersheds used to organize hydrologic data, and HUC numbers are identifiers assigned by the U.S. Geological Survey (USGS). Twelve-digit HUCs are the smallest subdivision of hydrologic data currently available in Colorado, with an average of 33 square miles per unit.

To create the focus maps, GIS software was used to combine the environmental and recreational spatial data layers with the HUC spatial boundaries to create HUC-based environmental and recreational category areas. Each of the nine subcategories of environmental and recreational attributes was then mapped and represented in the HUCs in which it occurs in the Arkansas Basin. These HUC-based environmental and recreational categories areas were then overlaid on one another using GIS software to create a density or number of environmental and recreational categories in a given HUC. These results are shown in Figure 2.1.2. Areas with the most overlap of subcategories are shown in the darkest color, and represent areas with a high number of environmental or recreational attributes present. The areas with the highest density of attributes are primarily concentrated in three locations: 1) the mainstem Arkansas River upstream of Pueblo; 2) Fountain Creek watershed; and 3) areas around major reservoirs on the Lower Arkansas River between Las Animas and Eads.

The Arkansas Basin focus map (Figure 2.1.2) was created as a Geospatial PDF file, or GeoPDF, to provide users the ability to "click" areas of the map and view characteristics of that portion of the map, such as what attribute subcategories are present for a given HUC or stream segment. To use the maps interactively, users select the tools dropdown list and the analysis tools arrow, and click on the "object data tool." Using this tool, users can triple-click a reach to obtain additional information that will appear on the left side of the map

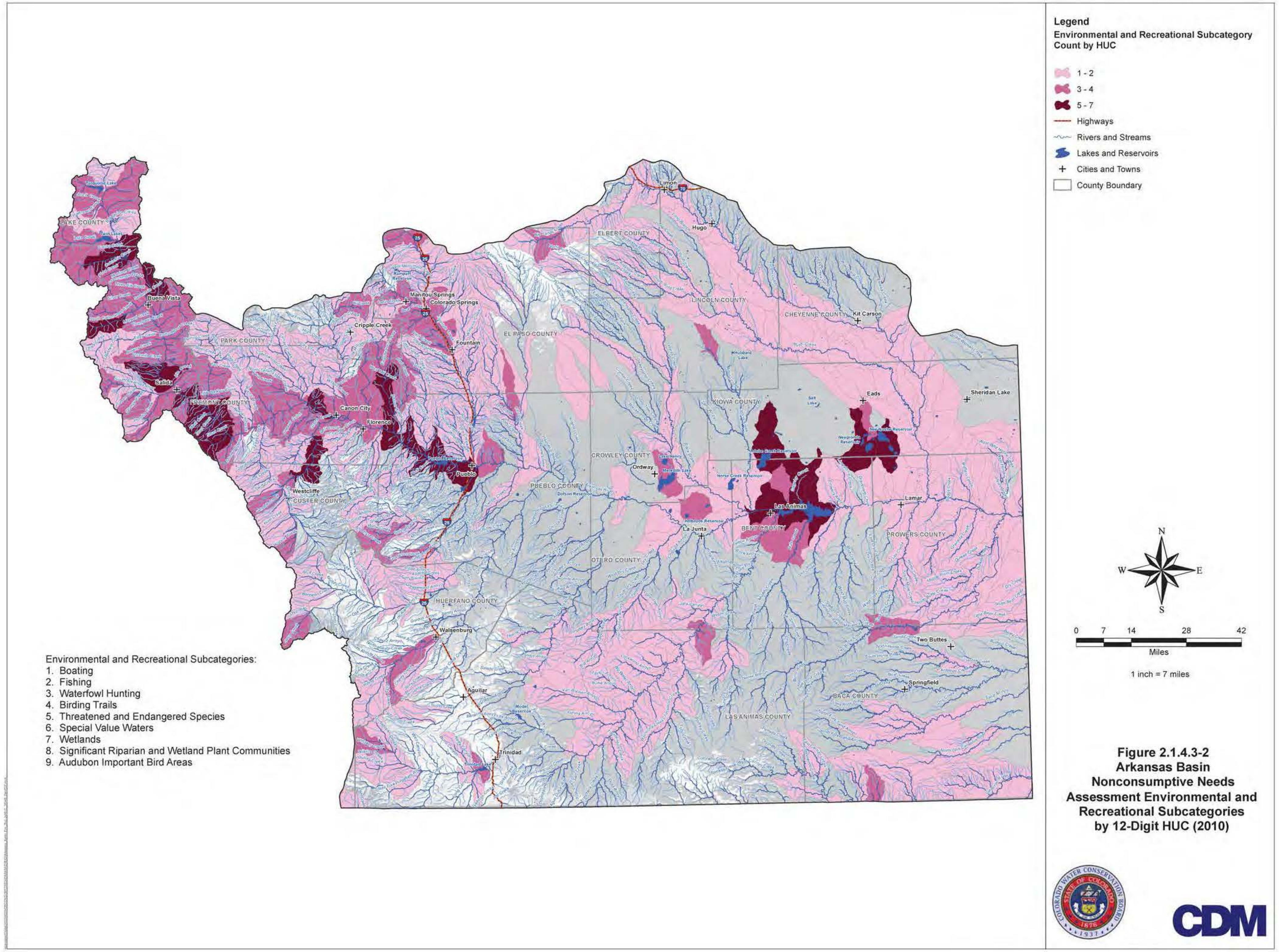
2.1.4.3 SWSI 2010 Arkansas Basin Report Basinwide Consumptive and Nonconsumptive Water Supply Needs Assessments (June 2011)

As directed by the Colorado Water for the 21st Century Act, each BRT prepared a consumptive and nonconsumptive needs assessment that was designed to provide a local perspective to SWSI 2010. The report assessed consumptive and nonconsumptive water needs, assessed available water supplies, and identified projects and methods (completed, ongoing, and planned) that address water needs and water supply sustainability. Consumptive projects and methods were further assessed and individually scored by the BRT on how well they were deemed viable, bearable, and equitable. A parallel assessment of nonconsumptive projects was under way to determine how best to support and/ or implement identified projects and methods, and was ongoing after the report was published. Figure 2.1.1 shows the process used by the CWCB and BRTs in completing the Nonconsumptive Needs Assessment. Distinguishing focus areas and conducting further study efforts were intended to facilitate the identification of projects and methods to address environmental and recreational water needs.

In January 2010, CWCB developed a survey to collect information across the state on existing and planned consumptive and nonconsumptive projects, methods, and studies. Studies were included because they may recommend or inform the implementation of projects or methods that will provide protection or enhancement of environmental and recreational attributes. The nonconsumptive survey data was compiled into a nonconsumptive needs projects and methods database (Database, Appendix 2.1-D).

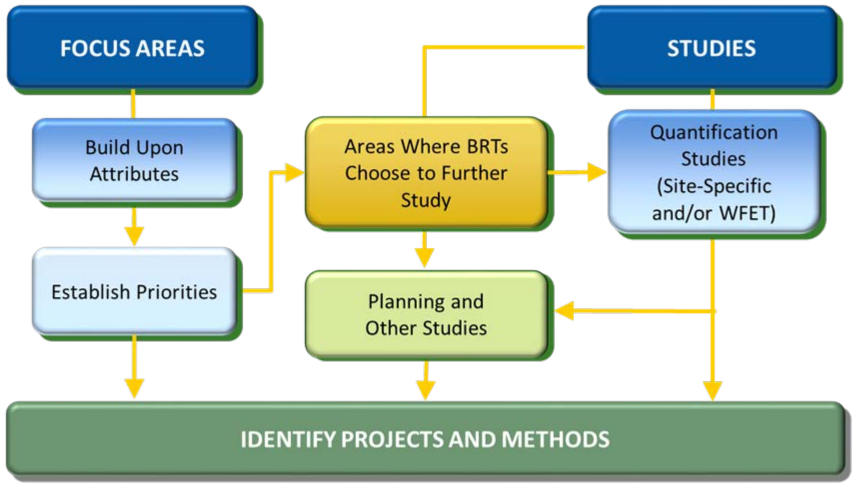
CWCB collected information for 40 nonconsumptive projects in the Arkansas Basin that were then spatially digitized in GIS to map the projects. CWCB had recommended BRTs use uniform mapping techniques to assist in consistency among the individual basin reports for the state. Being only one of two basins that had utilized the HUC watershed approach to mapping its nonconsumptive needs and focus areas, the HUC based system was converted to stream-based mapping practices, and projects and methods were assigned to stream reaches. Each project was digitized separately using the National Hydrography Dataset (NHD) stream reach database that uses 12-digit segments. The average length of an NHD 12-digit segment is 1.5 miles. Depending on the length of the project, multiple NHD segments could represent one project. In addition, depending on the project location, multiple projects could exist on the same NHD segment.

Figure 2.1.2 - Arkansas Basin Nonconsumptive Needs Focus Map



NOTE: The original attribute layers have been requested from CDM and will be included in the final version of the BIP.

Figure 2.1.3 - Nonconsumptive Needs Assessment Methodology, Source: CWCB 2011



. Figure 2.1.4 illustrates the nonconsumptive projects and methods through 2010 that were collected by CWCB. The figure represents spatial information for the nonconsumptive projects and methods that were planned, ongoing, or completed at that time in the Arkansas Basin. The map contains nonconsumptive projects and methods, including: 1) CWCB projects received at interviews and workshops; 2) CWCB watershed restoration projects; 3) Water Supply Reserve Account (WSRA) grants; 4) instream flows (ISFs); 5) USGS Southwest Regional Gap Analysis Project (SRGAP) information; and 6) Colorado Parks and Wildlife (CPW, formerly Colorado Division of Wildlife) projects. The projects and methods are summarized in Table 2.1.6 presented at the end of Section 2.1, including the project name, location, type, and status. The table also includes a summary of the attributes present within the project boundaries and information regarding direct or indirect protections the project provides to various attributes, as defined below.

In addition to identifying the spatial extent and status of the identified projects and methods, CWCB examined what type of protection the project or method may provide to environmental or recreational attributes that were identified by the BRTs during the focus area mapping effort. The projects were then classified as having direct or indirect protections for environmental or recreational attributes. The definitions used for protections are as follows:

Direct Protection – Projects and methods with components designed intentionally to improve a specific attribute. For example, ISFs have direct protection of fish attributes. Additionally, restoration of a stream channel would also provide direct protection for aquatic species.

Indirect Protection – Projects and methods with components that were not designed to directly improve the specific attribute but may still provide protection. For example, flow protection for a fish species may also indirectly protect riparian vegetation that is located in the area of the flow protection. Another example includes protective land stewardship, or a wetland or bank stabilization effort that could indirectly protect aquatic species

Figure 2.1.4 - Arkansas Basin Nonconsumptive Needs Assessment Focus Areas with Projects and Methods.

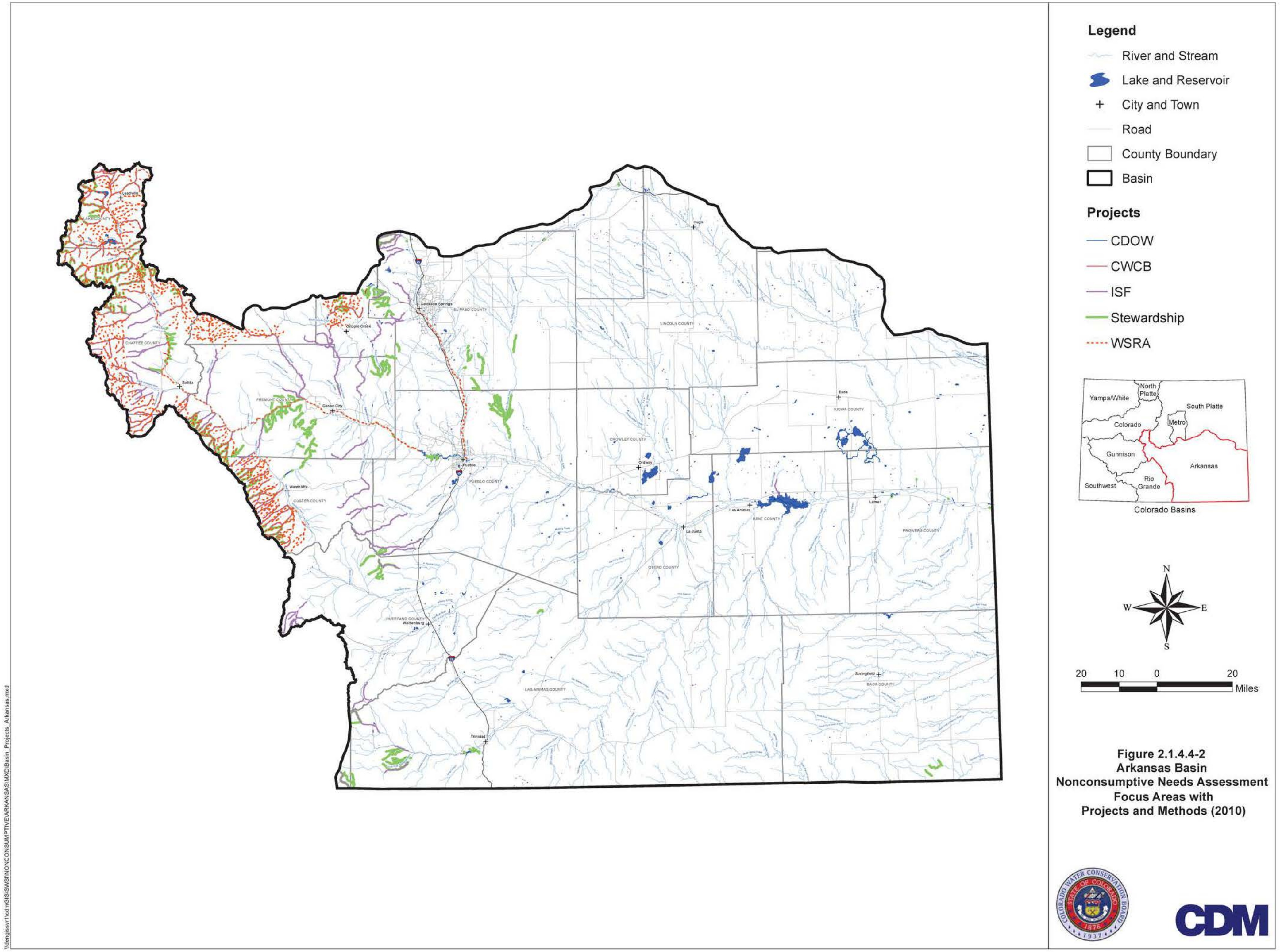


Table 2.1.3 below summarizes the project and method protections identified for the Arkansas Basin. In the attribute column, the environmental and recreational attributes collected by CWCB are summarized. Several of the attribute categories are specific individual attributes, whereas others include subcategories of multiple attributes. Individual attributes listed include the Arkansas darter, greenback cutthroat trout, piping plover, and least tern. The recreational attribute category includes attributes from both whitewater and flatwater boating. The important riparian and wetland areas category includes significant riparian areas, Audubon Important Bird and Biodiversity Areas (IBAs), and rare plant communities. Finally, the fishing attribute category includes streams and identified lakes as fishing areas.

Table 2.1.3 - Summary of Protections for Arkansas Basin Environmental and Recreational Attributes, Source: CWCB 2011

Attribute Category	Percent of Attribute Length with Direct Protections	Percent of Attribute Length with Indirect Protections	Percent of Attribute Length with Direct and Indirect Protections	Total Percent of Attribute Length with Protections
Arkansas Darter	1%	2%	0%	3%
Fishing	23%	3%	3%	29%
Greenback Cutthroat Trout	36%	3%	8%	47%
Important Riparian and Wetland	1%	13%	0%	14%
Piping Plover and Least Tern	17%	0%	0%	17%
Recreation	0%	2%	0%	2%
Waterfowl Hunting/ Viewing	0%	7%	0%	7%

The Arkansas BRT identified 14,030 miles of water bodies in the Arkansas Basin as focus areas with environmental and recreational attributes present. For these focus areas, 22 percent had an associated project or method. It is important to note that not all attributes require protection through projects and methods, and currently may be naturally sustained. This information will be further examined and used in future studies to determine where additional projects and methods are required to help meet the basin's nonconsumptive water needs. For more information, see Section 4.7.

2.1.4.4 Statewide Water Supply Initiative 2010 (CWCB, January 2011)

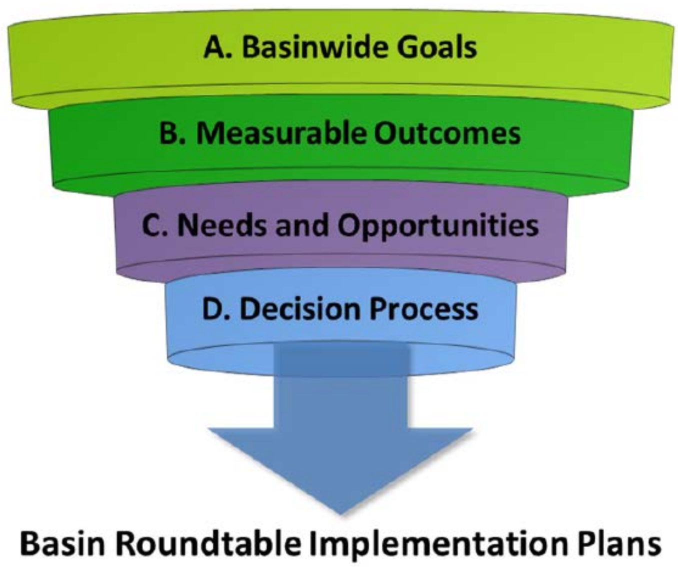
In 2005, enactment of the Colorado Water for the 21st Century Act established the IBCC and BRTs to facilitate conversations among Colorado's river basins and address statewide water issues. The Act charged the BRTs with developing consumptive and nonconsumptive water supply needs assessments, and with identifying projects and methods to meet those needs. Those water needs assessments were the basis for the SWSI 2010 Report, resulting in a comprehensive update that incorporated and summarized the work of the BRTs.

With the completion of the SWSI 2010 Report, CWCB updated its analysis of the state's water supply needs and recommended Colorado's water community enter an implementation phase to determine and pursue solutions to meet the state's consumptive and nonconsumptive water supply needs. Multiple recommendations were made to help accomplish that goal, which is the foundation for the BIPs.

2.1.4.5 Nonconsumptive Toolbox (July 2013)

The Nonconsumptive Toolbox was developed to aid in composing and executing the nonconsumptive portion of the BIPs. The tools and resources are intended to help BRTs and other stakeholders develop projects and methods to meet nonconsumptive needs. The toolbox provides a framework to evaluate existing information and identify opportunities and challenges toward implementation of nonconsumptive projects. It aids in analyzing information, identifying needs for project implementation, devising plans, and making decisions in light of existing water policies, laws, and regulations. The Toolbox is organized around four steps to encourage consistent, comprehensive planning for nonconsumptive needs (Figure 2.1.5).

Figure 2.1.5 - Nonconsumptive Portion of the Basin Roundtable Implementation Plans Overview, Source: CWCB, 2013



Step A. Basinwide Goals: Develop basin-level goals for the mapped attributes identified in the Statewide Nonconsumptive Needs Assessment Focus Area Map.

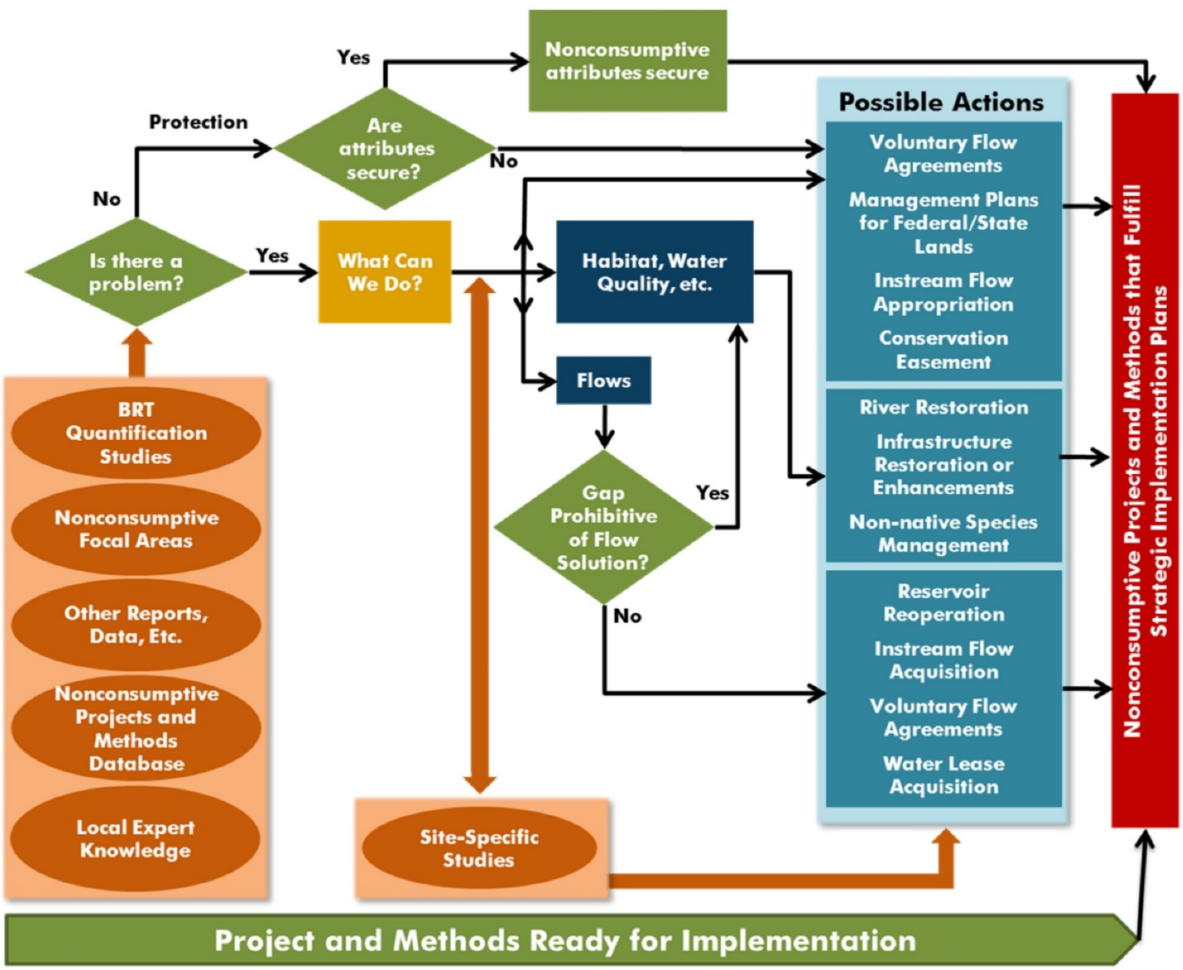
Step B. Measurable Outcomes: Establish quantifiable, measurable outcomes for nonconsumptive targets and attributes.

Step C. Needs and Opportunities: Using the project and methods Database, identify needs and opportunities for protecting attributes, and strategically plan to meet those nonconsumptive needs.

Step D. Decision Process: Use the decision template to determine what actions need to be taken to meet nonconsumptive needs and implement projects.

Regarding Step A, updated goals for the Arkansas Basin are listed in Section 2.1.1. The Database of nonconsumptive projects and methods, cited in Step C, that was originally compiled by the CWCB during the Basinwide Consumptive and Nonconsumptive Water Supply Needs Assessments will be updated by the Arkansas BRT for the BIP. The decision template, or decision tree, referred to in Step D, is shown in Figure 2.1.6. The decision tree can be applied to an area where an environmental or recreational attribute is present to help determine the projects and methods needed to protect or sustain the specific attribute. Alternatively, the decision tree can also be applied to an individual stream segment to identify what should be done for that area in order to protect attributes that may be present.

Figure 2.1.6 - Decision Tree for Planning and Implementing Nonconsumptive Projects, Source: CWCB 2013



The toolbox is intended as a guide, and the approach each BRT will take and the effort put into these steps will vary depending on basin-specific nonconsumptive needs, focus areas, and goals. Use of the toolbox for the Arkansas Basin is further discussed in Section 4.7.

2.1.5 Available GIS Information

Multiple GIS layers were collected and created for the SWSI 2 effort in 2007 and were then used as the foundation for the SWSI 2010 update and the Nonconsumptive Needs Assessment Focus Mapping. The GIS information was further built upon and used for analysis and production of maps for the Arkansas BIP (see Section 4.7). A list of GIS shapefiles available for use in the BIP is shown in Table 2.1.4.

2.1.6 Attributes and Focus Areas

The Nonconsumptive Needs Assessment Focus Mapping effort (Section 2.1.4.3) resulted in the identification of focus areas based on the density of environmental and recreational attributes present in individual areas.

Nine subcategories, including five environmental and four recreational, were established that represented all individual attributes. The subcategories are listed below followed by a brief description of each and the types of attributes represented by the broader category.

Environmental Subcategories

- Threatened and endangered species
- Audubon Important Bird and Biodiversity Areas (IBAs)
- Significant riparian and wetland plant communities
- Special value waters
- National Wetlands Inventory (NWI) wetlands

Recreational Subcategories

- Waterfowl hunting (state wildlife areas)
- Significant fishing areas
- Birding trails
- Significant whitewater and flatwater boating waters

Table 2.1.4 – Nonconsumptive Related GIS Layers Available for Use in the Arkansas Basin Implementation Plan, Sources: Watershed Health Arkansas BIP Spatial Data Inventory, 2014; CDM Smith, 2014; and SWSI 2 Focus Mapping, 2011

GIS Layers for Nonconsumptive Mapping			
Additional Fishing	Common Shiner	Highest Fire Threat	Riparian Data
Additional Greenback Cutthroat Trout Waters	Conservation Sites and Occurrences	Historic Fire Perimeters	River Otter Confirmed Sightings
Additional Paddling, Rafting, Kayaking, Flatwater Boating	Conveyance	Humpback Chub	River Otter Overall Range
Additional Rio Grande Sucker and Chub Streams	Conveyance Reservoirs	ISF Streams	Rivers
Agriculture Points of Interest	County Digital Elevation Models	Irrigated Cropland	Rocky Mountain Biological Laboratory Scientific and Educational Reaches
Arkansas Darter	County Special Districts - Metro, Water, Water and Sanitation	Land Cover: National Gap Analysis	Roundtail Chub
Arkansas River Basin	Critical Habitat	LandFire Data	S1 and S2 Element Occurrence Regions
Audubon Important Bird and Biodiversity Areas (IBAs)	Croplands	Least Tern	Sandhill Crane Staging Areas
Bald Eagle Active Nest Sites	CWCB ISF Rights	M&I Points of Interest	Significant Bird Areas
Bald Eagle Summer Forage	CWCB Natural Lake Levels	M&I Reservoirs	Significant Riparian / Wetland Communities
Bald Eagle Winter Concentration	CWCB Water Rights Where Water Availability had a Role in Appropriation	Moderate Threat	Significant Wetland Plant Communities
Bald Eagle Winter Forage	Designated Drinking Water Basin	National Land Cover (tiff image)	Snow Data Assimilation system (SNODAS) - Provide Snow Cover Estimates for Hydrologic Modeling

GIS Layers for Nonconsumptive Mapping			
BLM Areas of Critical Environmental Concern	Direct Use Reservoirs	National Wetlands Inventory	Southwestern Willow Flycatcher
BLM Colorado Statewide Mineral Mining Disposal Sites	Diversion	Natural Lake Level Lakes	State Forest Service
BLM Colorado Statewide Mining Claims - Active	Division of Water Resources - Division 1-5 and Statewide Data	Northern Leopard Frog Locations	State I and D data
BLM Colorado Statewide Mining Claims - Closed	Department of Local Affairs Title 32 Special Districts - Fire, Hospital, Metro, Recreation, Sanitation, Water and Sanitation, Water (State)	Northern Redbelly Dace	Stonecat
BLM Colorado Wilderness Areas	Ducks Unlimited Project Areas	Natural Resources Conservation Service (NRCS) SSURGO Soil Data	Stream Fishing
BLM Land Ownership Classifications	Educational Segments	Osprey Nest Sites and Foraging Areas	Supply Reservoirs
BLM Public Land Survey System (PLSS) Survey Data - Corners, Control Points, Grid	Elevation Raster	Outstanding Waters	Urban Areas
Bluehead Sucker	Eligible/Suitable Wild and Scenic	Piping Plover	USFS Wildfire Risk Assessments-Regional
Bonytail Chub	Environment Point of Interest	Plains Minnow	U.S. Department of Agriculture (USDA) National Agriculture Statistic Service (NRCS Data Gateway)
Boreal Toad Breeding Sites	Federal Emergency Management Agency (FEMA) 100-Year Flood Zones	Plains Orangethroat Darter	USFS Watershed Condition Classification System
Boreal Toad Critical Habitat	Flannelmouth Sucker	Preble's Meadow Jumping Mouse	USGS Stream Gages with Hotlinks and Water Quality Data
Brassy Minnow	Flatwater Boating	Rafting and Kayak Reaches	Water Supply Stream Segments

GIS Layers for Nonconsumptive Mapping			
Colorado Department of Public Health and Environment (CDPHE) Source Water Assessment water provider data, source water zones, and potential sources of contamination (PSOCs)	USFS	Rare Riparian Wetland Vascular Plants	Waterfowl Hunting Areas
CPW Species Activity Data	Front Range Fuels Treatment Partnership	Razorback Sucker	Wetland and Riparian Habitat
Colorado Birding Trails	Gold Medal Trout Lakes	Recreation Points of Interest	Whitewater Boating
CDPHE Water Quality Control Division 303(d) Listed Segments	Gold Medal Trout Streams	Recreational In-Channel Diversions	Wild and Scenic Study Rivers
Colorado Outstanding Waters	Grand Mesa, Uncompahgre, and Gunnison Wilderness Waters/Areas	Reservoirs	Wilderness Areas and Wilderness Study Area Water
Colorado Pikeminnow	Greenback Cutthroat Trout Streams/Lakes	Reservoir and Lake Fishing	Wildfire / Watershed Risk Assessments – Upper Arkansas, Arkansas, and Pikes Peak Region
Colorado River Cutthroat Trout	High Fire Threat	Rio Grande Cutthroat Trout	Wildlife Viewing
Colorado Vegetation Classification Project	High Recreation Areas	Rio Grande Sucker	Yellow Mud Turtle
Common Garter Snake			

Threatened and Endangered Species

Attributes in this subcategory include federally listed threatened and endangered plants and animals as well as other state species of concern. Many of these species are protected by state or federal mandates, or have current management plans resulting from concern for the species survival. Threatened and endangered species in the Arkansas Basin that were included as attributes in past analysis include the bald eagle, piping plover, least tern, lesser prairie chicken, Arkansas darter, boreal toad, and greenback cutthroat trout. *Audubon Important Bird and Biodiversity Areas (IBAs)*

The IBA Program is a global initiative of BirdLife International that is implemented by Audubon and local partners in the United States. The program identifies areas vital to birds and other biodiversity, and works to implement conservation strategies to minimize the effects of habitat loss and degradation. Audubon IBAs were included as an environmental attribute in the Arkansas Basin due to the protection potentially offered directly to sensitive bird species, and indirectly to other species and habitats.

Significant Riparian and Wetland Plant Communities

Data included in this subcategory are derived from the work of the Colorado Natural Heritage Program (CNHP), which serves as a comprehensive source of information on the status and location of Colorado's rare and threatened species and plant communities. The program provides scientific information and expertise and aids in the conservation of the state's biological resources. The Botany Team at CNHP tracks the location and condition of more than 500 globally and/ or state-imperiled plants in an effort to guide effective management and protection of those species and, thereby, prevent extinctions or statewide extirpations of Colorado's native plant species.

Special Value Waters

This subcategory includes a wide range of waters that have been designated as important for their beneficial features and uses, which may include public water supplies, domestic, agricultural, industrial and recreational uses, water quality, habitat, and the protection and propagation of terrestrial and aquatic species. The special value waters subcategory consists of Colorado Outstanding Waters, Gold Medal Trout Waters, waters with CWCB instream water rights or natural lake level water rights, waters with recreational in-channel diversion structures (RICD), BLM Wilderness Study Area waters, Arkansas Wilderness Area waters, and Wilderness Study Area waters.

National Wetlands Inventory (NWI) Wetlands

The NWI is maintained by the USFWS, which produces information on the characteristics, extent, and status of the nation's wetlands and deepwater habitats. Wetlands provide many ecological, economic, and social benefits, and provide habitat for fish, wildlife, and a variety of plants that have environmental, commercial, and recreational importance. Wetlands are also important landscape features because they hold and slowly release floodwater and snow melt, recharge groundwater, recycle nutrients, and provide recreational and wildlife-viewing opportunities. Numerous wetlands are present throughout the basin, including emergent, forested, and scrub-shrub, and can be found in low-lying depressions and alongside ponds, lakes, and rivers.

Waterfowl Hunting

This subcategory is comprised of CPW parcels designated as waterfowl hunting areas, including State Wildlife Areas. CPW manages more than 300 State Wildlife Areas across the state, totaling more than 650,000 acres. These areas help manage and preserve wildlife habitat, and provide the public with opportunities to hunt, fish, and watch wildlife. All state wildlife areas in the Arkansas Basin were included in this subcategory.

The Arkansas Basin is known for its prime waterfowl hunting areas. During the early winter months, cold air pushes duck populations from the northern arctic regions into southern regions, including the Arkansas Basin where high-quality habitat is present. In the spring, goose hunting is popular as the snow geese migrate through the area. Turkey and quail hunting is also a popular within the basin, and Colorado's prime quail habitat is in southeastern Colorado within the Arkansas Basin.

Significant Fishing Areas

Attributes in this category include significant reservoir, lake, stream, and river fishing areas. The information was gathered from Nonconsumptive Needs Subcommittee members, Trout Unlimited, and other stakeholders. Some of these areas include trout lakes and streams, Pueblo fishing areas, State Wildlife Areas, State Fishing Units, and the Arkansas Headwaters Recreation Area.

Extensive public fishing areas and access points occur along the entire Arkansas River, the river's numerous tributaries, and at the basin's many lakes and reservoirs. The Arkansas Headwaters Recreation Area, Colorado State Parks, and local commercial fishing guides work together to maintain and provide access to these exceptional fishing areas in the Arkansas Basin.

Birding Trails

Colorado birding trail locations were received from the National Audubon Society. Birding trails provide watchable wildlife areas. Migrating birds, part-time residents, and year-round resident bird species often require habitat with immediate water features or habitat associated with water features. Some of the popular bird watching areas include Wet Mountain Valley in Custer County, Lake Pueblo, The Nature and Raptor Center of Pueblo, Pueblo City Park, Lake Henry, Lake Meredith, Lake Cheraw, Lake Holbrook, Rocky Ford State Wildlife Area, Picket Wire Canyon, and the Purgatoire River.

Significant Whitewater and Flatwater Boating Waters

Waters used for whitewater and flatwater recreational boating are included in this subcategory. Information was received from CPW, nonconsumptive subcommittee members, and other stakeholders. Popular rafting areas are located along the Arkansas River from Granite through the Royal Gorge. The Arkansas Headwaters Recreation Area and Colorado State Parks work with a number of local commercial rafting guides to provide rafting opportunities for locals and tourists on the Arkansas River, one of the most popular rafting destinations in the country.

The list of attributes important to the Arkansas Basin has continued to grow and evolve, and includes an array of environmental and recreational nonconsumptive features. The attributes are being used for further assessment in the Arkansas BIP and the SWSI 2016 update. More information on the updated list of attributes can be found in Section 4.7, including Gold Medal Trout Waters that were designated in the upper Arkansas River in 2014.

2.1.7 Environmental and Recreational Programs, Projects, and Methods

Nonconsumptive projects, methods, and studies that were planned, ongoing, or completed in the Arkansas Basin were collected in 2010 by CWCB and evaluated by the Arkansas BRT and its Nonconsumptive Needs Subcommittee during the nonconsumptive needs assessment (Section 2.1.4.4). Forty projects were identified from the outreach and included projects surveyed and interviewed by CWCB, WSRA grants, CWCB ISFs and natural lake levels, CWCB restoration projects, and USGS SRGAP information. Examples of the types of projects collected include the following:

- Habitat restoration projects, such as bank stabilization projects, or instream habitat restoration, including pool and riffle development, as well as projects that focus on maintaining connectivity for fish passage, such as fish ladders.
- Flow protection projects, such as voluntary flow agreements, ISF donations, or voluntary re-operation of reservoirs for releases for environmental or recreational needs.

The projects and methods Database was comprised of specific projects and studies occurring or planned in the basin as mentioned above, as well as broader methods and systems that provide information and/or protections to environmental and recreational attributes. The database incorporates information from the following:

- Projects and studies identified through information sent directly to CWCB from public and private stakeholders that had received the survey information or learned about the effort.
- Information gathered from divisions within the Colorado Department of Natural Resources, including ISFs and natural lake levels.
- WSRA grant programs were also included. Those projects fully or partially address nonconsumptive needs. Funding programs that coordinate WSRA grants include the Colorado Healthy Rivers Fund, Colorado Water Restoration Program, Fish and Wildlife Resources Fund, and Multi-Objective Watershed Protection Plans.
- The Aquatic Research Section leads fishery management for CPW and has assigned a water management classification (relating to fishery objectives) for every water body, stream, or river segment in Colorado. This information summarizes projects, methods, and potential protections to nonconsumptive attributes, and was included in the database of Arkansas Basin projects and methods.
- USGS SRGAP information.

For the Arkansas BIP, an updated list of identified projects and processes was compiled, similar to the projects and methods database described above. The revised list will be used in analyses that will help identify the projects and methods that are required to meet the nonconsumptive needs of the Arkansas Basin. Refer to Section 4.7 for more information.

2.1.8 Summary: Nonconsumptive Needs Assessment

The Colorado Water for the 21st Century Act charged BRTs with developing consumptive and nonconsumptive water supply needs assessments, and with identifying projects and methods to meet those needs. Analysis of environmental and recreational attributes as well as known projects and methods occurred in the nonconsumptive needs assessment and the focus mapping efforts, resulting in identification of nonconsumptive needs, and protections afforded to those needs by current projects and methods. These studies and results will be used as a basis for the Arkansas BIP and as a next step of the SWSI and the CWP, in which projects and methods required to meet the nonconsumptive needs of the Arkansas Basin will be identified, analyzed, and prioritized. Section 4.7 provides details of those processes and results.

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2.2 Consumptive Needs

The Consumptive Needs section details anticipated water demand for municipal and industrial needs, self-supplied industrial needs, and agricultural needs. The primary source for data and projections is the Statewide Water Supply Initiative (SWSI) 2010 report, which documents anticipated population growth and projected water demands through 2050. Consumptive needs in the Arkansas Basin have been growing, driven by population and economic growth, particularly in urban areas. Through SWSI 2010 and preceding processes, the Arkansas Basin Roundtable has developed an understanding of available water supplies within the basin. Consumptive users, including municipalities, agricultural producers, and industry have engaged in water transactions, transferring water to new uses. Anticipating a continuation of this trend, the Roundtable has developed a set of identified projects and processes and methods to address the pressure on agriculture as the primary source of municipal supply. There is no unused water originating within the Arkansas River basin, thus a clear "gap" emerges between future demand projections and available water supplies.

Section 2.2.1 details the background of this document and the information resources used in its development. Section 2.2.2 provides information regarding population and economic growth, including projections from the Colorado State Demographer's Office and the SWSI 2010 report. Section 2 then details municipal and industrial needs (2.2.3), including self-supplied industrial, agricultural needs (2.2.4), and Arkansas Basin Roundtable initiatives (2.2.5).

Section 3.0 of this basin plan will address in greater detail the relationship between native water, imported water, and the reuse of water for greater efficiency within the Arkansas Basin. The recent call for a Colorado Water Plan brings the relationship between various uses of water in to greater focus.

2.2.1 Background

The Governor's executive order (D 2013-005) emphasizes the water values of Colorado and its natural importance as a headwater state. Water users throughout the Arkansas Basin are challenged by extremes in hydrologic conditions. The Arkansas River, whose headwaters starts in the Rocky Mountains, depends on snowfall to support the various uses of water downstream. Consumptive water users include agricultural producers, municipal and industrial (M&I) users, and self-supplied industrial (SSI) users. Water availability has concrete impacts on the economy and quality of life in the Arkansas Basin, and drought conditions have brought to the fore concerns regarding the basin's water future. In addition to drought conditions, rapid economic and population growth and interstate compact obligations have illuminated the constraints and challenges of the future. The first step toward understanding the basin's challenges is to assess its water needs.

The Consumptive Needs section will provide an overview of Roundtable initiatives since SWSI 2010 and detail the current and future anticipated needs of consumptive users in the Arkansas Basin. By applying estimates of population in the Year 2050, SWSI 2010 demonstrated that municipal supply gaps were inevitable, absent permanent transfers of water from agriculture to municipal uses. The SWSI 2010 Executive Summary was explicit that portions of the basin dependent on groundwater, particularly the non-renewing sources in the Denver Basin Aquifer, faced imminent challenges. Providing an aggregate view of the impact of the basin's growth by subregions, SWSI 2010 captures the consequences of population growth as a shortfall of water supply several decades in the future. Activities by the Arkansas Basin Roundtable provide the insight that localities face immediate challenges to near-term water availability, both for municipal and agricultural uses.

While projections of population growth within the basin are the metric for projecting water demand, and SWSI 2010 projects a significant "gap," the reality is that many subregions within the basin have declining populations. Table 2.2.1 provides county level population data for the years 2000 and 2010, demonstrating the shift in population from rural to urban counties.

Table 2.2.1 - Changes in County Level Population, Source: SCEDD

County	2000 Population	2012 Population	Percent Change
Baca	4,517	3,788	-19%
Bent	5,998	6,499	8%
Crowley	5,518	5,823	5%
Kiowa	1,622	1,398	-16%
Otero	20,311	18,831	-8%
Prowers	14,486	12,551	-15%
Chaffee	16,242	17,809	9%
Custer	3,503	4,255	18%
Fremont	46,145	46,824	1%
Lake	7,812	7,310	-7%
Las Animas	15,207	15,507	2%
Pueblo	141,472	159,063	11%

In part, this demographic shift is related to the transfer of water from agriculture to municipalities, some outside the natural drainage of the Arkansas River. The *Southern Colorado Economic Development District's 2010 Comprehensive Economic Development Strategy Report*[1]shows that 5 of the 12 member counties lost population over the period 2000 to 2010. The trend continues and is part of the impact adaptation to changing water needs, with economic effects throughout the basin. The effects may include changes in agricultural production and practices, changes in employment and sectors, and shifts in urban to rural ratios. These impacts are addressed in detail in the following sections.

Over the past decade, The Colorado Water Conservation Board has developed a series of needs assessments, from the first *Statewide Water Supply Initiative* in 2004, a water needs update report in 2008, to the most recent *Statewide Water Supply Initiative 2010*, which have provided robust information regarding consumptive users' water needs. The following sections detail:

- Information garnered through the Statewide Water Supply Initiative 2010, including:
    - Population projections through 2050;

[1] P. 11

- Municipal and Industrial demand through 2050 (including passive conservation);
- Self-Supplied Industrial demand through 2050;
- Irrigated acreage estimates;
- Agricultural demand through 2050;

- Conclusions and initiatives by the Arkansas Basin roundtable based on intermediate studies and the on-going effort to address the needs of the basin.

Over preceding years, the Arkansas Basin Roundtable developed a series of documents detailing the Basin's needs and potential supply gaps, including *the Arkansas Basin Consumptive Use Water Needs Assessment of 2008 (Applegate)*, *Projects and Methods to Meet the Needs of the Arkansas Basin 2009*, and the *Projects and Methods 2012 Update*. The assessments helped to develop a more comprehensive understanding of consumptive needs within the Basin. The relevant findings are that:

- Municipal water demand gaps in SWSI 2010 were aggregated into regional projections for the Years 2030 and 2050, where a clear gap exists even with 100% success of Identified Projects and Processes (IPP's) in several subregions. Further investigation, in part in response to Western Resource Advocates "Filling the Gap" of 2012[2], revealed that the municipal gap is imminent when the data is disaggregated. The Arkansas Roundtable's dialogue about the consequences of application of fully consumable, imported water to both the future municipal supply gap and its current use to augment agricultural efficiency were captured in the 2012 Update memorandum.
- Agricultural gaps when calculated on an acreage basis mask the unique challenges of water supply constraints within the Arkansas Basin. At the same time, the importance of agricultural water beyond farm income, specifically environmental and recreational benefits, should be articulated. To that end, the roundtable formed a Value of Agriculture subcommittee which took several proactive steps to bring clarity to the conversation.
- The Applegate Study of 2008 quantified the municipal gap required to replace the current dependence on Denver Basin aquifer nonrenewable sources. The economics of developing a "replacement" water supply remain a critical component of meeting the future municipal gap.

These items are each addressed specifically below.

Review of the SWSI reports and the Applegate 2008 Study consistently identify a municipal supply gap that will likely be met by the historic pattern of permanently drying up irrigated agriculture. The Arkansas Basin Roundtable's perspective on irrigation dry-up remains that:

- Alternatives to permanent transfers from agriculture are critical; and,
- New Supply is essential to preclude significant loss of agriculture.

The following section provides background population and economic growth information for the Arkansas Basin.

[2] http://westernresourceadvocates.org/water/fillingthegap/FTG_Joint_ES.pdf

2.2.2 Population and Economic Growth

Colorado's economic and population growth are the driving forces behind increasing water demand. In 2013, Colorado's population was estimated at 5.27 million, up 4.8 percent from the 2010 census, with approximately 2.1 million households.[3] In 2010, the population of the Arkansas Basin was estimated at approximately 978,500. The SWSI 2010 report estimates that by 2050, the Arkansas Basin will have between 1.58 and 1.84 million residents, with annual growth between 1.2 and 1.6 percent.[4]

The ranges of potential population growth are underpinned by economic growth projections. In 2012, Colorado's Nominal Gross Domestic Product (GDP) was $274 billion.[5] In 2012, GDP grew by 2.1 percent in Colorado, a slight increase over 2011. Expectations are for eventual upward revisions of growth and a continued trend for higher growth statewide.[6] As economic and population growth continue, water demand will increase concurrently.

The top ten industries in the Arkansas Basin produced approximately $21.8 billion worth of output in 2011,[7] $1.5 billion of which is derived from agriculture and animal husbandry, as detailed in Table Two.

Table 1.2.2 - Economic Output by Sector, Arkansas Basin, Source: Colorado State University

Sector #	Description	Employment	Output
440	Federal Government* (military)	44,059	$8,057,465,000
413	Food services and drinking places	34,288	$1,859,604,000
438	State & local government, Education	32,804	$1,741,668,000
437	State & local government, Non-education	28,395	$1,734,837,000
360	Real estate establishments	20,968	$2,948,849,000
394	Offices of physicians, dentists, and other health practitioners	16,485	$1,752,376,000
329	Retail Stores - General merchandise	10,873	$635,245,800
331	Retail Non-stores - Direct and electronic sales	10,151	$615,881,300
1-14	All agriculture and animal husbandry	10,036	$1,514,920,221
36	Construction, other new nonresidential structures	9,640	$955,054,800
	Total of Top Ten	**217,699**	**21,815,901,121**

Agriculture, while representing approximately 7 percent of the basin's top ten industry total, is the largest user of water within the basin. As indicated in Table Three, water withdrawals in the Arkansas River Basin total approximately 1,827 million gallons per day, and crop irrigation accounts for 87 percent of all withdrawals.

[3] United States Census Bureau, 2010 Census and Population Estimates – Quick Stats.
[4] Statewide Water Supply Initiative 2010 Arkansas Basin Report, CDM.
[5] Federal Reserve Bank of St. Louis, FRED Economic Data, Gross Domestic Product by State.
[6] Wells Fargo Economics Group, *Colorado Economic Outlook*, August 7, 2013: https://www08.wellsfargomedia.com/downloads/pdf/com/insights/economics/regional-reports/Colorado_08072013.pdf
[7] Jake Salcone and James Pritchett, *Value of Water Used in Agriculture for the Arkansas River Basin,* February 4, 2014.

Table 2.2.3 - Water Withdrawals by Use, Arkansas Basin, Source: Colorado State University

	Million gal/day	Percent of Ark Basin
Crop Irrigation	1,590.25	87.01%
Livestock	5.93	0.32%
Public Supply	106.73	5.84%
Domestic (self-supply)	7.01	0.38%
Industrial	73.79	4.04%
Mining	2.79	0.15%
Thermoelectric	36.90	2.02%
Total Withdrawals	1,827.58	99.77%

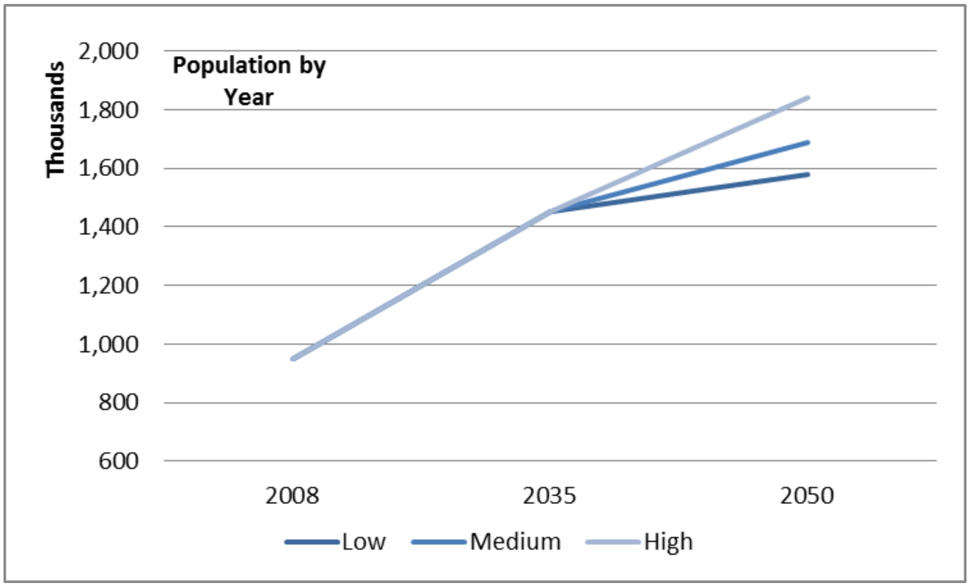
2.2.3 Municipal and Industrial Consumptive Needs

The municipal and industrial (M&I) water demand forecast is based on capturing the predicted needs of a growing population. M&I demands, as defined by SWSI 2010, are those water uses typical of municipal systems, including residential, commercial, light industrial, non-agricultural related irrigation, non-revenue water, and firefighting services. SWSI 2010 also included households within the basin that are self-supplied and not connected to a public water system.

SWSI 2010 used standard methods to project future M&I demands in the Arkansas Basin. The process was intended to use standardized data and was for statewide and basin wide planning. The M&I demand forecast used a "driver multiplied by rate of use" approach, a commonly accepted forecast methodology that projects changes in demand based on changes in the underlying demand driver. The M&I forecast performed by SWSI 2010 was based on population growth multiplied by the rate of use in gallons per capita per day (gpcd).

Population projections for the Arkansas Basin were developed by the SWSI 2010 report using State Demographer's Office (SDO) projections through 2035. The SDO predicted that by 2035 the Arkansas Basin would have a population of approximately 1.45 million. SWSI 2010 then extended the projection to the year 2050, estimating that under low economic growth, the Basin would have nearly 1.58 million residents; under high economic growth the basin could have as many as 1.84 million residents.

Figure 2.2.1 - Population Projections by Year, Data Source: SWSI 2010, Graphic: WWR



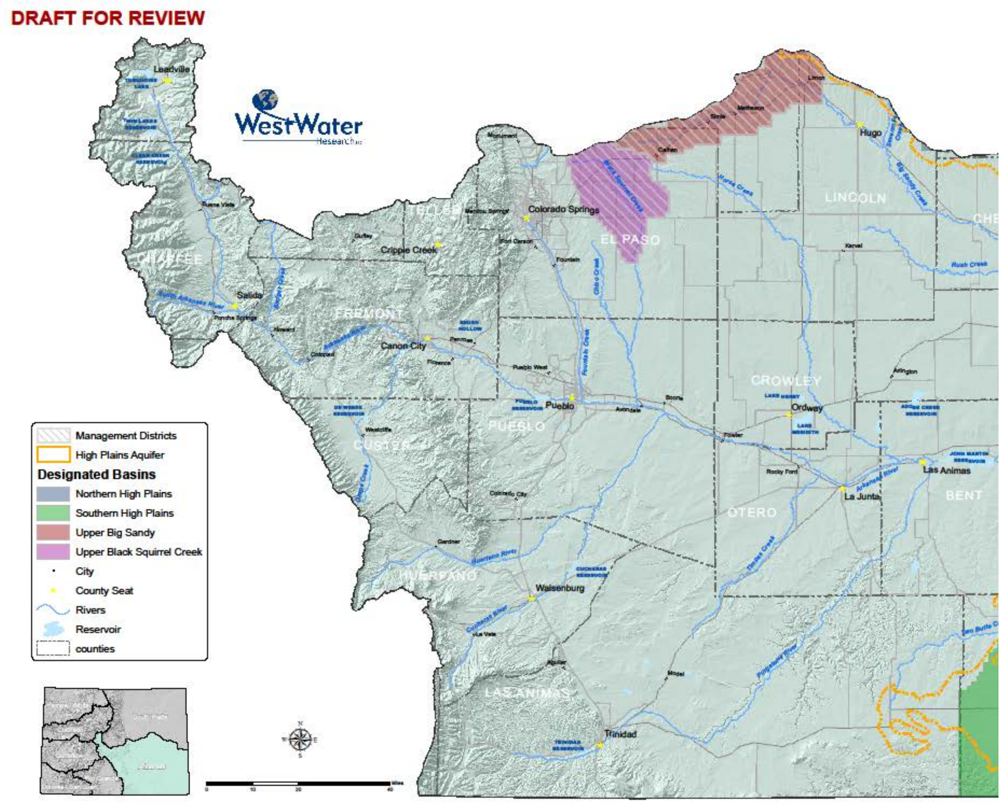
Under medium population growth assumptions, the Arkansas Basin population is expected to grow approximately 78 percent between 2008 and 2050, although select subregions will experience declines in population.[8] Much of this growth will be in El Paso County, the county seat of which is Colorado Springs. Overall, urban counties will account for most of the population and economic growth within the Arkansas Basin.

2.2.3.1 Methodology for Projecting Future M&I Consumptive Needs

The following section provides brief insight into the methodology employed by SWSI 2010 and highlights the need for continued analysis. SWSI 2010 made reasonable assumptions that municipal water supplies were permanently available. While this is generally accurate, a significant exception is the Denver Basin (see section 2.2.3.5). The methodology used for municipal and industrial (M&I) water demand forecasting by SWSI 2010 was based on a survey of water providers throughout the state. The estimated per capita water rates for each county were multiplied by the projected population of each county to estimate current and future municipal water demand. Water available in many groundwater systems, including the Designated Basins and the Ogalla aquifer in South-East Colorado, are becoming unsustainable and will not be available in the future. Therefore, while water is generally available to meet municipal needs, some subregions will experience supply constraints.

[8] See Section 2.2.1, Background, above for further information.

Figure 2.2.2 - Designated Basins and Ogalla Aquifer in Baca County



To address these potential constraints, a new approach is currently under development. The new Basin Needs Decision Support System will provide a more detailed assessment of current water availability and future water supplies in order to assess regional and subregional challenges. The methodologies used in the SWSI 2010 report, detailed below, can be updated and adapted to fit within this new tool going forward.

In the SWSI 2010 report, M&I water demand forecast was developed by multiplying the population projections (provided above) by the estimated rate of use. There are various factors that affect use rates, identified by SWSI 2010 as:

- Number of households;
- Persons per household;
- Median household income;
- Average temperatures;
- Precipitation;
- Employment;
- Ratio of irrigated public lands (parks) to population;
- Mix of residential and commercial water use and types of commercial use;
- Level of tourism;
- Ratio of employment by sector;

- Urban and rural mixtures within a county.

To assess water use rates, a database was created with power water use and service population data gathered from various sources. Existing data was compiled during the SWSI 1 process (in 2004), sourced from 254 water providers. For SWSI 2010, 214 water service providers contributed updated data, covering 87 percent of the basin's population. A system-wide gpcd estimated was calculated for each local water provider by dividing the total water deliveries by the service area population. To adapt these data to 2050 population projections at the county level, gpcd values were aggregated from the water provider level to the county level. SWSI 2010 then applied a weighting process to develop a county average system-wide gpcd based upon the portion of the county population served by each water provider.

Once county level data was created, the M&I demand forecasts were developed for the Arkansas Basin, representing the permanent population and its water demand baseline through 2050. Going forward, new tools and processes can be adapted to accurately forecast subregional challenges in water supplies and to provide a more comprehensive overview of the Arkansas Basin's water needs.

2.2.3.2 Passive Conservation applied to M&I Consumptive Needs

In addition to the methodology above, passive conservation savings were incorporated into the analysis. SWSI 2010 calculated passive water savings based upon assumptions that pre-2016 housing and business stock would be retrofitted through replacement of:

- Household appliances, such as washing machines and dishwashers; and,
- Toilets and household water fixtures.

Replacement of these appliances and fixtures with low-flow, high efficiency substitutes, and assuming new constructions continue to use efficiency methods and products, allowed SWSI 2010 to estimate a passive water savings range of 19 to 33 gpcd through 2050. These assumptions were built into the baseline water demand assumptions going forward and are detailed in Table Four below.

2.2.3.3 M&I Consumptive Needs Forecast

Based on population projections, estimated use levels per capita, and passive conservation, total basin-wide 2050 M&I demands were estimated between 300,000 and 350,000 acre-feet per year. Without passive conservation, M&I water demand estimates increase to between 320,000 and 380,000 acre-feet per year in the Arkansas Basin. The following table provides a summary of the SWSI 2010 conclusions regarding Municipal and Industrial demand forecasts.

Table 2.2.2 - M&I Consumptive Needs Forecast, Source: SWSI 2010

Arkansas Basin	Water Demand AFY				
	2008	2035	2050 Low	2050 Med	2050 High
Base Demand	200,000	300,000	320,000	350,000	380,000
With Passive Conservation	200,000	270,000	300,000	320,000	350,000

Passive conservation methods would save significant water over time, accruing to approximately 8.5 percent of basin M&I demand by 2050 at a medium growth level. With passive conservation, M&I water demand is forecast to grow between 50 and 75 percent by 2050 from 2008 consumption levels.

2.2.3.4 Self-Supplied Industrial Consumptive Needs

Self-Supplied Industrial (SSI) water demands include water use by self-supplied and municipal provided large industries. The subsectors comprising SSI are:

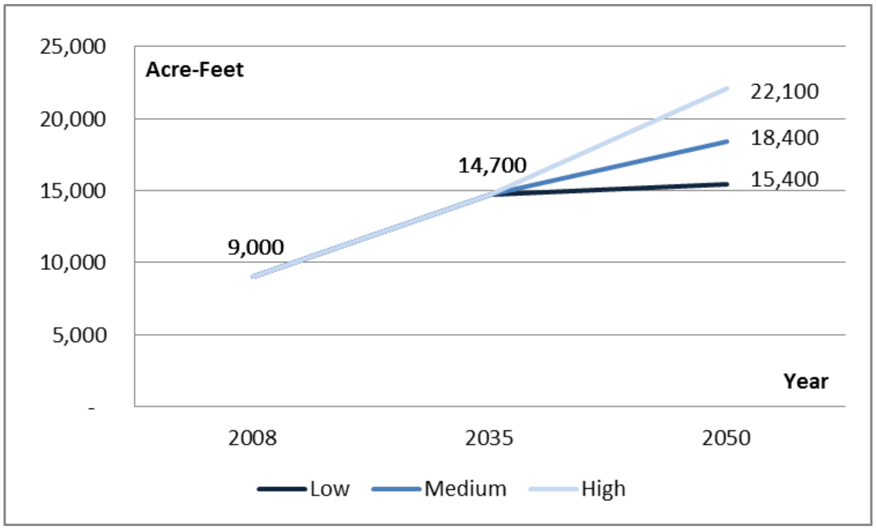
- Large industries such as mining, manufacturing, brewing, and food processing;
- Snowmaking;
- Thermoelectric power generation (coal and natural gas facilities);
- Energy development, such as extraction and production/processing of natural gas, coal, uranium, and oil shale.

These industries generally have self-sufficient water supplies or lease raw water from other large suppliers. Some of the subsector industries are growing within Colorado and water supplies are critical to their continued growth and development. SWSI 2010 provided information for each SSI subsector.

Large industry demands in the Arkansas Basin include steel manufacture in Pueblo County. No growth for large industry in the Arkansas Basin is forecast. In 2008, SSI demand in the Arkansas Basin was approximately 49,400 acre-feet per year, with no change expected through 2035 or 2050, according to SWSI 2010.

Thermoelectric facilities generate 95 percent of Colorado's electricity with production by the use of coal accounting for 71 percent and natural gas 23 percent (rounded to 95%) as of 2004. Despite adoption by Colorado's General Assembly of a standard of 20 percent renewable energy by 2020, thermoelectric power generation will continue to demand significant water into the future. SWSI 2004 collected information from power producers regarding their estimated current and future water uses. SWSI 2010 used the SWSI 1 baseline estimates through 2035. To extend the projections through 2050, estimates were based on growth of 5 percent (low growth), 25 percent (medium growth), and 50 percent (high growth) for water demanded by thermoelectric SSI subsector users. Figure 2.2.4 provides details of anticipated SSI demand for thermoelectric users according to SWSI 2010.

Figure 2.2.3 - SSI Thermoelectric Forecasts through 2050, Source: SWSI 2010



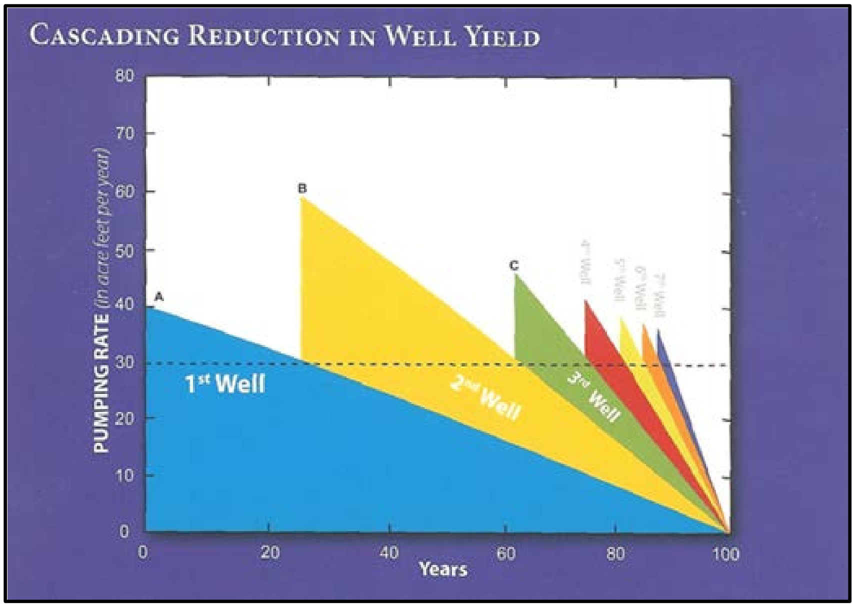
Snowmaking and energy development were not expected to generate any demand through 2050. They were therefore excluded from the SWSI 2010 analysis of SSI demand within the Arkansas Basin. Total SSI demand was estimated to increase throughout the Basin by between 6,400 and 13,100 acre-feet per year between 2008 and 2050, depending on economic conditions.

2.2.3.5 Nonrenewable Water Supplies

The SWSI 2010 recommendations referenced regional dependence on the nonrenewable groundwater of the Denver Basin aquifers, a supply source for many of Colorado's Front Range communities. Future studies need to consider the impact and seek to address the depletion of nonrenewable water supplies. The Denver Basin aquifer in particular presents two challenges for meeting municipal water supplies:

1) The theoretical life of the aquifer is 100 years. Many providers have been extracting water from this source for more than 30 years and the projection of water availability to the year 2050 approaches the theoretical extinction of the supply;
2) While relatively inexpensive to develop in the near-term, the declining hydro-static pressure in the aquifer results in a continuously increasing cost for both operations and infrastructure development.

Figure 2.2.4 - Cascading Reduction in Well Yield[9]



The Colorado Foundation for Water Education *Citizen's Guide to the Denver Basin Groundwater* illustrates that as pumping rates decrease with use, capital expenditures in new wells are required to sustain water deliveries. Capital expenditures to sustain this water source beyond the year 2015 run to millions of dollars. Since this source must be replaced, every dollar invested in pumping from a depleting source is a dollar not available to defray the cost of the replacement supply. Many of the areas that are Denver Basin dependent also provide a major tax base for local communities. Failure to identify and fund a vialble replacement could have catestrophic effect on local economies.

Within the Arkansas Basin, the urban regions of unincorporated El Paso County include many water providers whose only source of drinking water is the Denver Basin aquifer. The *2008 Applegate Study* quantified the future demand for replacement of this source of supply at approximately 13,500 acre-feet. Continued growth in the suburban areas of El Paso County adds another 9,000 acre-feet through the Year 2030, suggesting a 22,500 acre-foot gap by 2030. The 2009 report *Meeting the Needs of the Arkansas Basin* emphasized the importance of finding a replacement supply and the potential for a collaborative solution, including alternatives to permanent agricultural land dry-up and regional cooperation on delivery infrastructure.

The Denver Basin is a high quality, drought proof source of drinking water. Due to the low cost of development in the 1980's, significant housing developments rely on it as their only source of water, while potential weather volatility stresses tributary sources. Conjunctive use of tributary and non-renewable sources requires examination. Going forward, new studies and documentation should incorporate the anticipated future dry-up of the Denver Basin Aquifer. The Arkansas Basin Roundtable needs to focus on projects and methods to encourage alternative water supply development to those municipal and industrial users dependent on the aquifer.

[9] Colorado Foundation for Water Education: *Citizen's Guide to the Denver Basin Groundwater, p.21.*

2.2.4 Agricultural Consumptive Needs

This section provides details derived from the SWSI 2010 process regarding agricultural consumptive needs in the Arkansas Basin. It also summarizes how irrigated acreage in 2050 was estimated, and provides an overview of existing and future estimated agricultural demands.

Irrigated agriculture in the Arkansas Basin is estimated to be responsible for 87 percent of water withdrawals, of which approximately 55 percent is consumptively used. In 2010, U.S. Geological Survey estimated that crop irrigation withdrawals accounted for 1.59 billion gallons per day.[10] The SWSI 2010 estimates included only consumptively used water as opposed to diverted quantities. Agricultural demand includes water consumed by plants through evapotranspiration, as well as water "lost" to soil evaporation and deep percolation into the groundwater aquifer.

To determine demand, SWSI 2010's authors assumed that water supply was not a binding constraint early in the irrigation season, but became a constraint as water supplies declined over the course of the season. Consumptive use was therefore not limited early in the irrigation season. The methodology then assumed that at some point water supplies would be less than the crops' uptake capacity, limiting the consumptive use. This leads to two measurements: the irrigation water requirement, or total water capacity uptake of crops throughout the irrigation season; and, the water-supply-limited consumptive use, or the total water consumptively used for agriculture in the basin at present. The minima of the two, the irrigation water requirements (consumptive use capacity) or the water-supply-limited consumptive use (current use), was considered to be the available water supply. These values were estimated over a ten year period and encompassed time-varying information regarding climate (precipitation and temperature) and water supply currently available for agriculture. Where data was available, Colorado Decision Support System methodology was used to determine agricultural consumptive use in livestock and stockpond evaporation.

Irrigated acres estimates were based on the following factors:

- Urbanization of existing irrigated lands;
- Agricultural to municipal water transfers;
- Water management decisions;
- Demographic factors;
- Biofuel production;
- Climate change;
- Farm programs;
- Subdivision of agricultural land, including lifestyle farm growth;
- Yield and productivity;
- Open space and conservation easements; and,
- The economics of agriculture.

[10] Ivanhnenko, Tamara, and Flynn, J.L., (2010). *Estimated withdrawals and use of water in Colorado, 2005*: US Geological Survey Scientific Investigations Report 2010-5002.

The first three factors were quantified by SWSI 2010 based on future growth estimates, municipal water demand gaps that will be met by 2050, and interviews with water management agencies statewide. The remaining eight factors were qualitatively assessed using information provided by CWCB and Colorado's Department of Agriculture.

Urbanization of existing irrigated lands was established using 2050 population projections, estimation of future urban area size, and the current irrigated acres. Future losses of irrigated acres were calculated by SWSI 2010 first for each county, and then re-distributed by water district.[11] The SWSI 2010 M&I gap analysis was used as the basis for the analysis of irrigated acreage changes associated with agricultural to municipal transfers. In order to estimate future irrigated acres, it was assumed by SWSI 2010's authors that 70 percent of the M&I gap would be met from agricultural to municipal transfers without taking into account projects or methods that may not be successful (it assumes 100 percent IPP success in M&I projects and methods). In addition, SWSI 2010 included a safety factor of 25 percent, applied to account for additional irrigated acres that may be needed to provide the transferred water on a yield basis.

Other factors, including demographics, biofuel production, climate change, farm programs, and subdivision of agricultural lands, CWCB identified trends that are expected to occur within each area over a forty year period. Using this information CWCB developed a qualitative assessment on whether each factor would cause a negative of positive impact on irrigated agriculture by 2050.

2.2.4.1 Alternatives to Permanent Loss of Agricultural Water

Based on the factors above and the methodology,[12] SWSI 2010 determined that out of an estimated 428,000 irrigated acres in the Arkansas Basin (as of 2008), approximately 2,000 to 3,000 irrigated acres would be lost to urbanization, 7,000 irrigated acres would be dried up through previously planned agricultural to municipal transfers, and between 26,000 and 63,000 acres would be dried up due to potential or anticipated agricultural to municipal transfers used to address the M&I gap.

Agriculture has been a default source of water for municipal growth for many decades. SWSI 2010 states:

> "Given the lack of developable new supplies in the Arkansas Basin, agricultural transfers throughout the basin will continue via purchases, developer donations, and development of irrigated lands."[13]

The roundtable attempted to reframe agricultural consumptive needs in the 2012 Update Report based on the following conclusions from SWSI 2010:

- Proceed with development of Alternative to Agricultural Transfers methods by pursuing three (3) tracks simultaneously: 1) A common technical platform for streamlined engineering and administrative processes; 2) Public policy initiatives to provide avenues for alternatives while

[11] For more information, see SWSI 2010, Appendix I.
[12] See SWSI 2010, Section Four and Appendix I for more methodological details.
[13] SWSI 2010, page ES 8

respecting the body of law known as the Prior Appropriation Doctrine, and; 3) Initiating Pilot Projects to identify the practical impediments to implementation.

- Define and advocate for a better understanding of the importance of agricultural uses, particularly as uses in the Lower basin underpin the environmental and recreational uses in the Upper basins. Two initiatives were started: 1) Colorado Water Institute Study of agricultural water value (see side box); and, 2) Organization of *"Valuing Colorado's Agriculture: A Conference for Water Policy Makers,"* held October 7, 2013.
- Recognition of the need for additional augmentation water as farm efficiency improves and municipal imported water return flow is reduced to meet the municipal gap in growth areas, or in response to drought.

Colorado Water Institute Study Thesis

In the Arkansas River basin, as in many growing regions, agricultural and irrigation water is being reallocated to non-agricultural uses. Transferring water from agriculture may reduce the productive capacity of the industry, alter economic activity in rural communities, change recreation opportunities and diminish the provision of ecosystem services. Conversely, positive benefits may accrue to the municipal and industrial industries engaged in purchasing agricultural water. Many of these costs and benefits are not reflected in the price at which water trades.

In order to better understand the implications of agricultural to municipal transfers, a broader measure of the value of water used in agriculture needs be determined. A broader method of determining the value of agricultural water would consider irrigated crop sales, the value of agriculture water to recreational users as well as the economic spillovers from agriculture sales and recreational activity. Colorado State University researched applied a specific application using the criteria above. The direct, indirect and induced economic activity from the Arkansas River basin's irrigated agriculture was estimated using IMPLAN and recreation values were estimated using benefit transfer methods.

Results suggest economic activity from agricultural water (including both agriculture activity and recreational activity) are closely intertwined, and this collective activity totals more than $1.36 billion as of 2013.

2.2.4.2 Future Agricultural Consumptive Needs

Throughout the state of Colorado, 500,000 to 700,000 irrigated acres may be lost by 2050 due to all of the factors discussed above. This represents 15 to 20 percent of current irrigated lands (2008 estimates). In the Arkansas Basin, SWSI 2010 and the CWCB estimated that between 35,000 and 73,000 irrigated acres may be lost by 2050, a reduction of 8 to 17 percent. Total remaining irrigated acreage in the Arkansas Basin is estimated between 355,000 and 393,000 acres in 2050.

As described above, the SWSI 2010 process characterized irrigation demand by the Irrigation Water Requirement and the Water-Supply-Limited Consumptive Use. The Water-Supply-Limited Consumptive Use is the amount of water required to sustain current agricultural output in the Arkansas Basin, while the Irrigation Water Requirement details the amount of water that would be used by irrigation were it legally and physically available. In other words, the Irrigation Water Requirement is an idealized quantity of water which would theoretically maximize output on irrigated croplands, while the Water-Supply-Limited Consumptive Use is the amount of water used currently by irrigated farming activities. SWSI 2010 identifies the difference between these numbers as the shortage in supply. This methodology compares reality to an ideal and thus ascribes a shortage based on a perceived gap, without any further analysis to determine whether the current distribution of water within the agricultural community is sufficient. Thus, the SWSI 2010 process risks a significant overestimation of the potential consumptive demand within the Arkansas Basin.

Results of the SWSI 2010 current (2008) agricultural demand are provided in Table 2.2.5:

Table 2.2.3 - Agriculture Consumptive Needs Forecast, Source: SWSI 2010

Arkansas Basin	Irrigated Acres	Irrigation Water Requirement (AFY)	Water-Supply-Limited Consumptive Use (AFY)	Shortage (AFY)	Non-Irrigation Demand (AFY)
Total	428,000	995,000	542,000	453,000	56,000

The methodology used by SWSI 2010 to estimate the agricultural shortage likely results in significant overestimation, which necessarily implies that the estimate of a future shortage is also a significant overestimation of the true agricultural supply-demand gap. Since the Arkansas River was essentially fully appropriated in 1890, an estimate of water supply need based on acreage is inappropriate in characterizing the needs of the basin. The 2012 Update describes the need to 25-30,000 acre-feet of augmentation supply needed to maintain the current acreage. Hence, the Section 1.0 Goals and Measurable Outcomes articulates the Agricultural Goals in economic terms, seeking to maintain the $1.5 Billion industry.[14] There is recognition that achieving this goal may entail reductions in irrigate acres offset by an increase in economic productivity per acre.

2.2.5 Arkansas Roundtable Considerations

Three considerations for the future have emerged in response to SWSI 2010 and the intervening studies, reports and extremes of hydrologic conditions in the Arkansas Basin:

- The relationship between fully consumable municipal water and augmentation of agricultural wells;
- The importance of water deliveries to the Lower Arkansas Valley and the dependence of environment benefits and the recreation economy of the Upper Arkansas basin to the continuation of those deliveries; and,
- The imminent municipal supply need derived from dependence on nonrenewable Denver Basin groundwater.

In Section 4.0 of the basin plan, the background and progress on projects and methods to further these initiatives will be provided in greater detail.

[14] Section 1.6.2.2 – Agricultural Goals.

2.2.6 Summary: Consumptive Needs Assessment

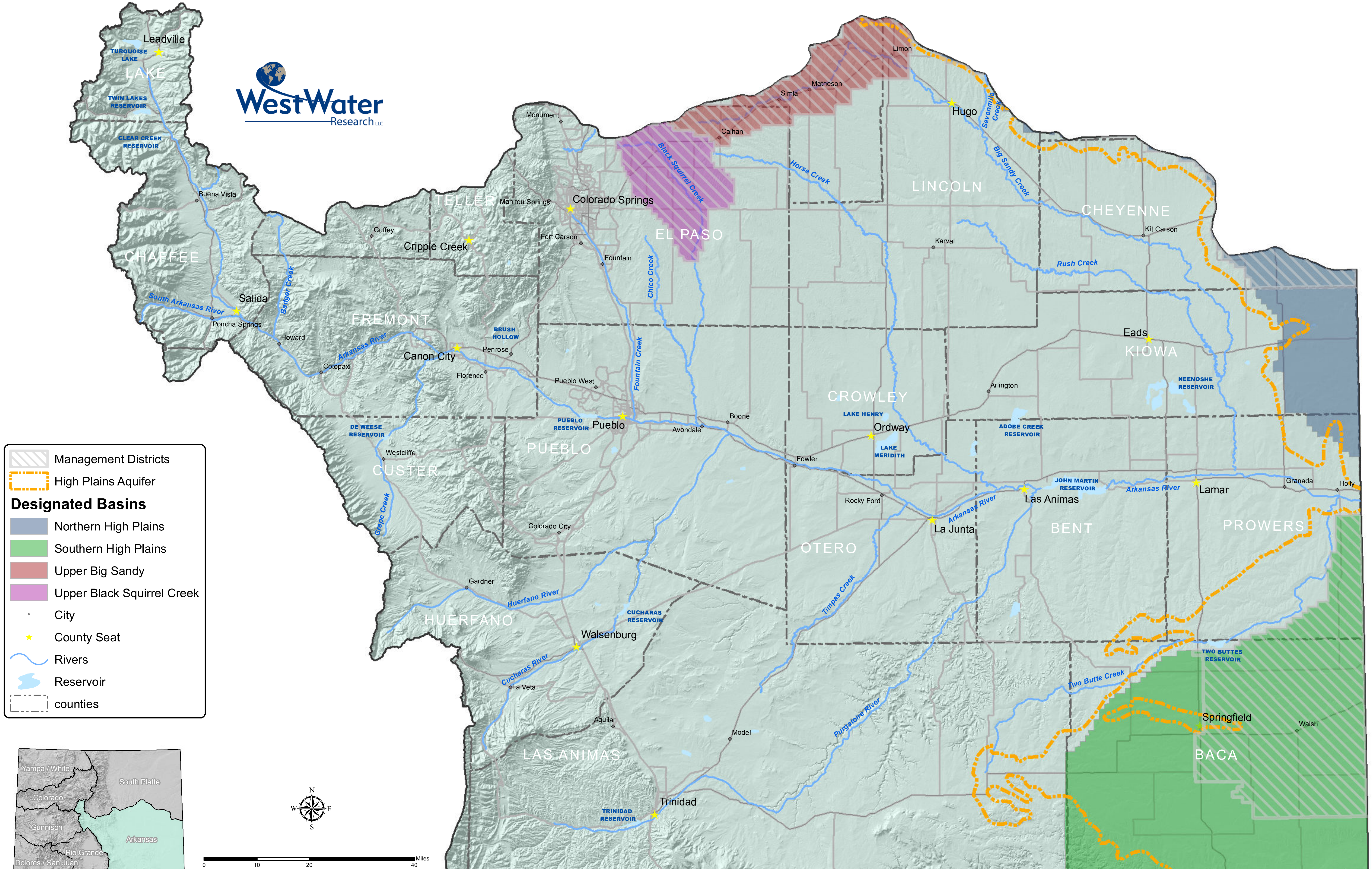
Presently, water resources within the Arkansas Basin are strained by population and economic growth, and the water supply gap is expected to increase going forward. SWSI 2010 makes clear that as population and economic development continue, further work needs to be done to address supply gaps.

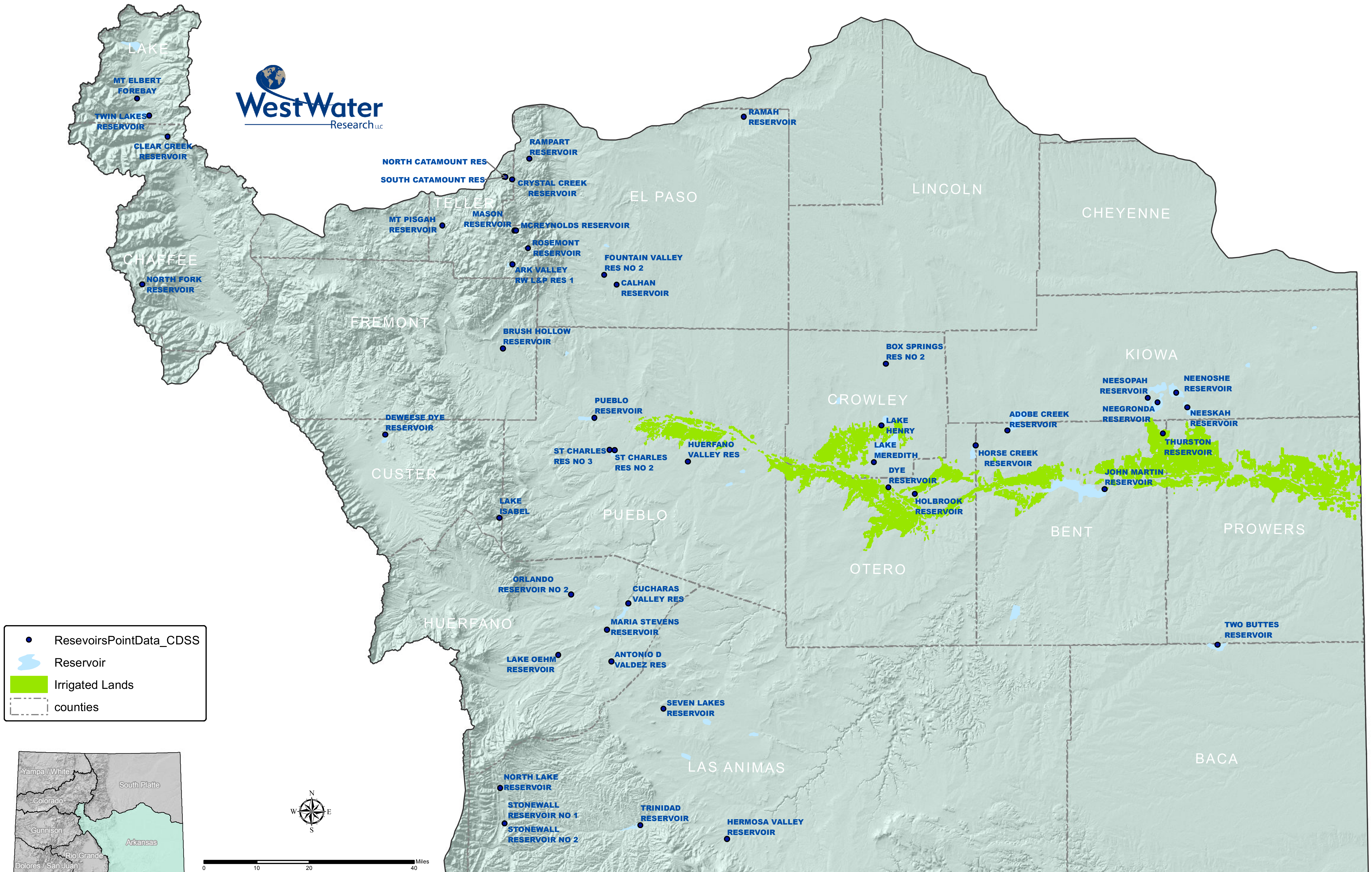
The Arkansas Basin has unique constraints, such as adherence to the Colorado-Kansas Compact, and a complex regulatory regime related to imported water.[15] These constraints, combined with declining local water resources, make the water supply gap a problem for the present. There are calls for current alternatives to agricultural to municipal transfers, which have been used historically to meet municipal supply gaps. Additionally, various subregions within the Basin rely on nonrenewable water sources, the replacement of which demands attention in the near future. Significant efforts must be made going forward to detail current and near-term gaps, identify and assist at-risk subregions, and further understand the economic effects of changing water needs. Section 4 provides overviews of Identified Projects, Processes and Methods to meet these needs.

The consumptive water users of the Arkansas Basin are interdependent. Agricultural producers and municipal and industrial water users have a shared future in developing and maintaining adequate water supplies. Projects and methods underway in the Basin allow for many of the concerns to be addressed, but without cooperation, they are unlikely to yield positive results. The challenge for the Arkansas Basin Roundtable is to foster cooperation among users and continue to develop projects and methods to meet the ongoing needs of the basin's water stakeholders.

[15] See Sections 1.2.1, Basin Themes, and section 1.2.2, Basin Fundamentals.

DRAFT FOR REVIEW





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TWIN LAKES RESERVOIR
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MASON RESERVOIR
MCREYNOLDS RESERVOIR
ROSEMONT RESERVOIR
ARK VALLEY RW L&P RES 1
EL PASO
FOUNTAIN VALLEY RES NO 2
CALHAN RESERVOIR
RAMAH RESERVOIR
LINCOLN
CHEYENNE
FREMONT
BRUSH HOLLOW RESERVOIR
BOX SPRINGS RES NO 2
KIOWA
NEESOPAH RESERVOIR
NEENOSHE RESERVOIR
NEEGRONDA RESERVOIR
NEESKAH RESERVOIR
ADOBE CREEK RESERVOIR
CROWLEY
LAKE HENRY
LAKE MEREDITH
PUEBLO RESERVOIR
DEWEESE DYE RESERVOIR
ST CHARLES RES NO 3
ST CHARLES RES NO 2
HUERFANO VALLEY RES
HORSE CREEK RESERVOIR
THURSTON RESERVOIR
DYE RESERVOIR
JOHN MARTIN RESERVOIR
HOLBROOK RESERVOIR
CUSTER
LAKE ISABEL
PUEBLO
BENT
PROWERS
OTERO
ORLANDO RESERVOIR NO 2
CUCHARAS VALLEY RES
MARIA STEVENS RESERVOIR
HUERFANO
TWO BUTTES RESERVOIR
LAKE OEHM RESERVOIR
ANTONIO D VALDEZ RES
SEVEN LAKES RESERVOIR
LAS ANIMAS
BACA
NORTH LAKE RESERVOIR
STONEWALL RESERVOIR NO 1
STONEWALL RESERVOIR NO 2
TRINIDAD RESERVOIR
HERMOSA VALLEY RESERVOIR
ResevoirsPointData_CDSS
Reservoir
Irrigated Lands
counties
Yampa / White
South Platte
Colorado
Gunnison
Arkansas
Rio Grande
Dolores / San Juan
N
W
E
S
0
10
20
40
Miles

Section 3 Constraints and Opportunities

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Tables

3.0 Constraints and Opportunities Based on Existing Data

This section of the Arkansas BIP provides an overview of operations and a review of existing data. During that review of basin operations potential constraints and opportunities associated with water resources planning in the Arkansas River basin were identified.

3.1 Basin Operations and Analysis of Existing Data

This section provides an overview of current operations within the Arkansas Basin. It describes the water supply systems of major water providers and users, infrastructure, programs, and operations that are central to the water supply picture for all basin users. Where available, water supply data is summarized and presented for a representative wet, dry, and average year to show general volumes of water moving through the basin as well as variability under differing hydrologic conditions.

3.1.1 Identification of Major Users

A list of major users, infrastructure, and programs that are significant diverters in the basin was compiled and used as a framework for the information and analysis of current basin operations presented in this section. This list was based on knowledge of the basin and several sources, including Arkansas River straightline diagrams, Statewide Water Supply Initiative (SWSI) reports, the 1985 United States Geological Survey (USGS) basin operations report (USGS 1985), and data provided by the Division of Water Resources (DWR) Division 2 office. Selection criteria included not only overall water use amounts, but impacts and interplay with other basin users, including potential future projects or changes.

The major users described in this report are as listed below and shown in Figure 1. Figure 1 also shows key gage locations, consistent with the Colorado Water Conservation Board (CWCB) Hydrology Streamflow Analysis Tool memo and shown in Table 3.1.1. There are numerous stream gages in the basin that could have been included but some did not have adequate period of record or had significant data gaps so these gages were selected that have good date, period of record and are at what are viewed as key locations to represent overall basin hydrology.

Table 3.1.1 - Major Gages in the Arkansas Basin

Gage Name	USGS Gage ID	DWR Gage ID
Arkansas River at Cañon City	07096000	ARKCANCO
Arkansas River at Las Animas	07124000	ARKLASCO
Arkansas River at Lamar	07133000	ARKLAMCO
Arkansas River near Coolidge, KS	07137500	ARKCOOKS
Arkansas River at Granite	07086000	ARKGRNCO
Arkansas River near Wellsville	07093700	ARKWELCO
Arkansas River near Avondale	07109500	ARKAVOCO
Arkansas River at Portland	07097000	ARKPORCO
Fountain Creek at Pueblo	07106500	FOUPUECO
Huerfano River near Boone	07116500	HEUBOOCO
Apishapa River near Fowler	07119500	APIFOWCO
Purgatoire River near Las Animas	07128500	PURLASCO

Cities and Municipalities

- Leadville;
- Buena Vista;
- Salida;
- Cañon City;
- Pueblo;
- Rocky Ford;
- La Junta;
- Las Animas;
- Lamar;
- Colorado Springs;
- Walsenburg;
- Trinidad;
- Fountain;
- Security;
- Widefield;
- Aurora.

Irrigation Systems

- Bessemer Ditch;
- Rocky Ford Highline Canal;
- Colorado Canal;
- Oxford Farmers Ditch;
- Otero Canal;

- Catlin Canal;
- Holbrook Canal;
- Rocky Ford Ditch;
- Fort Lyon Canal and Fort Lyon Storage Canal;
- Las Animas Consolidated Ditch;
- Keesee Ditch;
- Amity Canal and Kicking Bird Canal for Great Plains Reservoirs Storage;
- Fort Bent Canal;
- Lamar Canal;
- X-Y Irrigating Canal;
- Buffalo Canal.

Reservoirs

- Twin Lakes Reservoir;
- Turquoise Reservoir;
- Clear Creek Reservoir;
- Pueblo Reservoir;
- John Martin Reservoir;
- Trinidad Reservoir;
- Colorado Canal Reservoirs
  - Lake Meredith;
  - Lake Henry;
- Holbrook Canal Reservoirs
  - Holbrook Reservoir;
  - Dye Reservoir;
- Fort Lyon Canal Reservoirs;
  - Horse Creek Reservoir;
  - Adobe Creek Reservoir;
- Great Plains Reservoirs Serving the Amity Canal.

Transmountain Systems

- Frying Pan-Arkansas Project (Fry-Ark);
- Twin Lakes Project;
- Homestake Project;
- Blue River Project.

Industrial Water Users

- EVRAZ (formerly Colorado Fuel and Iron Company [CF&I]);
- Comanche Power Plant.

Groundwater Augmentation Associations

- Arkansas Ground Water Users Association (AGUA);
- Colorado Water Protective & Development Association (CWPDA);
- Lower Arkansas Water Management Association (LAWMA).

Exchanges

- To Turquoise Reservoir;
- To Twin Lakes Reservoir;
- To Clear Creek Reservoir;
- To Pueblo Reservoir;
- Holbrook Canal Exchanges;
- Colorado Canal Exchanges.

Other Programs

- Voluntary Flow Management Program for Upper Arkansas River;
- Flow Management Program for Arkansas River below Pueblo Reservoir;
- Winter Water Storage Program at Pueblo Reservoir.

3.1.2 Wet, Dry, and Average Years

To develop a better understanding of changes in basin operations under varying hydrologic conditions, water supply data is presented for representative wet, dry, and average water years. These years were selected using CWCB's Historical Streamflow Analysis Tool (CWCB 2014). The hydrology tool categorizes water years as drought, dry, average, wet, or dry based on a percentile ranking system using historical data.

For the Arkansas Basin, the Arkansas River at Cañon City gage (IUSGS ID 07096000) was selected as the most representative of the natural hydrology in the basin (CWCB 2014). Representative wet, dry, and average years were selected based on the hydrological classification of water years at this gage, with an emphasis on choosing more recent years in order to better capture current basin operations.

The selected years are as follows:

- Wet study year: WY 2011;
- Dry study year: WY 2005;
- Average study year: WY 2010.

The Cañon City gage was selected as most representative of the natural hydrology within the basin due to its location. Streamflows in the Arkansas Basin are primarily snowmelt-driven, with thunderstorms contributing intermittent, peak flows in the plains in the lower portion of the basin. The Cañon City gage is located low enough in the basin to capture a significant portion of the snowmelt flows, while still being located above most major diversions, including Pueblo Reservoir. However, it is recognized that there is no single gage that can perfectly capture the hydrology for the entire basin. The Cañon City gage is not a direct indicator of hydrology in the lower tributaries in the basin, including the St. Charles, Huerfano, Cucharas, Apishapa, and Purgatoire Rivers. Within the study years chosen for this report, this effect is particularly evident in 2011. The Cañon City gage indicates a wet year in 2011, although it was a dry or drought year for several of the lower tributaries. It was determined that the Cañon City gage is the most representative of the natural flows within the basin and, therefore, 2011 was maintained as a wet year. Comparing water operations throughout the basin across a single year provides a consistent basis of comparison of overall basin operations.

3.1.3 Data Inventory

Pulling together the descriptions and data to provide a comprehensive overview of basin operations required extensive data collection. Key data sources included:

- Correspondence with numerous people with working knowledge of the various major users, programs, and operations in the basin, and data provided by same;
- USGS Arkansas Basin Operations Report, 1985;
- Hydrologic Modeling Documentation Report, Southern Delivery System Environmental Impact Statement (SDS EIS);
- AVC modeling report;
- HydroBase.

Data describing quantitatively how much water is used, stored, imported, or exchanged in the basin was compiled from many different sources. HydroBase is a central database that houses real-time, historic, and geographic data related to water resources in Colorado. HydroBase can be accessed online via the Colorado DWR website (http://water.state.co.us/DataMaps/Pages/default.aspx). HydroBase was used where possible (primarily for agricultural diversion records and transbasin imports), but many individual entities also contributed their own accounting data or records. The result is that although a substantial amount of data is available, the scope and time period of available data can vary significantly between the various major users. Tables summarizing data in this report each state the data source.

The report authors wish to acknowledge the many people who contributed to this report with their knowledge of the Arkansas Basin and its various water supply systems.

3.1.4 Basin Operations Summary

This section describes each of the major users identified in Section 3.1.1. Where available, data on those systems is summarized for the wet, dry, and average years. In addition, data for wet, dry, and average years is shown on basin maps in Section 3.1.5.

3.1.4.1 Cities and Municipalities

Municipal systems tend to be some of the most complicated water supply systems, combining water from several sources and locations. In the Arkansas Basin, groundwater augmentation requirements add an additional level of complexity to this system. Some descriptions of municipal systems include information from various reports; however, most rely primarily or wholly on interviews with personnel at each individual entity. Information provided in those interviews has generally not been verified by a second source.

Where municipalities have provided historical water use data, it is summarized here for the wet, dry, and average study years. Data summarized here for individual municipalities is generally based on the accounting conducted by each individual entity. As such, the availability and level of detail of data varies considerably between municipal users.

Leadville

The City of Leadville is supplied by the Parkville Water District. The district uses a combination of groundwater and surface water supplies. The primary surface water source is a water right in Evans Creek, east of Leadville. The Evans Creek water right is original to Parkville and is very senior, dating back to 1860, and is for just over 10 cubic feet per second (cfs). It is primarily used as direct use, but Parkville does have about 300 acre-feet (AF) of storage in three reservoirs.

For groundwater supplies, Parkville owns three well fields. One is on the Arkansas River and the other two are east of Leadville. The Arkansas River well field has augmentation requirements due to a change in the point of diversion. Pumping from this well field is augmented with a combination of a 1.5 cfs water right transferred from the Stevens & Leiter ditch and a portion of the Iowa Gulch rights owned by Parkville.

The Iowa Gulch water right is for 11.4 cfs of direct use and dates to 1860. The portion of the right not currently used for augmentation is not currently active, but could be used in the future to meet additional future water needs.

Buena Vista

Currently, Buena Vista is supplied completely by groundwater supplies. They own a 1,000 gallons-per-minute (gpm) surface water treatment plant, but it is currently not in regular use, although it can be placed into service as an emergency supply. Groundwater comes from an infiltration gallery and a municipal well. There is an additional small (0.1 cfs) well used to supply the rodeo grounds when in use.

The infiltration gallery is the primary source of supply and is nontributary and does not require augmentation. The well is currently used in the summer only, to supplement the infiltration gallery supplies during peak demand, so overall augmentation needs are small. The municipal well has been operated under a substitute water supply plan, wherein Buena Vista can use rights the town owns on Cottonwood Creek for augmentation, as well as Fry-Ark water when the town's rights are not in priority. However, they have a new agreement with the Upper Arkansas Water Conservancy District (UAWCD) to provide augmentation water for the city. The town is also in the process of permitting a new well for park irrigation with raw water, expected to be operational in the fall.

From 1996 through 2004, production from the infiltration gallery and municipal well averaged 765 acre-feet per year (AFY). (Source: well production data provided by Buena Vista.)

Salida

The City of Salida is supplied by a combination of surface water and groundwater. Surface water rights include several Arkansas River ditch rights converted from agricultural to municipal use: rights from the Herrington Ditch, the Tennassee Ditch, and the Champ Ditch. They also have two junior groundwater rights. The groundwater rights are augmented with excess surface water rights.

Salida has 295 AF of storage in North Fork Reservoir in addition to an "if-and-when" leased space account in Pueblo Reservoir. From April through October, Salida stores excess water credits in Pueblo Reservoir. From November through March, they make releases from storage to meet groundwater lagged depletion augmentation requirements as well as to meet historical agricultural return flows from their converted ditch rights.

Cañon City

The City of Cañon City is supplied entirely by direct flow surface water rights from the Arkansas River. The direct flow water rights include an 1864 right for 3.5 cfs original to Cañon City Water Works, 1,298 shares of the Cañon City Hydraulic & Irrigating Ditch Company, and the Frank Mayol Ditch right, for 4.68 cfs and dating to 1872. The total shares of the Cañon City Hydraulic & Irrigating Ditch Company result in 35.6 cfs total; 19 cfs from that can be diverted at the city's primary diversion point, and the remaining 16.5 is taken through the original ditch headgate.

Although Cañon City does not have any of its own surface water storage, they have an allocation of Fry-Ark water in Pueblo Reservoir through participation in the Southeastern Colorado Water Conservancy District (SECWCD). This water is released to meet their historical return flow obligations on their converted agricultural rights.

A summary of Cañon City's raw water diversions in wet, dry, and average conditions is shown in Table 3.1.2.

Table 3.1.2 - City of Cañon City Water Use, Source, Data provided by Cañon City

	Total Raw Water Diversions (AFY)
Overall Average, WY 1982 – 2014	5,500
Wet Study Year – WY 2011	6,500
Dry Study Year – W 2005	6,000
Average Study Year – WY 2010	5,800

Pueblo

The Pueblo Board of Water Works (PBWW) supplies drinking water to the City of Pueblo from surface water sources, including a combination of native and transbasin water supplies. Native supplies include original Pueblo municipal rights dating to 1874, as well as converted agricultural water from the Hobson Ditch, the West Pueblo Ditch, and the Booth Orchard Ditch, as well as storage rights in Clear Creek Reservoir. Transbasin supplies include the Busk-Ivanhoe system (shared equally with Aurora), the first 2,500 AFY from the Homestake Project, a 10 percent share of Fry-Ark water, Ewing Ditch, and Wurtz Ditch. They own about 23 percent of Twin Lakes Company, which includes native water as well as transbasin water from the Independence Pass system, and includes storage rights in Twin Lakes Reservoir.

PBWW can store water in Pueblo Reservoir, Clear Creek Reservoir (owned by PBWW), Twin Lakes Reservoir, and Turquoise Lake.

PBWW reuses return flows from transmountain sources by exchange. Generally flows are exchanged from the wastewater treatment plant into Pueblo Reservoir, but they can also be exchanged to other storage and intake locations in PBWW's system. They also exchange Ewing and Wurtz Ditch transmountain inflows into Turquoise, Twin Lakes and Clear Creek Reservoirs for storage.

PBWW's primary surface water intake is a pipeline from Pueblo Reservoir completed in 2002. They can also divert water at the old North Side and South Side river intakes and also own Comanche Pump Station. The Comanche Pump Station supplies PBWW water to the Comanche Generating Station owned by Xcel Energy, as described in Section 3.1.4.2.

Several of the projects in which PBWW participates are described elsewhere in this report, including the Fry-Ark Project, the Twin Lakes Project, the Homestake Project (all three in Section 3.1.4.5), the Voluntary Flow Management Program, and the Flow Management Program for Arkansas River below Pueblo Reservoir (both in Section 3.1.4.8).

A summary of PBWW's raw water diversions (at their municipal intake in Pueblo Reservoir) in wet, dry, and average conditions is shown in Table 3.1.3.

Table 3.1.3 - PBWW Water Use, Source, Data provided by PBWW

	Total Raw Water Diversions (AFY)
Overall Average, WY 2005 – 2012	28,000
Wet Study Year – WY 2011	28,600
Dry Study Year – WY 2005	28,700
Average Study Year – WY 2010	27,700

Rocky Ford

The City of Rocky Ford is supplied by a combination of surface water and groundwater rights. In addition to three wells, they own shares in the Rocky Ford and Catlin Canal ditch companies. Water is diverted through the original ditch headgates and then conveyed from the ditch to Rocky Ford. The city uses a combination of the Rocky Ford Ditch and Catlin Canal water and Fry-Ark water released from Pueblo Reservoir to meet groundwater augmentation requirements and match historical agricultural return flows from the converted agricultural water.

Rocky Ford currently owns 14.361 (of 800) shares of Rocky Ford, of which 8.7 shares have been changed to municipal use. Similarly, they own 412.473 shares of the Catlin Canal, of which 218.3 shares have been changed to municipal use. The unconverted shares continue to be used for agricultural irrigation.

In dry years in the past, Rocky Ford has leased additional water from the Fry-Ark project, the City of Aurora, or other entities in the basin.

La Junta

The City of La Junta is entirely supplied by 11 alluvial groundwater wells. Augmentation sources include Fry-Ark return flows purchased through SECWCD.

Florence

Florence is supplied completely with surface water rights. They have rights on Adobe, Minnow, and Newlin Creeks, as well as on the Arkansas mainstem. They can pull up to 2.5 cfs from Adobe and Minnow Creeks combined, 5 cfs from Newline Creek, and 6.61 cfs from the Arkansas mainstem. The Arkansas mainstem water comes from Union Ditch (which gets its water via the Minnequa Canal). All surface water rights are sent to one of their four reservoirs, South Reservoir 1 and 2 and North Reservoir 1 and 2, totaling about 580 AF of surface water storage. In the summer irrigation season, about 1 million-gallon-per-day (mgd) is released directly from Union Ditch to a local golf course irrigated with raw water.

Florence also supplies water to several other communities. East Florence does not have their own water supply at this time, and purchases water from Florence. The water provided to East Florence is included in the water rights described above. Florence also pumps water to three other communities – Coal

Creek, Williamsburg, and Rockvale. These communities are using infrastructure owned by Florence to convey their own water rights; their water supplies are not included in Florence's rights, described above.

Las Animas

The City of Las Animas is 100 percent reliant on groundwater supplies. They meet augmentation obligations by buying return flows through SECWCD and by participation in CWPDA.

A summary of Las Animas' groundwater pumping in wet, dry, and average conditions is shown in Table 3.1.4.

Table 3.1.4 - Las Animas Water Use, Source, Data provided by Las Animas

	Total Raw Water Diversions (AFY)
Overall Average, WY 2001 – 2012	500
Wet Study Year, WY 2011	540
Dry Study Year, WY 2005	480
Average Study Year, WY 2010	490

Lamar

The City of Lamar is 100 percent reliant on groundwater supplies. The majority of their wells are in the Clay Creek alluvium, with some in the Dakota and Cheyenne Creek alluviums. They recharge the Clay Creek alluvium using converted agricultural ditch water. They owned about 1/3 of Fort Bent ditch and over 2,000 preferred shares of the Lamar Canal. This water is brought to the Clay Creek Recharge Area for recharge. They also participate in LAWMA for additional augmentation of groundwater depletions.

A summary of Lamar's groundwater pumping in wet, dry, and average conditions is shown in Table 3.1.5.

Table 3.1.5 - City of Lamar Water Use, Source, Data provided by Lamar

	Total Raw Water Diversions (AFY)
Overall Average, WY 2004 – 2012	2,200
Wet Study Year, WY 2011	2,200
Dry Study Year, WY 2005	2,200
Average Study Year, WY 2010	2,100

Colorado Springs

Colorado Springs Utilities (CSU) relies primarily on surface water, drawing from a number of different sources including original, local water rights, transbasin projects including several shared regional projects, and water rights converted from agricultural to municipal use. Water is collected from these various sources and conveyed to five different potable water treatment plants. Less than 1 percent of supplies are from groundwater.

CSU also has a nonpotable water system used for irrigation of municipal parks and residential lawns. The system uses raw supplies from several of the sources outlined below, and also includes a reuse system treating wastewater effluent.

The CSU system includes a combination of local supplies and regional and transbasin supplies. The following is a summary of their regional and transbasin water supply systems.

- South Slope of Pikes Peak;
  - This system collects water from the south slope of Pike's Peak. Water is collected and stored in the South Slope system and transported into the Arkansas Basin via the St. John's Tunnel, where it is stored in Morraine Reservoir (1,323 AF) and Big Tooth Reservoir (277 AF) before being sent to the Mesa Treatment Plant for treatment and distribution.
- North Slope of Pikes Peak;
  - CSU operates three reservoirs on the north slope of Pike's Peak: Crystal Reservoir (3,523 AF), North Catamount Reservoir (12,030 AF), and South Catamount Reservoir (2,604 AF). Water can be treated at the Ute Pass Treatment Plant, the Mesa Treatment Plant, or can be transferred to the Northfield system (see below) for treatment at the Pine Valley Treatment Plant. Blue River water is also stored and conveyed in this system, as described below.
- Northfield Water System;
  - The Northfield water system includes Nichols Reservoir (586 AF), Northfield Reservoir (276 AF), and Rampart Reservoir (40,871). Water from several other CSU water supply systems makes up a substantial portion of supplies stored in the Northfield water system, including water from the Blue River Project, North Slope of Pikes Peak system, Homestake Project, Twin Lakes Project, Fry-Ark Project, Colorado Canal, and exchange water via the Otero pump station. Water is treated at the Pine Valley Treatment Plant or the McCullogh Treatment Plant.
- Blue River Water System;
  - Water is collected in the Blue River Basin on the West Slope and transferred to Montgomery Reservoir (5,088 AF) via the Hoosier Tunnel. From there the water is conveyed to the North Slope water system via the Blue River pipeline. The water can also be sent to the Northfield water system via the Twin Rocks pump station. This project is discussed in more detail in Section 3.1.4.5.
- Homestake Project;
  - The Homestake Project is a joint effort with Aurora, with each party sharing equal costs and receiving half the water. Water from the Eagle River Basin on the West Slope is stored in Turquoise and Twin Lakes Reservoirs. The CSU share is ultimately conveyed to the North Slope and Northfield systems. These supplies can flow down the Arkansas River mainstem to

Pueblo Reservoir to be taken through the Fountain Valley Authority (FVA) pipeline. This project is discussed in more detail in Section 3.1.4.5.

- Twin Lakes Project;
  - CSU is a major shareholder in the Twin Lakes Canal Company. The Twin Lakes supply comes from a Colorado River Basin collection system via the Twin Lakes Tunnel, also known as the Independence Pass tunnel. Imported water is stored in Twin Lakes Reservoir. From Twin Lakes, the CSU supply is conveyed to the Northfield and North Slope Watershed systems with the Otero pump station. Water supplies can also flow down the Arkansas River mainstem to Pueblo Reservoir to be taken through the FVA pipeline. This project is discussed in more detail in Section 3.1.4.5.
- Fryingpan-Arkansas Project;
  - The Fry-Ark Project brings water from the Colorado River Basin into Turquoise, Twin Lakes, and Pueblo Reservoirs in the Arkansas Basin. CSU supply is generally taken from Pueblo Reservoir via the FVA pipeline to the Fountain Valley water treatment facility. Supplies can also be taken from Twin Lakes via the Otero pump station. This project is discussed in more detail in Section 3.1.4.5.
- Colorado Canal;
  - CSU owns controlling shares in the Colorado Canal Company, the Lake Meredith Reservoir Company, and the Lake Henry Reservoir Company. The Colorado Canal is an agricultural ditch company that historically diverted water from the mainstem of the Arkansas upstream of Boone, Colorado. The Colorado Canal supplies Lake Meredith and Lake Henry. Water rights associated with these companies are exchanged to Pueblo Reservoir and conveyed to Colorado Springs via the FVA pipeline and treatment plant, or exchanged to Twin Lakes or Turquoise and conveyed to Colorado Springs via the Otero pump station. Exchanges can be made by release from Lake Meredith (Lake Henry released to Lake Meredith). Colorado Canal is also discussed in Section 3.1.4.5.

CSU also has a number of local water supplies systems, as summarized below.

- Rosemont Water System;
  - The Rosemont water system diverts from Gould and East Beaver Creeks. It is primarily used for nonpotable irrigation use, but can be stored in the South Suburban and Gold Camp reservoirs and treated at the Mesa Water Treatment Plant.
- South Suburban Water System;
  - The South Suburban water system collects water from North Cheyenne Creek water. The water is stored in South Suburban or Gold Camp reservoirs and treated at the Mesa Water Treatment Plant.
- Fountain Creek;
  - Water is conveyed from the 33rd St. pump station and intake to the Mesa Water Treatment Plant. This includes Fountain Creek rights as well as rights from Sutherland Creek.

- Pikeview Reservoir;
  - Monument Creek water is diverted into Pikeview Reservoir. This system is used primarily for nonpotable uses, but water can also be sent to the Mesa Water Treatment Plant for treatment and distribution.

CSU also makes significant use of return flows from their transbasin supplies. These return flows are discharged to Fountain Creek and exchanged up to other storage locations in the Arkansas Basin. Some transbasin return flows are also treated and used as a supply to CSU's nonpotable system.

In addition to accounts in Pueblo, Turquoise, and Twin Lakes Reservoirs, CSU has a number of smaller reservoirs within its own collection systems, as described in each system description above. Table 6 summarizes CSU's storage capacity. In addition to the storage indicated in the table, CSU has additional storage in Turquoise Reservoir purchased from CF&I (now EVRAZ), and utilizes storage in the excess capacity storage program in Pueblo Reservoir.

Table 3.1.6 - CSU Surface Water Storage, Source: CSU Water Tour

Reservoir	Capacity (AF)	Primary System
Homestake (CSU Account)	21,441	Homestake
Turquoise (CSU Account)	32,416	Homestake
Twin Lakes (CSU Account)	29,789	Twin Lakes
Pueblo (CSU Fry-Ark Account)	55,698	Fry-Ark
Henry (CSU Account)	6,704	CO Canal
Meredith (CSU Account)	20,650	CO Canal
Big Horn	191	South Slope
Big Tooth	277	South Slope
Boehmer	541	South Slope
Mason	1,965	South Slope
McReynolds	2,050	South Slope
Lake Moraine	1,323	South Slope
Wilson	669	South Slope
Crystal	3,523	North Slope
North Catamount	12,030	North Slope
South Catamount	2,605	North Slope
Nichols	586	Northfield
Northfield	276	Northfield
Rampart	40,871	Northfield
Montgomery	5,088	Blue River
Upper Blue	2,090	Blue River
Rosemont	2,541	Local – Rosemont
South Suburban	232	Local – South Suburban
Gold Camp	368	Local – South Suburban
Pikeview	90	Local – Pikeview
Total	**244,014**	

Table 3.1.7 shows the unconstrained system yields for the various water supply systems described above. This is a hydrologic yield only; it does not describe CSU's ability to capture, exchange, convey, or store the hydrologic yield of each system for use. Table 3.1.8 shows the firm yield for CSU's systems.

Table 3.1.7 - CSU Unconstrained System Yields, Source: CSU Water Tour

System	1950 – 2003 Average (AFY)
33rd Street	6,700
Pikeview	19,900
South Slope	6,400
Ruxton Creek	5,800
Rosemont	2,200
South Suburban	5,200
Bear Creek	2,300
North Slope	7,700
Northfield	1,500
Blue River	8,100
Homestake	15,500
Fry-Ark	15,200
Sugarloaf (Turquoise, formerly CF&I)	800
Twin Lakes	28,900
Colorado Canal	27,800

Table 3.1.8 - CSU Firm Yield, Source: CSU Water Tour

System	Firm Yield, 2010 (AFY)
Local System	17,800
Blue River Pipeline	7,800
Otero Pipeline	64,400
Fountain Valley Conduit	10,000

Table 9 and 10 summarize CSU's water use under wet, dry, and average hydrologic conditions. Table 3.1.9 shows the average amount of water stored in CSU's major reservoirs. Table 3.1.10 shows the amount of water captured or released from those reservoirs, split by account within each reservoir.

Table 3.1.9 - CSU Reservoir Storage Summary, Source: CSU

Average Amount in Storage (AF)	Overall Average, WY 1982 – 2012	Wet Study Year – WY 2011	Dry Study Year – WY 2005	Average Study Year – WY 2010
Twin Lakes	22,400	20,700	19,100	22,200
Turquoise Lake	26,500	29,100	25,600	29,300
Pueblo Reservoir	49,800	65,100	34,500	71,000

Table 3.1.10 - CSU Major Reservoir Capture and Release

	Total Annual Capture and Release (AF)	Overall Average, WY 1982-2012	Wet Study Year, WY 2011	Dry Study Year, WY 2005	Average Study Year, WY 2010
Twin Lakes	**Total Captured**	**14,400**	**18,300**	**22,300**	**11,800**
	Total Released	**14,100**	**18,100**	**20,100**	**12,300**
Turquoise Reservoir	Homestake – Captured	10,800	10,500	16,100	6,500
	Homestake – Released	10,600	10,500	16,100	6,500
	CF&I – Captured	800	2,700	—	2,500
	CF&I – Released	500	2,700	—	100
	Total Captured	**10,900**	**12,500**	**16,100**	**8,600**
	Total Released	**8,200**	**10,400**	**10,200**	**5,600**
Pueblo Reservoir	Fry-Ark – Captured	5,200	5,000	8,100	1,600
	Fry-Ark – Released	3,600	5,000	900	3,700
	Excess Capacity Acct – Captured	7,600	21,900	10,000	11,000
	Excess Capacity Acct – Released	7,400	20,300	6,000	12,300
	Total Captured	**11,100**	**25,500**	**16,900**	**11,100**
	Total Released	**8,100**	**25,200**	**10,600**	**7,500**

Walsenburg

Walsenburg is supplied entirely by surface water. The city diverts water from the Cucharas River and Wahatoya Creek. This water can be stored in Wahatoya Lake, Daigre Lake, and Walsenburg Reservoir before treatment and distribution. Total storage in these three lakes is about 850 AF. As a secondary supply, the city also owns storage rights in Lake Miriam and Lake Oehm (also known has Horseshoe Lake and Martin Lake, respectively). These lakes are supplied from the Cucharas River by a separate ditch.

Trinidad

Trinidad is supplied entirely by surface water. The city's primary supply is water from The North Fork of the Purgatoire River, which can be stored in the 4,315-AF North Lake along with a small amount of water from Coal Creek. As a secondary supply, water can be stored in Monument Lake from the North Fork of the Purgatoire River as well as the tributaries Brown Creek, Whiskey Creek, and Cherry Creek.

Fountain

About 70 percent of Fountain's water supply is Fry-Ark water through membership in the FVA, with the remaining 30 percent coming from nine alluvial wells. Fry-Ark return flows are the primary source of augmentation water, with additional augmentation supplies coming from share ownership in two agricultural ditches: Chilicott Ditch and the Fountain Mutual Irrigation Company.

Table 3.1.11 shows Fountain's pumping and FVA deliveries in wet, dry, and average conditions.

Table 3.1.11 - City of Fountain Water Use, Source: Fountain

	Fountain Valley Authority Pipeline Deliveries (AFY)	Well Production (AFY)	Total (AFY)
Overall Average, WY 1983-2012	1,200	610	1,900
Wet Study Year, WY 2011	2,000	1,100	3,100
Dry Study Year, WY 2005	1,900	530	2,400
Average Study Year, WY 2010	2,100	930	3,000

Security

Security is supplied by a mix of surface water and groundwater. In addition to 24 wells providing groundwater supply, Security is a member of the FVA. Augmentation for groundwater use is a combination of Fry-Ark return flows and shares of several agricultural ditches in the Fountain Basin: the Fountain Mutual Irrigation Company (FMIC), the Chilcotte Ditch, and the Locke Ditch. Share ownership in FMIC also includes storage space in Big Johnson Reservoir. In addition to space in Pueblo Reservoir allotted to Security as a Fry-Ark participant, Security participates in SECWCD's excess capacity storage program in Pueblo Reservoir.

Table 3.1.12 shows Security's pumping and FVA deliveries in dry and average conditions; data was not available for 2011, the wet study year.

Table 3.1.12 - City of Security Water Use

	Fountain Valley Authority Pipeline Deliveries (AFY)	Well Production (AFY)	Total (AFY)
Overall Average, WY 2001-2010	1,100	2,400	3,500
Dry Study Year, WY 2005	430	3,000	3,500
Average Study Year, WY 2010	1,300	2,000	3,300

Widefield

Widefield is supplied by a mix of surface water and groundwater. Over half of Widefield's supply comes from alluvial wells in the Widefield aquifer with the remainder coming from Fry-Ark supplies through membership in the FVA.

Aurora

Although the City of Aurora is not located within the Arkansas Basin, Aurora has several water supply sources within the basin. Aurora has a 50 percent stake in the Homestake Project (although the first 2,500 AFY of Aurora's supply goes to PBWW by agreement), a 50 percent share in the Busk-Ivanhoe system, 5 percent ownership in Twin Lakes, and owns shares in the Colorado Canal and the Rocky Ford Ditch. Aurora's water is delivered to the South Platte Basin via the Otero pump station, which delivers Aurora's water from Twin Lakes Reservoir to Spinney Mountain Reservoir. Aurora is entitled to pump 77.5 cfs through the Otero pipeline.

Aurora's Homestake water is delivered to the basin in Turquoise Lake and can be released to Twin Lakes for delivery to the Otero pump station intake. The Busk-Ivanhoe system delivers water from Ivanhoe Creek in the Colorado Basin, through the Busk-Ivanhoe tunnel and ultimately into Turquoise Reservoir. The Colorado Canal water can be taken through the Colorado Canal headgate and stored in Lake Henry and Lake Meredith, then released to the river for exchange up to Pueblo Reservoir when exchange potential is available. The Rocky Ford Ditch system does not include storage and water rights are exchanged directly into Pueblo Reservoir. From Pueblo Reservoir, Aurora can exchange the water higher up in the basin for ultimate diversion at Otero pump station.

Table 3.1.13 shows Aurora's surface water storage ownership within the Arkansas Basin.

Table 3.1.13 - Aurora Surface Water Storage (Arkansas Basin), Source: Aurora Water Supply Fact Book

Reservoir	Capacity (AF)
Homestake	21,441
Turquoise	20,000
Twin Lakes	2,724
Pueblo	10,000 (leased)
Henry and Meredith	9,117
Total	**63,282**

Fountain Valley Authority

The FVA is a joint entity of Colorado Springs, Fountain, Security, Widefield, and Stratmoor Hills. It was established to manage shared infrastructure, including a pipeline and a water treatment plant, to convey Fry-Ark supplies from Pueblo Reservoir to participating municipalities. The FVA has 78,000 AF of storage in Pueblo Reservoir and a pipeline with a capacity of 30.6 cfs. Table 14 shows the FVA allocation and ownership divisions.

Table 3.1.14 - Fountain Valley Authority Ownership Allocation, Source: SECWCD

FVA Entity	Percent of Total Fry-Ark Allocation	FVA Ownership	Pueblo Reservoir Space (AF)	FVA Pipeline Capacity (cfs)
Colorado Springs Utilities	17.85%	71.41%	55,700	21.85
Fountain	2.49%	9.95%	7,761	3.04
Security	2.05%	8.19%	6,388	2.51
Stratmoor Hills	0.75%	2.99%	2,332	0.91
Widefield	1.87%	7.46%	5,819	2.28
Total	**25.00%**	**100.00%**	**78,000**	**30.60**

3.1.4.2 Industrial

There are two major industrial water users in the Arkansas Basin, as summarized below. Water use for these users is also shown in Figures 4 through 6 in Section 3.1.5.

CSU (a combined utility providing electricity, natural gas, water, and sewer service) also has two major thermoelectric power stations, including the Nixon Plant. Their water systems and use will be described further in the final draft of this report.

Xcel Energy – Comanche Generating Station

The Comanche generating station is a coal-fired steam-electric generation facility near the City of Pueblo, owned and operated by Xcel Energy. Electricity is produced using coal boilers to produce superheated steam, which is run through a turbine. The steam is then cooled (using either air or water in cooling towers) and the water is recirculated through the plant to be heated into steam again. The primary water use of the facility is water for the cooling system, with small amounts used to fill the boilers or treated onsite for potable uses.

The facility relies on surface water supplies. They own over 750 shares of the Twin Lakes Canal Company, providing a share of Twin Lakes Tunnel imports and that can be stored in Twin Lakes Reservoir. They also have a long-term contract with PBWW for use of surface water rights owned by PBWW. Water from either source is conveyed to the generating station via a pipeline from the Comanche pump station below Pueblo Reservoir. The pump station is owned and operated by PBWW.

A third power generation unit went into service in 2009, adding significant electrical generation capacity. The unit has a hybrid cooling system, using air cooling when possible and supplementing with water cooling as needed.

About 83 percent of the water is consumptive use, with return flows sent to the St. Charles River.

Table 3.1.15 shows annual water use by the Comanche generating station under wet, dry, and average hydrologic conditions. Because a new generating unit was put into service during 2009, data from prior to 2010 is not representative of current demand. Note that the use of Twin Lakes water has been curtailed in recent years due to maintenance issues and may not be representative of typical operations.

Table 3.1.15 - Comanche Generating Station Water Use, Source: Excel Energy

Average Amount in Storage (AF)	Overall Average, WY 1984-2012	Wet Study Year, WY 2011	Dry Study Year, WY 2005	Average Study Year, WY 2010
PBWW Contract Water (AF)	7,900	7,800	10,700	10,600
Twin Lakes or Other Water (AF)	840	420	0	230
Total Raw Water (AF)	8,800	8,300	10,700	10,800
Return Flows (AF)	1,900	1,600	1,900	1,700

EVRAZ Pueblo (CF&I)

EVRAZ Pueblo, formerly known as CF&I or the Colorado Fuel and Iron Company, is a steel mill located in the City of Pueblo along Salt Creek. EVRAZ has not responded to email requests for additional information, so the water system here is as described in the 1985 basin operations report (USGS 1985). However, the USGS report notes that as of 1983, EVRAZ (then CF&I) experienced a reduction in production and a corresponding reduction in water needs. At that time, CF&I sold 5,000 AF for storage in Turquoise Lake to Aurora and other water rights and storage were for sale. The following describes the water system prior to 1983.

CF&I held direct flow rights on the Arkansas mainstem as well as the St. Charles River, and additional water rights from Lake Fork, Tennessee Fork, and East Fork in the upper basin that could be stored in Turquoise Lake (the latter two by exchange).

CF&I was the original owner of Turquoise Lake, originally known as Sugarloaf Lake. When the Bureau of Reclamation (Reclamation) purchased the lake for expansion for the Fry-Ark project (at which point the lake was renamed), CF&I retained ownership of 17,416 AF of storage and the option to lease an additional 10,000 AF from Reclamation. In addition to storage in Turquoise, CF&I held three smaller reservoirs in the Salt Creek Basin: Reservoir No. 2 and Reservoir No. 3, as well as Lake Minnequa (Reservoir No. 1), used only as a standby supply.

About 85 percent of the surface water supplies to the plant were supplied from the mainstem of the Arkansas River via the Minnequa Canal, with the remainder delivered from the St. Charles River through the St. Charles Flood Ditch.

CF&I fully consumed about 20 percent of their water supplies, with the remainder treated and returned to Salt Creek.

Table 3.1.16 shows total deliveries through the Minnequa Canal headgate. Deliveries to Union Ditch, which has its headgate on the Minnequa close to the river, are subtracted out.

Table 3.1.16 - EVRAZ Pueblo Water Use,
Source Data: HydroBase data for Minnequa Canal and Union Ditch

	Total Minnequa Canal Deliveries (AFY)
Overall Average WY 1982-2012	61,500
Wet Study Year, WY 2011	49,000
Dry Study Year, WY 2005	51,900
Average Study Year, WY 2010	46,400

3.1.4.3 Irrigation Ditches

All the major agricultural ditch systems in the Arkansas Basin discussed in this report have historically diverted water from the mainstem of the Arkansas River. Several have transbasin supplies in addition to native rights. Many systems now have significant ownership by municipal entities that have converted the water rights for municipal use and now use them either as surface water supplies or for augmentation of groundwater supplies (see Section 3.1.4.6).In addition to the surface water supplied by these ditches, there is significant groundwater use for irrigation. Major agricultural surface water storage is described in Section 3.1.4.4. The following is a brief description of each of the major agricultural ditches. The canals and irrigated acreage are shown in Figure 2. Water use for these users is also shown in Figures 4 through 6 in Section 3.1.5.

- **Bessemer Ditch** has an outlet in the Pueblo Reservoir dam and irrigates acreage southeast of the City of Pueblo, as well as supplying water to the St. Charles Mesa Water District for municipal use through shares that have been changed to municipal use.
- **Rocky Ford Highline** diverts near the confluence with the Huerfano.
- **Colorado Canal** diverts from the river above the confluence with the Huerfano River. Major surface water storage includes Lake Henry and Lake Meredith. A significant portion of the shares of Colorado Canal and shares of Lake Henry and Lake Meredith (which are separate) have been converted to municipal use. The shares converted to municipal use are shown Table 17, below.
- **Oxford Farmer's Ditch** diverts from below the Huerfano.
- **Otero Canal** diverts above the Apishapa River.
- **Catlin Canal** diverts from just below the Apishapa River confluence.
- **Holbrook Canal** diverts near Manzanola. Major storage includes Holbrook Reservoir and Dye Reservoir.
- **Rocky Ford Ditch** diverts below Manzanola but above the City of Rocky Ford.
- **Fort Lyon Storage Canal and Fort Lyon Canal**
  - The Fort Lyon Storage Canal headgate is adjacent to the Rocky Ford Canal headgate and supplies Horse Creek Reservoir and Adobe Creek Reservoir. No land is irrigated directly from the Fort Lyon Storage Canal. The two reservoirs release to the Fort Lyon Canal for irrigation. The Fort Lyon Canal has a separate headgate downstream, above La Junta.

- **Las Animas Consolidated Ditch** diverts about 8 miles upstream of the City of Las Animas. The system includes the Highland Ditch and the Las Animas Consolidated Extension. The Las Animas Consolidated Canal becomes the Las Animas Consolidated Canal Extension on the east side of the Purgatoire River. The Highland Ditch, with the headgate located on the Purgatoire River above the City of Las Animas, delivers water into the Las Animas Consolidated Ditch. The downstream portion of this ditch is known as the Las Animas Consolidated Extension. This ditch was purchased by Xcel Energy's predecessor Public Service Company of Colorado in the 1980s and the use changed to include industrial. It was intended to supply a proposed thermoelectric power plant near Las Animas but it was never constructed. The water is leased back to farmers for irrigation use.
- **Keesee Ditch** Shares a diversion dam with the Fort Bent Canal, about about 4.5 miles downstream of the John Martin dam. This ditch was purchased by LAWMA for groundwater augmentation use.
- **Amity Canal** diverts from the Arkansas mainstem about 8 miles below the John Martin dam. In addition to the mainstem headgate, the Amity can divert from Big Sandy, Big Bend, Gould's, and May Valley Creeks. Major storage includes the four Great Plains reservoirs – Nee Gronda (Big Water), Nee Skah (Queens), Nee So Pah (Black Water), and Ne Noshe (Standing Water) Reservoirs. Amity also has an agreement to store some Great Plains water in John Martin Reservoir (see Section 3.1.4.4). About one-half of the shares in the Amity Canal were purchased by Tri-States Power for a proposed thermoelectric plant near Holly. The use has been changed but the plant has not been constructed and the water is being leased back to the farmers.
  - **Kicking Bird Canal** receives water from the Fort Lyon Canal for delivery to the Great Plains Reservoir system. Water from the Great Plains Reservoirs is delivered to the Amity Canal via the Comanche Canal. No acreage is irrigated directly from this canal. This canal has low or zero flows in many years. Water rights priorities are such that water can only be diverted into the Great Plains Reservoirs during wet years, and as much as possible is typically stored in John Martin Reservoir instead.
- **Fort Bent Canal** diverts about 4.5 miles below the John Martin dam
- **Lamar Canal** diverts just above Lamar. Discharge from the City of Lamar power plant cooling well water is sent directly to the Lamar Canal and accounted for under the canal's decree along with direct diversions from the headgate.
- **X-Y Irrigating Canal** diverts about 11 miles below Lamar. It has been purchased by LAWMA for well depletion augmentation.
- **Buffalo Canal** diverts near Holly. In addition to the mainstem headgate, the canal can divert water from Buffalo and Simpson Creeks and House, Deadman, and Puntney Draws.

Table 3.1.17 - Colorado Canal Share Ownership.

	Colorado Canal	Lake Meredith	Lake Henry
Total Shares			
Colorado Springs Utilities	28012.76	21084.75	6923.15
Aurora, City of	14225.38	13061.8	1163.58
Other Municipal	972.28363	88228363	134
Total Agricultural Shares	632.28363	609.28363	83
Total Shares	43210.42363	35028.83363	8220.73
Percent of Total Shares			
Colorado Springs Utilities	65%	60%	84%
Aurora, City of	33%	37%	14%
Other Municipal	2%	3%	2%
Total Agricultural Shares	1%	2%	1%

Table 3.1.18 shows the acreage irrigated by surface water for each major agricultural ditch as of 2003 (2003 is the most recent year available in the Colorado Decision Support System [CDSS] geographic information system [GIS] data.) It is recognized that this dataset represents only a single year and may be influenced by lower than average hydrology and does not include irrigated acreage near Trinidad. Table 3.1.19 shows the total diversion through each headgate under wet, dry, and average hydrologic conditions. In addition to water used for irrigation and storage, water diverted at these headgates may also include water for municipal use, groundwater augmentation, maintenance of return flows of converted water, and other miscellaneous uses. The values in Table 3.1.19 represent the total physical diversion through each headgate, regardless of the ultimate use of that water. The Kicking Bird Canal takes deliveries from the Fort Lyon Canal; the values in Table 3.1.19 for Fort Lyon Canal exclude the flows delivered to Kicking Bird Canal.

Table 3.1.18 - Irrigated Acreage (2003), Source: CDSS – "Division 2 Irrigated Lands 2003" shapefile, DWR 2012

Ditch	Total Associated Acres	Acres Under Irrigation, 2003
Amity	43,900	37,300
Bessemer	18,000	12,000
Buffalo	6,100	6,000
Catlin	18,400	11,600
Colorado Canal	35,400	6,300
Fort Bent	5,800	4,100
Fort Lyon Canal	92,200	69,900
Holbrook	15,100	7,800
Keesee	1,900	500
Lamar	11,300	7,900
Las Animas Consolidated	6,900	3,200
Otero Canal	3,500	600
Oxford Farmer's	5,300	3,800

Ditch	Total Associated Acres	Acres Under Irrigation, 2003
Rocky Ford Ditch	7,500	400
Rocky Ford Highline	22,100	13,100
X-Y	3,400	900
Total	297,000	185,500

Table 3.1.19 - Agricultural Headgate Diversions, Source: HydroBase

Total Headgate Diversions (AFY)	Overall Average, WY 1982-2012	Wet Year Average, WY 2011	Dry Year Average, WY 2005	Average Year, WY 2010
Bessemer	72,700	146,000	57,100	68,500
Rocky Ford Highline	94,600	184,500	61,900	88,100
Colorado Canal	91,900	150,900	91,400	68,700
Oxford Farmer's	30,000	59,500	26,900	32,400
Otero Canal	9,900	25,700	7,100	6,600
Catlin	102,800	183,500	96,400	95,900
Holbrook	52,300	88,000	34,700	48,700
Rocky Ford Ditch	34,300	40,200	22,500	22,000
Fort Lyon Storage Canal	72,900	75,800	0	53,400
Fort Lyon Canal	251,800	368,600	208,500	219,000
Las Animas Consolidated	31,100	55,700	26,000	29,400
Keesee	5,900	200	0	0
Kicking Bird	3,300	0	0	0
Fort Bent	18,900	32,900	12,700	19,000
Lamar	49,400	69,000	34,300	52,400
X-Y	9,800	0	0	0
Buffalo	24,800	59,100	22,600	25,700
Amity	94,700	123,800	70,700	110,800
Total	**1,046,000**	**1,663,000**	**773,000**	**951,000**

3.1.4.4 Reservoirs

This section describes the storage and operations of major reservoirs within the Arkansas Basin. Water use of these reservoirs is also shown in Figures 7 through 9 in Section 3.1.5.

Twin Lakes Reservoir

Twin Lakes Reservoir is located on Lake Creek in the upper Arkansas Basin. It has a total storage of 140,339 AF, of which 67,833 is active storage. Twin Lakes Reservoir was originally owned by the Twin Lakes Canal Company and used to store water from the Twin Lakes (Independence Pass) Tunnel as well as a small amount of native rights. The reservoir was purchased by Reclamation for expansion for Fry-Ark project water, with the Twin Lakes Canal Company maintaining storage rights in the reservoir after the purchase by Reclamation. The Twin Lakes company has since largely been converted from agricultural use to municipal and industrial (M&I) use, with shareholders allotted a percentage of the transbasin and native water rights yields as well as a portion of the storage space in Twin Lakes Reservoir. Major water users with stakes in Twin Lakes include PBWW, CSU, Pueblo West, Aurora, and Xcel Energy (for use at the Comanche Generating Station). The Otero pump station intake is located at Twin Lakes Reservoir, conveying water to CSU and Aurora. CSU and Aurora also store Homestake water in Twin Lakes, and have the ability to exchange water from Pueblo Reservoir, Colorado Canal, Rocky Ford Canal, and CSU's return flows up to Twin Lakes for delivery via Otero. The Twin Lakes, Fry-Ark, and Homestake projects are described in more detail in Section 3.1.4.5. CSU and Aurora's exchanges are described in more detail in Section 3.1.4.5.

The Mount Elbert hydroelectric power plant is located on the shore of Twin Lakes Reservoir. The Mount Elbert forebay is an 11,530-AF reservoir; power is generated by letting water flow from the forebay, through the power plant, and into Twin Lakes. Water can be delivered to the forebay by the Mount Elbert Conduit from Turquoise Reservoir. The power plant is designed to supply power during peak times. During periods of off-peak electricity demand, water is also pumped from Twin Lakes Reservoir back up to the Mount Elbert forebay in order to generate additional power at peak times.

Table 3.1.20 shows the average amount of water stored in Twin Lakes Reservoir for wet, dry, and average years. The table also shows the total amount captured and released within that year. The table treats Twin Lakes Reservoir and the Mt Elbert forebay as a single, combined reservoir.

Table 3.1.20 - Twin Lakes Reservoir Capture, Release, and Storage, Source: Reclamation

	Total Captured (AFY)	Total Released (AFY)	Average Amount in Storage (AF)
Overall Average, WY 1997-2012	53,600	49,200	120,200
Wet Study Year, WY 2011	65,200	57,200	115,900
Dry Study Year, WY 2005	58,000	52,400	114,100
Average Study Year, WY 2010	46,700	36,000	123,000

Turquoise Reservoir

Turquoise Reservoir (also known as Sugar Loaf Lake) is located on the Lake Fork west of Leadville and is the highest major reservoir storage in the basin. Sugarloaf Reservoir was originally owned by CF&I (now EVRAZ). It was purchased and expanded by Reclamation and renamed Turquoise Reservoir for the development of the Fry-Ark project. Fry-Ark water arrives in Turquoise Reservoir from the Boustead tunnel. CSU, Aurora, and PBWW are major water users in the basin with additional storage in Turquoise Reservoir. PBWW can store water rights from some smaller transmountain projects; CSU and Aurora can store Homestake Project water there as well as exchange converted agricultural water rights from the Colorado Canal; Aurora can exchange Rocky Ford water to Turquoise; CSU and PBWW can exchange fully consumable transmountain return flows to Turquoise; all three entities can exchange water up from Pueblo or Twin Lakes Reservoirs. Total storage In Turquoise Reservoir is 129,398 AF.

Table 3.1.21 shows the average amount of water stored in Turquoise Reservoir for wet, dry, and average years. The table also shows the total amount captured and released within that year.

Table 3.1.21 - Turquoise Reservoir Capture, Release, and Storage, Source: Reclamation

	Total Captured (AFY)	Total Released (AFY)	Average Amount in Storage (AF)
Overall Average, WY 1997-2012	60,100	59,900	91,300
Wet Study Year, WY 2011	85,700	75,000	86,800
Dry Study Year, WY 2005	65,100	24,600	86,800
Average Study Year, WY 2010	68,800	70,500	91,400

Clear Creek Reservoir

Clear Creek Reservoir is owned by PBWW and is used to store a variety of water rights, including local Clear Creek rights and transbasin import water including Ewing and Wurtz Ditches. PBWW is able to move water by exchange into Clear Creek Reservoir from other parts of PBWW's system, including fully consumable return flows and water stored in Pueblo Reservoir. Total storage in Clear Creek Reservoir is 11,400 AF. For more information on PBWW's system, see Section 3.1.4.1.

Table 3.1.22 shows the average amount of water stored in Clear Creek Reservoir for wet, dry, and average years. The table also shows the total amount captured and released within that year.

Table 3.1.22 - Clear Creek Reservoir Capture, Release, and Storage, Source: PBWW

	Total Captured (AFY)	Total Released (AFY)	Average Amount in Storage (AF)
Overall Average, WY 2002-2012	5,400	4,500	7,100
Wet Study Year, WY 2011	7,500	7,500	7,500
Dry Study Year, WY 2005	4,600	4,800	8,500
Average Study Year, WY 2010	5,700	4,100	7,800

Pueblo Reservoir

Pueblo Reservoir is a 357,678 AF reservoir owned by Reclamation and was completed in 1975 as a crucial piece of the Fry-Ark project. The reservoir includes a 30,000 AF recreation pool, a 66,000 joint-use pool, and a 234,000 conservation pool. The joint-use pool serves as flood control space from April 15 through November 1 of each year, but can be used for regulation of irrigation supplies for the remainder of the year. The conservation pool stores water for M&I or agricultural use. The Winter Water Storage program is also operated in part out of Pueblo Reservoir, as described in Section 3.2. The Fry-Ark project is described in more detail in Section 3.1.4.5.

The reservoir was constructed as part of the Fry-Ark project and includes 163,000 AF of storage allocated to municipal Fry-Ark participants. However, entities can store other water in Pueblo through contracts with Reclamation. These are known as "if-and-when" or "excess capacity storage program" accounts. The spill priorities for Pueblo Reservoir are complex, but generally favor Fry-Ark project water and entities within SECWCD over other entities with if-and-when accounts. Entities with additional if-and-when storage in Pueblo include Aurora, CSU, PBWW, Salida, Security, and Fountain, and other municipal and agricultural users, plus a fish and recreation pool contracted jointly to the Bureau of Land Management and the Colorado Division of Parks and Wildlife. Currently the excess capacity storage is a total of about 69,000 AF. This value can change each year as some storage contracts must be renewed each year and others specify an increasing storage amount over time.

The Arkansas Valley Conduit EIS (Reclamation 2013) includes an evaluation of a Long Term Excess Capacity Master Contract, allowing SECWCD to have a long-term contract with the Bureau for excess capacity storage in Pueblo; providers could then contract with SECWCD for allocation of that storage. This would work similarly to the existing excess capacity storage program and follow Reclamation's current rules, but allow 27 providers to be grouped under a single, longer-term contract.

Table 3.1.23 shows the average amount of water stored in Pueblo Reservoir for wet, dry, and average years. The table also shows the total amount captured and released within that year.

Table 3.1.23 - Pueblo Reservoir Capture, Release, and Storage, Source: Reclamation

	Total Captured (AFY)	Total Released (AFY)	Average Amount in Storage (AF)
Overall Average, WY 1997-2012	91,800	77,700	176,900
Wet Study Year, WY 2011	97,000	95,000	216,400
Dry Study Year, WY 2005	60,100	57,000	119,000
Average Study Year, WY 2010	90,300	75,600	229,200

John Martin Reservoir

The 335,000-AF John Martin Reservoir was originally built for flood control and irrigation storage for irrigators in both Colorado and Kansas, emerging from negotiations between the two states that eventually resulted in the Arkansas River Compact of 1948. The operation of the reservoir has evolved over time, including the 1980 Operating Agreement revising the distribution of water between the two states and the addition of a recreation pool. Under the compact, the reservoir stores water intended to be distributed 60 percent to Colorado irrigators and 40 percent to irrigators in Kansas. There are a few accounts for other kinds of water, including storage of Amity Canal water from the Great Plains Reservoirs, water stored under the Winter Water Storage Program, and water stored in the Offset Account as part of the settlement with Kansas.

More details on the Arkansas River Compact and the 1980 John Martin Reservoir operating agreement can be found in Section 3.2.

Table 3.1.24 shows the average amount of water stored in John Martin Reservoir for wet, dry, and average years. The table also shows the total amount captured and released within that year.

Table 3.1.24 - John Martin Reservoir Capture, Release, and Storage, Source: CDNR

	Total Captured (AFY)	Total Released (AFY)	Average Amount in Storage (AF)
Overall Average, WY 1982-2012	122,300	94,500	119,900
Wet Study Year, WY 2011	45,700	49,000	29,400
Dry Study Year, WY 2005	78,000	71,800	32,300
Average Study Year, WY 2010	86,700	64,600	47,700

Trinidad Reservoir

Trinidad Reservoir was constructed by the U.S. Army Corps of Engineers (USACE) and began operations in 1977. It provides flood control and irrigation storage for agricultural users comprising 19,000 acres in the Purgatoire River Basin.

- Flood control: 50,000 AF;
- Irrigation: 20,000 AF;
  - The irrigation storage is under the transferred Model Reservoir senior storage right for 20,000 AF. Model Reservoir has been abandoned.
- Joint-use: 39,000 AF. This pool is for sediment, but available space is used for additional irrigation storage if John Martin Reservoir is spilling (indicating that water is available under the Arkansas River Compact);
- Fish and recreation (the "permanent pool"): 4,500 AF.

The City of Trinidad also has the option, not currently exercised, for 7,100 AFY of Trinidad Project water. Using this option would require conversion to municipal use as well as either a new treatment plant below Trinidad Reservoir or the ability to exchange up to North/Monument, higher in the basin, to go through the existing treatment plant.

The administration of the reservoir, and the repayment of federal funding for the irrigation portion of the reservoir, is managed by the Purgatoire River Water Conservancy District.

Table 25 shows the average amount of water stored in Trinidad Reservoir for wet, dry, and average years. The table also shows the total amount captured and released within that year.

As noted in Section 3.1.2, the Purgatoire River hydrology can vary from that of the Cañon City gage. At USGS gage 07128500 (Purgatoire River near Las Animas), 2011 was a drought year, 2005 was a wet year, and 2010 was an average year. Therefore, the basinwide study years are included in Table 3.1.25, along with the addition of 2006, representing a dry year in the Purgatoire Basin.

Table 3.1.25 - Trinidad Reservoir Capture, Release, and Storage, Source: USACE

	Purgatoire River Hydrologic Classification	Total Captured (AFY)	Total Released (AFY)	Average Amount in Storage (AF)
Overall Average, WY 1982-2012		21,800	19,800	24,600
Wet Study Year, WY 2011	Drought	10,800	9,000	16,400
Dry Study Year, WY 2005	Wet	21,000	19,700	24,700
Average Study Year, WY 2010	Average	22,700	19,400	20,600
Additional Dry Year, WY 2006	Dry	13,100	12,400	17,600

Colorado Canal Reservoirs

The Colorado Canal system has two major reservoirs: Lake Meredith (active storage of 40,413 AF) and Lake Henry (active storage 10,915 AF). For irrigation water, much of the irrigated acreage is below Lake Meredith. To provide irrigation water to these portions of the Colorado Canal system, water is released from Lake Meredith to the mainstem and exchanged back up to the canal headgate. The water released for exchange can also be taken directly by the Fort Lyon Storage Canal or the Holbrook Canal (which cross the outlet canal from Lake Meredith), with a like amount still taken at the Colorado Canal headgate.

As noted in Section 3.1.4.3, over 95 percent of the Colorado Canal, Lake Meredith, and Lake Henry shares have been purchased by municipal shareholders, although not all of the water available to municipalities is currently put to municipal use. Water for municipal use is stored in Lake Meredith and Lake Henry and released to the river, often for exchange upstream to Pueblo Reservoir or a municipal headgate.

Holbrook Canal Reservoirs

The Holbrook Canal system includes two major reservoirs: Holbrook Reservoir (7,472 AF) and Dye Reservoir (7986 AF). To use water stored in either of these reservoirs, water is released from storage back to the mainstem and exchanged back up to the Holbrook Canal through a reach that includes the Rocky Ford Ditch headgate.

Holbrook Reservoir is also currently utilized for a program known as "Recovery of Yield." When exchanges to Pueblo Reservoir are limited by flow, including as stipulated under the Arkansas River Flow Management Program, water can be stored in Holbrook and exchanged up to Pueblo Reservoir at a later time when conditions are more favorable for exchange. See Section 3.1.4.8 for more information on the Voluntary Flow Management Program.

Fort Lyon Canal Reservoirs

The Fort Lyon Canal system includes two major reservoirs: Horse Creek Reservoir (28,000 AF) and Adobe Creek Reservoir (85,000 AF). These reservoirs are filled by the Fort Lyon Storage Canal (which does not irrigate any land directly), and make releases into the Fort Lyon Canal. Adobe Creek Reservoir also has a right for storage of Adobe Creek water. The Fort Lyon Canal can make direct diversions from the Arkansas River mainstem, Horse Creek, and Adobe Creek, as well as deliver water from these two reservoirs.

Amity Canal Company Reservoirs

The Great Plains Reservoirs comprise four reservoirs in the Amity Canal System: Nee Gronda (Big Water), Nee Skah (Queens), Nee So Pah (Black Water), and Ne Noshe (Standing Water), with a combined capacity of 265,552 AF. These reservoirs are filled by the Kicking Bird Canal, which diverts from the Fort Lyon Canal. The Comanche Canal delivers water from these reservoirs to the Amity Canal for irrigation use. These reservoirs have large dead pools and high evaporative losses; the Amity Canal can store some Great Plains water in John Martin Reservoir in order to minimize losses. This is done under the consent of the Arkansas River Compact administration in the 1980 Operating Agreement. The Amity Canal has to pay a 35 percent storage charge to the administration for distribution. The storage charge water is distributed to irrigation systems in each state, excluding the Amity Canal.

3.1.4.5 Transmountain Systems

Configuration and operation of the four major transmountain systems is described below. Total imports are also shown in Figures 4 through 6 in Section 3.1.5.

Fryingpan – Arkansas Project

The Fry-Ark project brings surface water from the Fryingpan River and other tributaries of the Roaring Fork River in the Colorado Basin for delivery to municipal and agricultural users in the Arkansas Basin.

Congress authorized the project in 1962 and construction began in 1964. Construction was continuous until the completion of the fish hatchery at Pueblo Dam in 1990, with the first deliveries of Fry-Ark water in 1972 and most major infrastructure in place by 1980.

Project infrastructure on the West Slope includes Ruedi Reservoir on the Fryingpan River and two additional collection systems that collect surface water directly from 16 diversion locations on a number of Fryingpan and Roaring Fork tributaries. Water from Ruedi Reservoir is not conveyed into the Arkansas Basin; rather, the reservoir serves for regulation and replacement of water on the West Slope, providing water for irrigation, M&I needs, and environmental and recreational purposes.

Water is conveyed to the Arkansas Basin via the Charles H Boustead Tunnel (this water is commonly known simply as "Project Water"). Storage in the Arkansas Basin includes Turquoise Lake, Twin Lakes, and Pueblo Reservoir. Water is also conveyed through the Mt. Elbert pump-storage power plant for electrical power generation. Boustead Tunnel discharges into Turquoise Lake, the highest Fry-Ark storage in the Arkansas Basin. From there, water is conveyed to the Mt. Elbert forebay via a conduit, and from there into Twin Lakes. Twin Lakes releases water into Lake Creek, which flows into the Arkansas

River, for storage in Pueblo Reservoir (143 river miles downstream) or to project participants above Pueblo.

Major agricultural participants include:

- Bessemer Ditch;
- Excelsior Ditch;
- Colorado Canal;
- Rocky Ford Highline Canal;
- Oxford Farmer's Ditch;
- Otero Canal;
- Catlin Canal;
- Ft. Lyon Canal;
- Holbrook Canal.

Major municipal participants include:

- Fountain Valley Authority (FVA);
  - Colorado Springs;
  - Fountain;
  - Security;
  - Widefield;
  - Stratmoor Hills;
- PBWW.

The SECWCD was established in 1958 for administration of the Fry-Ark project. Today, SECWCD continues to administer several programs related to the Fry-Ark project. Return flows from this project are fully consumable. They are all owned by SECWCD; entities who wish to exchange their Fry-Ark return flows back into Pueblo Reservoir (or other basin storage) for reuse must purchase them from SECWCD. Other entities may also lease return flows from SECWCD even if they are not Fry-Ark participants; many users do this for augmentation of groundwater supplies.

Table 3.1.26 shows total imports through the Boustead Tunnel under wet, dry, and average conditions. Table 3.1.27 shows municipal allocations and Table 3.1.28 shows agricultural allocations, also under wet, dry, and average conditions.

Table 3.1.26 - Fry-Ark Project Imports, Source: HydroBase

	Annual Imports (AFY)
Overall Average WY 1982-2012	57,000
Wet Study Year, WY 2011	99,800
Dry Study Year, WY 2005	55,800
Average Study Year, WY 2010	56,700

Table 3.1.27 - Fry-Ark Municipal Allocations, Source: SECWCD

Annual Allocation Amounts (AFY)		Overall Average, WY 1982-2012	Dry Study Year, WY 2005	Average Study Year, WY 2010	Wet Study Year, WY 2011
Major Municipal Entities	Fountain Valley Authority	10,000	11,400	5,200	7,100
	Board of Water Works, Pueblo	860	4,580	5,000	0
	La Junta, City of	420	930	300	1,100
	Lamar, City of	1,100	1,000	1,600	1,600
	Las Animas, City of	140	250	300	300
	Rocky Ford, City of	160	450	750	480
	Buena Vista, Town of	74	200	200	190
	Cañon City, City of	120	300	100	200
	Florence, City of	47	75	200	200
	Salida, City of	210	400	400	0
Other M&I		1,700	2,960	2,790	3,560
Total Municipal		14,300	18,000	16,800	14,700

Table 3.1.28 - Fry-Ark Agricultural Allocations, Source: SECWCD

Annual Allocation Amounts (AFY)		Overall Average, WY 1982-2012	Dry Study Year, WY 2005	Average Study Year, WY 2010	Wet Study Year, WY 2011
Major Ditches	Bessemer	5,400	2,600	3,800	7,600
	Catlin Canal	3,800	2,500	2,900	5,100
	Colorado Canal	1,400	800	800	1,700
	Fort Lyon Canal	16,600	9,000	12,100	23,800
	Holbrook	4,100	2,200	3,100	6,300
	Las Animas Consolidated	120	150	710	0
	Oxford Farmers	1,200	800	1,200	2,100
Other Ag		7,100	3,700	6,000	12,700
Total Ag		39,700	21,700	30,700	59,200

Blue River Project

The Blue River project brings water from the Blue River in the Colorado Basin to CSU. The collection system on the West Slope includes several tunnel and pipeline facilities. Water comes through the Hoosier Tunnel to Montgomery Reservoir and then through the 30-inch Blue River Pipeline (also known as the Montgomery Pipeline) to tie in to the rest of CSU's system. Blue River project water is typically sent to CSU's North Slope water system and stored in North and South Catamount Reservoirs and Crystal Reservoir. It can also travel via the Twin Rocks pump station to the Northfield water system for storage in Rampart Reservoir.

Table 3.1.29 shows the annual imports through the Hoosier Tunnel under wet, dry, and average hydrologic conditions.

Table 3.1.29 - Blue River Project Imports, Source: HydroBase

	Annual Imports (AFY)
Overall Average WY 1982-2012	8,800
Wet Study Year, WY 2011	3,100
Dry Study Year, WY 2005	10,000
Average Study Year, WY 2010	10,100

Homestake Project

The Homestake Project is a joint project between CSU and Aurora. Aurora has an additional agreement to provide the first 2,500 AF of Aurora's project yield to PBWW. Each party has an equal stake and deliveries are divided evenly.

All project water, for both CSU and Aurora, is collected in Homestake Reservoir in the headwaters of the Eagle River and conveyed to the Arkansas Basin via Homestake Tunnel. The tunnel ends in Lake Fork Creek above Turquoise Reservoir. Similar to the Fry-Ark water, Homestake water is released from Turquoise to Twin Lakes, passing through the Mt. Elbert forebay and power plant. From Twin Lakes, the water is conveyed via pipeline to the Otero pump station. The pipeline to the Otero pump station transports Twin Lakes, Fry-Ark, Colorado Canal, and other CSU exchange water in addition to Homestake project water. The Otero pump station supplies the 66-inch Homestake pipeline. This pipeline has a bifurcation south of Spinney Mountain Reservoir where the Aurora portion of the project water is released into Spinney Mountain Reservoir and the CSU portion continues in a second, smaller pipeline, where it is boosted by the Twin Rock pump station. The CSU water from the Otero pump station, including Homestake water, can be either sent to the Northfield water system and stored in Rampart Reservoir, or sent via the Blue River pipeline to north Catamount Reservoir in the North Slope water system.

Table 30 summarizes deliveries through the Homestake tunnel under wet, dry, and average conditions. Values for each entity are calculated based on a 50/50 split between CSU and Aurora, with the first 2,500 AF of Aurora's water going to PBWW each year.

Table 3.1.30 - Homestake Project Imports, Source: HydroBase

AFY	Total	CSU	Aurora	PBWW
Average Annual Import, WY 1982-2012	26,000	13,000	10,600	2,400
Wet Study Year, WY 2011	32,200	16,100	13,600	2,500
Dry Study Year, WY 2005	23,900	12,000	9,500	2,500
Average Study Year, WY 2010	9,000	4,500	2,000	2,500

Twin Lakes Project

The Twin Lakes project began in the 1930s, with the intent to supply the Colorado Canal with an additional water supply. The Colorado Canal Company, Lake Meredith Reservoir Company, and the lake Henry Reservoir Company were originally all part of the Twin Lakes Reservoir and Canal Company. However, these were separated into four distinct companies in the 1970s.

The Twin Lakes supply is primarily transbasin water, but about 10 percent of the yield comes from native rights stored in Twin Lakes Reservoir. Transbasin water is collected from the Roaring Fork River, Lost Man Creek, New York Creek, and Lincoln Gulch and stored in the West Slope in Grizzly Reservoir. From there it passes through the Twin Lakes tunnel (also known as the Independence Pass tunnel) and into North Fork Lake Creek for storage in Twin Lakes Reservoir. Twin Lakes Reservoir was purchased by Reclamation and expanded for storage of Fry-Ark water, but the Twin Lakes Reservoir and Canal Company maintains ownership of 54,453 AF of storage in the expanded reservoir.

Over time, shares of the Twin Lakes Company have been purchased by a number of entities, and Twin Lakes project water has accordingly been transferred for use elsewhere. Major Twin Lakes shareholders include Colorado Springs, Aurora, PBWW, and Pueblo West. Colorado Springs and Aurora release their Twin Lakes water to the Otero pump station along with the Homestake water, as described above. PBWW releases water to their intake in Pueblo Reservoir.

Table 3.1.31 shows the distribution of Twin Lakes Ownership. Table 3.1.32 shows total imports through Independence Pass Tunnel under wet, dry, and average hydrologic conditions.

Table 3.1.31 - Twin Lakes Company Ownership, Source: Hydrologic Modeling Documentation Report, SDS EIS (Reclamation 2002)

Entity	Ownership Portion	Storage (AF)
CSU	55%	29,789
Aurora	5%	2,722
PBWW	23%	12,602
Pueblo West	11%	6,332
Augmentation	1%	519
Other M&I	3%	1,864
Other Ag and Inactive	1%	652

Table 3.1.32 - Twin Lakes Project Imports, Source: HydroBase

	Total Imports (AFY)
Overall Average WY 1982-2012	41,400
Wet Study Year, WY 2011	66,300
Dry Study Year, WY 2005	50,200
Average Study Year, WY 2010	46,800

3.1.4.6 Groundwater Pumping and Augmentation

Groundwater administration in the Arkansas Basin is unique and complex owning to the Arkansas Compact and subsequent litigation between Kansas and Arkansas. All wells decreed after 1948 must replace any depletion to the river and to the Stateline flow resulting from pumping. These replacements must be made in the river reach and at the same time as the stream depletions occur, which is different from the timing of well water use. Stream depletions are determined by a complex modeling process. Designated nontributary wells with no surface water interaction are exempt from this requirement; however, this represents only a small fraction of groundwater supplies within the basin. Water for this purpose can include agricultural water rights converted to use for augmentation or water from transmountain projects or from the fully consumable return flows of those transmountain projects. More details on the requirements for replacing stream depletions resulting from groundwater pumping, including information on the administrative process and history of agreements and litigation between Kansas and Arkansas, is provided in Section 3.2.

Several groundwater augmentation associations have emerged to provide augmentation water to their member entities. These associations may have decreed augmentation plans allowing for permanent ownership of water rights to be used for augmentation, as well as replacement water under Rule 14 plans providing water from leased sources. The three augmentation associations identified as 'major' for inclusion in this study collectively represent a significant portion of groundwater users within the basin, although there are several smaller associations as well as many entities with individual augmentation decrees or water replacement plans. All three associations provide augmentation for both municipal and agricultural members from a wide variety of water supply sources.

The **Lower Arkansas Water Management Association (LAWMA)** primarily includes members in the lower portion of the basin, including users below John Martin Reservoir. Along with some Fry-Ark return flows leased from SECWCD, most of LAWMA's supply comes from agricultural sources changed to augmentation use including the X-Y canal rights, Lamar Canal, Manvel Canal, and Keesee Ditch. LAWMA is the only one of the three major associations with a decreed augmentation plan; the other two operate solely under Rule 14 plans.

The **Colorado Water Protective and Development Association (CWPDA)** primarily serve members located between Fowler and Las Animas. Primary sources of augmentation water include: Fry-Ark return flows leased from SECWCD; agricultural water including the Catlin Canal, Ft Lyon, and the Colorado Canal; and Fry-Ark project water. CWPDA also has an "if and when" account in Pueblo Reservoir.

The **Arkansas Groundwater Users Association (AGUA)** members are largely located higher up in the basin. Primary sources of augmentation water include: Fry-Ark return flows leased from SECWCD; fully consumable municipal return flows from several entities including Cherokee Metro district, PBWW, and CSU; and agricultural water including Excelsior ditch rights owned by AGUA and Aurora's Rocky Ford ditch rights. AGUA maintains an "if and when" account in Pueblo Reservoir and receives small allocations of Fry-Ark project water.

Table 3.1.33 shows total pumping in the basin, divided by which wells are members are LAWMA, CWPDA, and AGUA, for wet, dry, and average years. Table 3.1.34 shows augmentation water use in the basin for each of the three major augmentation associations for wet, dry, and average study years.

Pumping data is also shown in Figures 10 through 12 in Section 3.1.5.

Table 3.1.33 - Pumping – Grouped by Augmentation Association

Total Pumping (AFY)	AGUA	CWPDA	LAWMA	Other
Overall Average, WY 1997-2012	9,400	66,600	64,400	31,400
Wet Study Year, WY 2011	9,400	66,600	64,400	31,400
Dry Study Year, WY 2005	3,200	47,700	35,100	19,400
Average Study Year, WY 2010	5,400	44,000	56,300	27,700

Table 3.1.34 - Groundwater Augmentation

Total Augmentation Supplies (AFY)	AGUA	CWPDA	LAWMA
Overall Average, WY 2002-2012	4,500	26,700	14,900
Wet Study Year, WY 2011	3,900	7,300	18,300
Dry Study Year, WY 2005	3,100	18,300	9,600
Average Study Year, WY 2010	2,500	3,600	13,300

3.1.4.7 Exchanges

Major exchanges in the Arkansas Basin are listed in Table 3.1.35 and shown in Figure 3. They are numbered in Table 3.1.35 for reference to the numbers in Figure 3. Exchange mechanisms are described in more detail in Section 3.2. Pueblo Reservoir is central to a significant number of exchanges in the basin. Several entities move water into Pueblo as an interim step to moving it higher up in the basin when exchange potential is available. Priority order for exchanges into Pueblo Reservoir is also detailed in Section 3.2.3 in Table 1.

Table 3.1.35 - Major Exchanges

ID on Figure 3	Entity	From	To
1	PBWW	Pueblo Reservoir	Clear Creek
2	PBWW, Salida, Pueblo West, Aurora, or CSU	Pueblo Reservoir	Twin Lakes
3	PBWW, Salida, Pueblo West, Aurora, or CSU	Pueblo Reservoir	Turquoise
10	Ft. Lyon Canal	John Martin	Ft. Lyon Canal
11	CSU	WWTP on Fountain Creek	Pueblo Reservoir
12	PBWW	Return flow locations: • PBWW WWTP • Comanche Generating Station (St. Charles River) • EVRAZ / CF&I (Salt Creek)	Pueblo Reservoir
14	Aurora	Rocky Ford Ditch Headgate	Pueblo Reservoir
4 & 5	Colorado Canal shareholders, including CSU and Aurora	Lake Henry or Lake Meredith	Pueblo Reservoir
6 & 7	CO Canal shareholders	Lake Henry or Lake Meredith	CO Canal
8 & 9	Holbrook Canal	Dye or Holbrook Reservoirs	Holbrook Canal

3.1.4.8 Other Programs

Voluntary Flow Management Program for the Upper Arkansas River

The voluntary flow management program (VFMP) concerns the operations of Twin Lakes and Turquoise Reservoirs for recreational and fishery flows. Parties to the agreement are SECWCD, the Colorado Department of Natural Resources (CDNR), The Colorado Division of Wildlife (DOW), Colorado Division of Parks and Outdoor Recreation (DPOR), Chaffee County, Arkansas River Outfitters Association (AROA), and Trout Unlimited. (Since this agreement was signed, DOW and DPOR have merged into the Colorado Division of Parks and Wildlife.) Releases from Twin and Turquoise are managed to meet the following flow parameters at the Wellsville gage:

- Minimum flow of 250 cfs year-round;
- Flows during the winter incubation period (November 16 – April 30) of 250 – 400 cfs, depending on flows during the spawning period (October 15 – November 15);
- Flows maintained between 250 – 400 cfs from April 1 through May 15;
- In higher flow years, reduction of flows to 250-400 cfs from Labor Day through October 15;
- Flow augmentation for recreational purposes to maintain flows at 700 cfs July 1 – August 15. The recreation target flow rate can be changed each year by agreement of the participating entities. DPOR provides water SECWCD to make up for evaporative losses to Fry-Ark project water due to these releases;

- When flow rates must be altered, maintain daily change to 10-15 percent.

Flow Management Program for the Arkansas River below Pueblo Reservoir

This flow management program is an agreement between SIX parties: the City of Pueblo, PBWW, CSU, Aurora, SECWCD, and Fountain. (The agreement itself is commonly known as the "6-party IGA.") The agreement was reached in May of 2004 after the City of Pueblo filed for a recreational in-channel diversion right for the reach of the river through the City of Pueblo, below Pueblo Reservoir, as part of the Arkansas River Corridor Legacy Project. The Legacy Project was a joint effort with USACE to enhance habitat and recreation on the Arkansas River through the City of Pueblo.

The remaining five parties to the agreement agreed to curtail exchanges into Pueblo Reservoir under certain flow conditions. The agreement concerns the reach from the gage above Pueblo to the confluence with Fountain Creek. The measured flow governing the exchanges is the sum of the gage above Pueblo and the return flows from the fish hatchery at Pueblo Dam. Exchanges are curtailed when this flow is below the values in Table 3.1.36. As specified in Table 3.1.36, the values are different in average and dry years. An average year is defined as one in which the "most likely" National Resources Conservation Services' Colorado Basin Water Supply Outlook Report water supply forecast is 100 percent of average or greater, and a dry year is defined as one in which that forecast is 70 percent of average or greater.

Table 3.1.36 - Flow Management Program Below Pueblo Reservoir, Flow Targets

Period	Average Year, cfs	Drier Year, cfs
Oct 01 through Oct 15	250	150
Oct 16 through Nov 14	200	150
Nov 15 through Mar 15	100	100
Mar 16 through Mar 31	250	200
Apr 01 through Apr 15	350	250
Apr 16 through Apr 30	400	300
May 01 through May 22	450	350
May 23 through Jul 31	500	500
Aug 01 through Aug 15	450	350
Aug 16 through Sep 07	300	300
Sep 08 through Sep 30	250	150

Aurora, PBWW, CSU, and SECWCD have also developed the Recovery of Yield program to maintain the yield on water rights they are not able to exchange due to the constraints of this flow management program. Currently, those rights can be stored in Holbrook, Dye, Henry, or Meredith Reservoirs by agreement with the Colorado Canal and Holbrook Mutual Irrigation Companies. When exchange potential is available, water is released from those four reservoirs for exchange back into Pueblo Reservoir, minus transit losses accrued from Pueblo Reservoir to the agricultural reservoirs. These entities are investigating a new lined gravel pit reservoir along the Arkansas River below the confluence with Fountain Creek.

Pueblo Reservoir Winter Water Storage Program

The Pueblo Reservoir Winter Water Storage Program allows for the storage of agricultural water in the winter (November 16 – April 15), for release to irrigation ditches during the following irrigation season. It includes some storage in John Martin in addition to storage in Pueblo Reservoir. It is described in detail in Section 3.2.

3.1.5 Basin Water Use Maps

Water supply use data is presented in Figures 3 through 12.

- Wet study year: WY 2011;
- Dry study year: WY 2005;
- Average study year: WY 2010.

Figures 4 through 6 show imports, irrigation headgate diversions, and gaged streamflows for the wet study year (2011), dry study year (2005), and average study year (2010). The symbols for each major irrigation diversion headgate are sized by the total diversion through that headgate for the given year, regardless of the ultimate use of that water. As in Table 3.1.19, Fort Lyon Canal excludes the flows delivered to Kicking Bird Canal. Similarly, the symbols for each transmountain import are scaled to the amount imported through the respective tunnels. The symbol for EVRAZ (CF&I) is scaled based on total diversions at the Minnequa Canal minus Union Ditch diversions. Similarly, the Comanche Generating Station symbol is scaled based on total raw water use at the plant.

Figures 4 through 6 also include gages and varying streamflows for the wet, dry, and average study years. The streamflow buffer values were developed using a combination of USGS NHD Plus average annual streamflow data for each segment and USGS gage data at a number of locations throughout the basin. The gages were used to calculate a ratio of wet and dry to average flows to vary the buffer sizes by flow. Table 37 shows the annual streamflow volumes for key gages in the basin.

As noted in section 3.1.2, the representative years chosen based on the Cañon City gage are not necessarily good indicators of the hydrology in other tributaries, including the Huerfano, Apishap, and Purgatoire Rivers. For the Huerfano River gage, 2005 was a wet year, 2010 was an average year, and 2011 was a dry year; all three hydrologic conditions are represented. For the Apishapa River gage, 2005 and 2010 were average years and 2011 was a wet year. 1999 was the most recent wet year, with an annual flow for 21,300 AF. At the Purgatoire River gage, 2005 was a wet year, 2010 was a dry year, and 2011 was a drought year. 2006, the most recent dry year, had an annual average flow of 21,900 AF.

Table 3.1.37 - Flows at Major Gages, Annual Flow Volume (AFY)

Gage Name	USGS ID	Overall Average, WY 1982 - 2012	Dry Study Year, WY 2005	Avg Study Year, WY 2010	Wet Study Year, WY 2011
Arkansas River at Cañon City	07096000	535,600	364,000	493,000	615,000
Arkansas River at Las Animas	07124000	205,300	99,000	155,000	119,000
Arkansas River at Lamar	07133000	98,500	64,000	56,000	39,000
Arkansas River near Coolidge, KS	07137500	170,600	90,000	114,000	64,000
Arkansas River at Granite	07086000	299,000	174,000	272,000	413,000
Arkansas River near Wellsville	07093700	520,000	362,000	493,000	654,000
Arkansas River near Avondale	07109500	680,000	460,000	594,000	642,000
Arkansas River at Portland	07097000	570,000	395,000	517,000	615,000
Fountain Creek at Pueblo	07106500	110,700	76,000	97,000	69,000
Huerfano River near Boone	07116500	22,900	49,000	19,000	1,200
Apishapa River near Fowler	07119500	11,900	15,000	9,100	6,500
Purgatoire River near Las Animas	07128500	42,900	91,000	50,000	9,900

Figures 7 through 9 show reservoir capture and release for wet, dry, and average study years, respectively.

Figures 10 through 12 show groundwater pumping for wet study year (2011), dry study year (2005), and average study year (2010), respectively. The pumping values are grouped by the major augmentation associations responsible for the corresponding augmentation. These values are shown by water district to show the spatial distribution of groundwater reliance in the basin on a logarithmic scale, showing that the lower portion of the basin relies significantly more on groundwater.

3.1.6 Constraints and Opportunities in the Arkansas River Basin

Through the review of existing data and operations in the Arkansas River Basin there are both constraints and several opportunities related to water resources development in the basin.

3.1.6.1 Constraints

- The Arkansas River Compact limits water development after 1948 if the development has the potential to reduce the usable water supply to which Kansas is entitled. Thus, post-compact water resources development such as new reservoirs, enlargement of existing reservoirs, improved irrigation efficiency for canal systems, and tributary groundwater use that could impact the native water supply of the Arkansas River Basin are not be feasible unless offsets to the reduction of usable Stateline flow are provided.
- The Arkansas River Basin is highly over-appropriated due to unmet demands of senior water rights and the Arkansas River Compact. Therefore, new water projects are not feasible because the yield of existing conditional or new water rights would be very limited. The unmet demands for both municipal and agriculture future demands will have to be met from better management

of existing supplies including reuse of transbasin water supplies to the maximum potential along with consideration of new transbasin diversions from an Interbasin Compact Committee (IBCC) approved project.

- Due to the highly over-appropriated nature of the Arkansas River Basin, any water resources project that will maximize the use of existing water supplies will require considerable engineering and legal support to be successful.
- The water quality in the Arkansas River Basin east of Pueblo is high in total dissolved solids (TDS) and the use of river and alluvial groundwater for future municipal demands requires expensive treatment or an alternative supply such as the Arkansas Valley Conduit (AVC).
- Baca County is located in the southeast part of the state with very limited surface water supplies and the water sources for communities and irrigated farmlands are from aquifers underlying the county that include the Ogallala, Cheyenne, Dakota and Dockum aquifers. The groundwater elevations have been monitored for a number of years and are generally declining with the majority of the wells showing a decline in water levels under 15 feet for the last 10 years. The gradual mining of these aquifers is a serious future issue that will require attention at some point in time.

3.1.6.2 Opportunities

- The ability to capture and reuse transbasin water return flows can be enhanced with additional storage including the Long-Term Excess Capacity Master Contract space in Pueblo Reservoir and new reservoirs, which could include a lined gravel pit reservoir below the confluence with Fountain Creek to capture transbasin return flows not immediately exchangeable to Pueblo Reservoir. This lined gravel pit is an example of a Recovery of Yield (ROY) reservoir being evaluated by several water providers.
- There is the opportunity for M&I water providers to increase conservation of existing supplies so as to better manage supplies during drought, often referred to as drought hardening. Increased conservation of agricultural water supplies is limited by the Arkansas River Compact as mentioned above.
- Additional water management programs may be feasible to increase the use of reusable water sources. These programs need to be carefully evaluated using the best water resources engineering and modeling available to determine feasibility.
- There may be the opportunity to partner with CSU and water providers that rely on Denver Basin groundwater to develop aquifer storage and recovery programs to extend the life of the nonrenewable aquifers in northern El Paso County. A conjunctive use program could utilize surface water supplies in above average hydrology years to reduce pumping and use groundwater in drought years to enhance the total water supplies of all parties.
- The completion of the SDS for its beneficiaries will enhance the ability to manage their water resources and maximize beneficial use.
- The AVC if funded and constructed will improve water supplies to participating entities and cities.

- The Super Ditch Project, which involves rotational fallowing of irrigated farmland, can provide renewable water supplies for municipal shortages while reducing the potential of permanent dry-up of farmland. There are irrigation companies willing to participate in the program and the project is moving forward albeit slowly due to new concept being proposed.
- The loss of water by Tamarisk infestation along the Arkansas River can be reduced by controlling this vegetation and a new concept is being evaluated using insects to destroy Tamarisk in other states. These programs in other states need to be investigated to see if they are feasible for the ARV. The potential water savings could be considerable and would improve water supplies to those relying on senior water rights from the Arkansas River.
- The current level of water rights administration and accounting in the Arkansas River Basin by the Colorado DWR provides the ability to properly manage and account for new water supply projects including exchanges and other new concepts.

3.1.7 References

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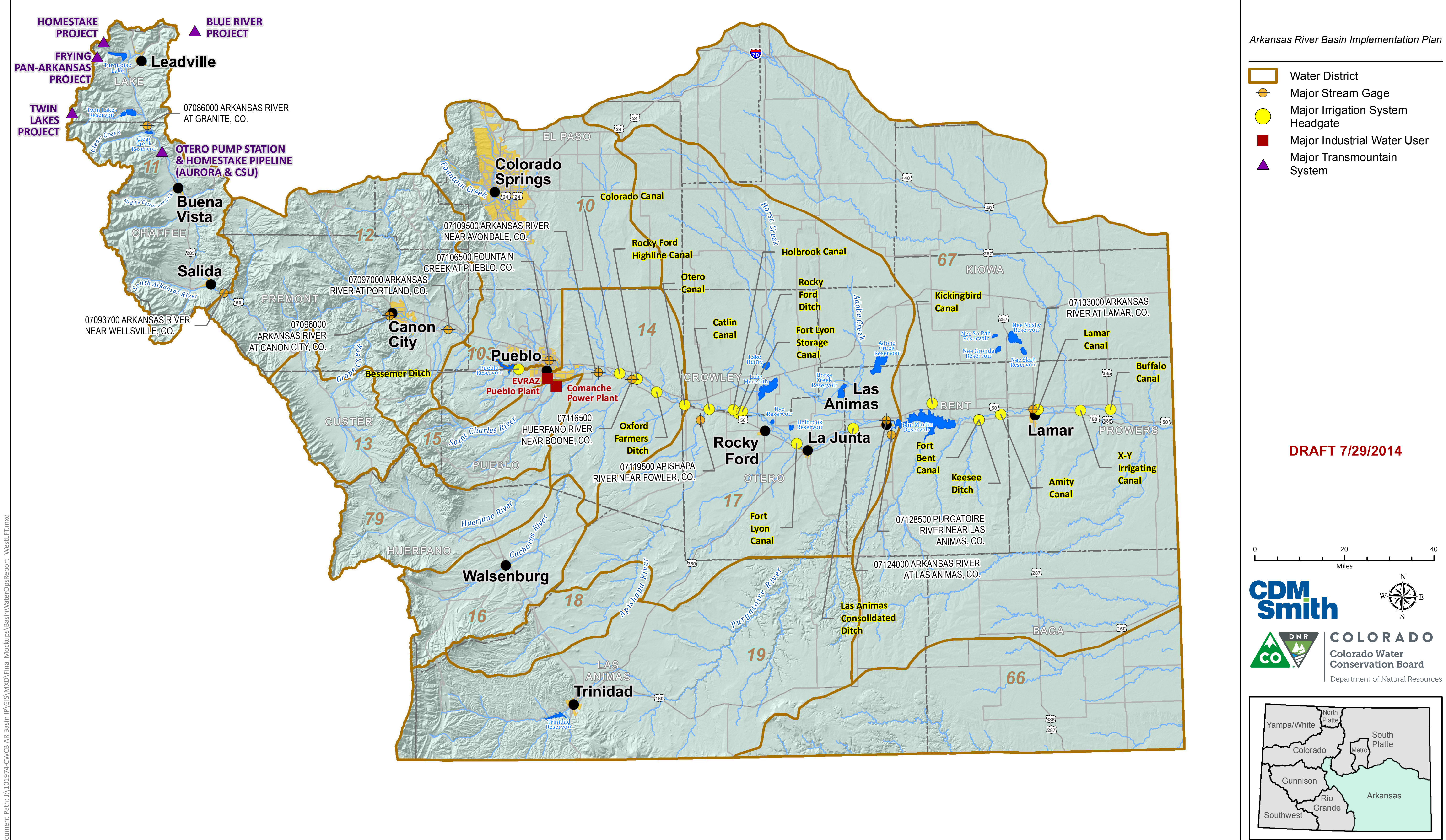
Wells, Pat. 2014. Personal Communication.

Willhite, Amy. 2014. Personal Communication.

Figure 1
Location Map

Arkansas River Basin Implementation Plan

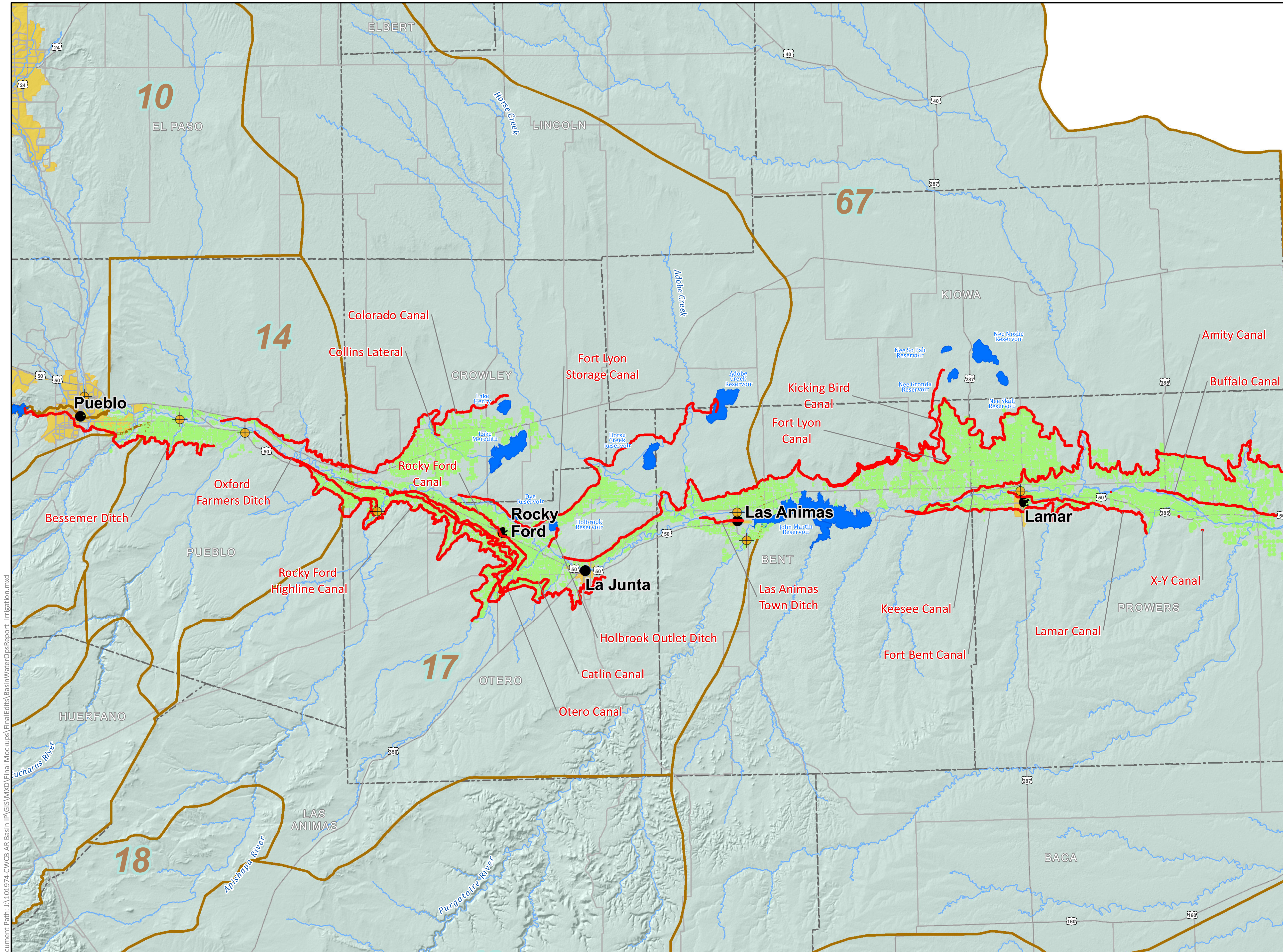


Document Path: J:\101974-CWCB AR Basin IP\GIS\MXD\Final Mockups\BasinWaterOpsReport_WestLT.mxd

Figure 2
Major Irrigation Canals and Irrigated Acreage

Arkansas River Basin Implementation Plan

Water District
Major Stream Gage
Major Irrigation Canal
Irrigated Acreage (2003)



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0 10 20
Miles

CDM Smith

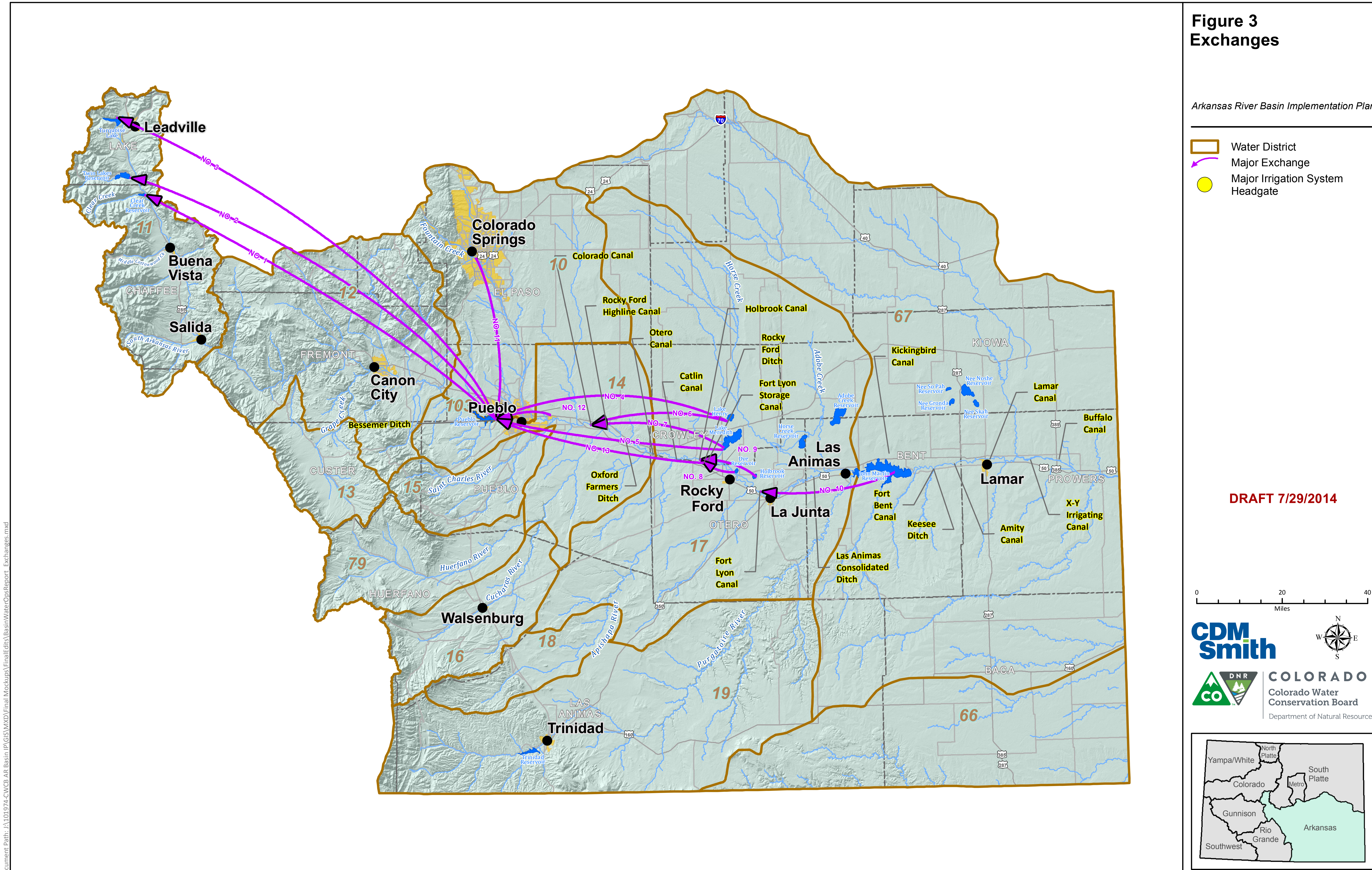
COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Yampa/White
North Platte
South Platte
Colorado
Metro
Gunnison
Rio Grande
Southwest
Arkansas

Document Path: J:\101974-CWCB AR Basin IP\GIS\MXD\Final Mockups\FinalEdits\BasinWaterOpsReport_Irrigation.mxd

Figure 3
Exchanges

Arkansas River Basin Implementation Plan



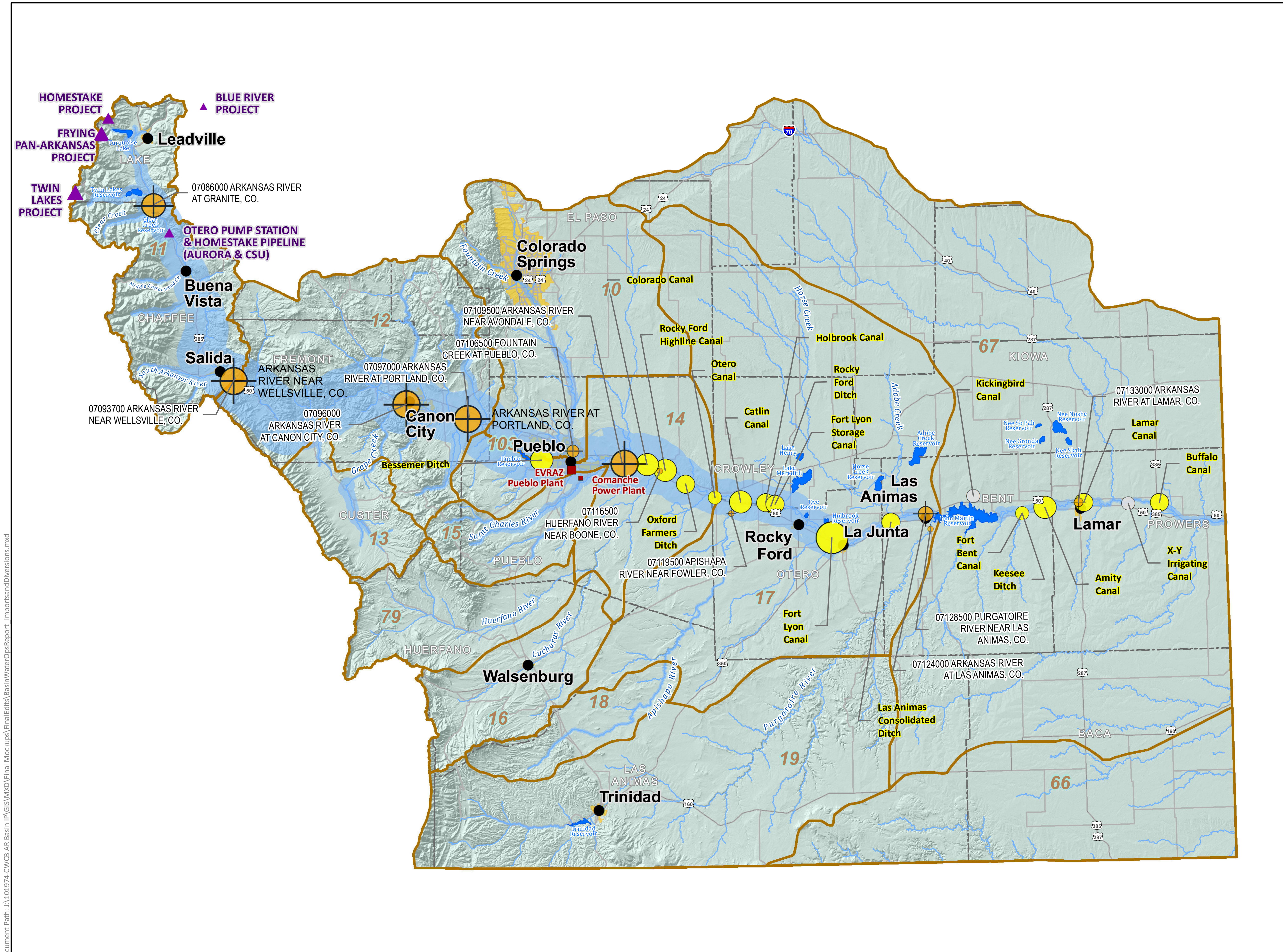


Figure 4
Imports and Diversions

WET YEAR [WR 2011]

Arkansas River Basin Implementation Plan

Streamflow - Width is proportional to annual flow volume

Water District

Major Imports and Diversions
Symbol size is proportional to annual flow (AFY)

< 1 000 — > 500 000

Symbol Types

- Major Stream Gage
- Major Irrigation System Headgate
- Major Industrial Water User
- Major Transmountain System
- Major Irrigation System Headgate - No Data Available for this year

DRAFT 7/29/2014

Headgate diversions and gages: Historical Records (Hydrobase)
Streamflow widths: National Hydrography Dataset, USGS and Gage Records

0 20 40 Miles

CDM Smith

COLORADO Colorado Water Conservation Board Department of Natural Resources

Yampa/White, North Platte, South Platte, Colorado, Metro, Gunnison, Rio Grande, Southwest, Arkansas

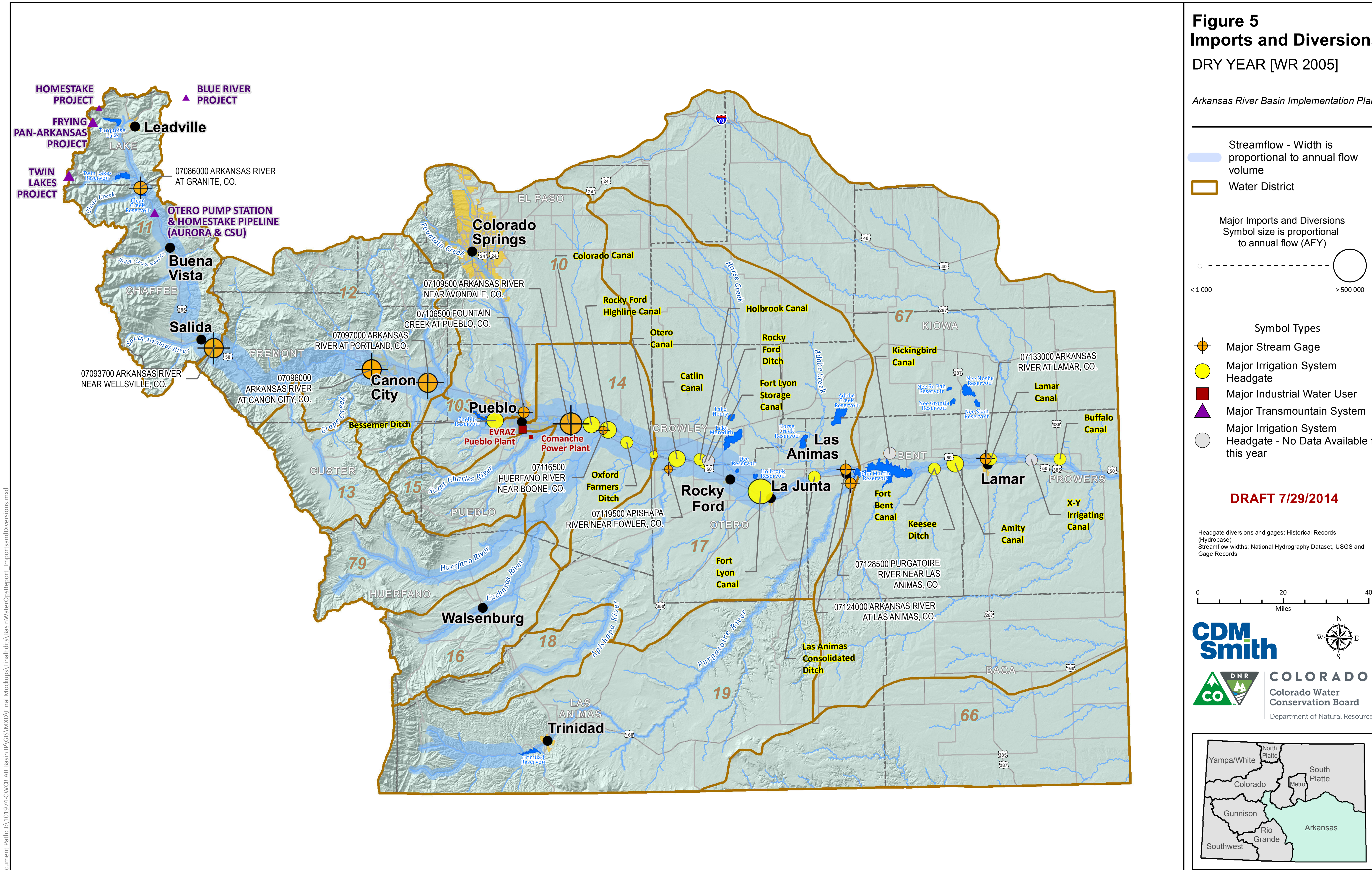


Figure 5
Imports and Diversions

Document Path: J:\101974-CWCB AR Basin IP\GIS\MXD\Final Mockups\FinalEdits\BasinWaterOpsReport_ImportsandDiversions.mxd

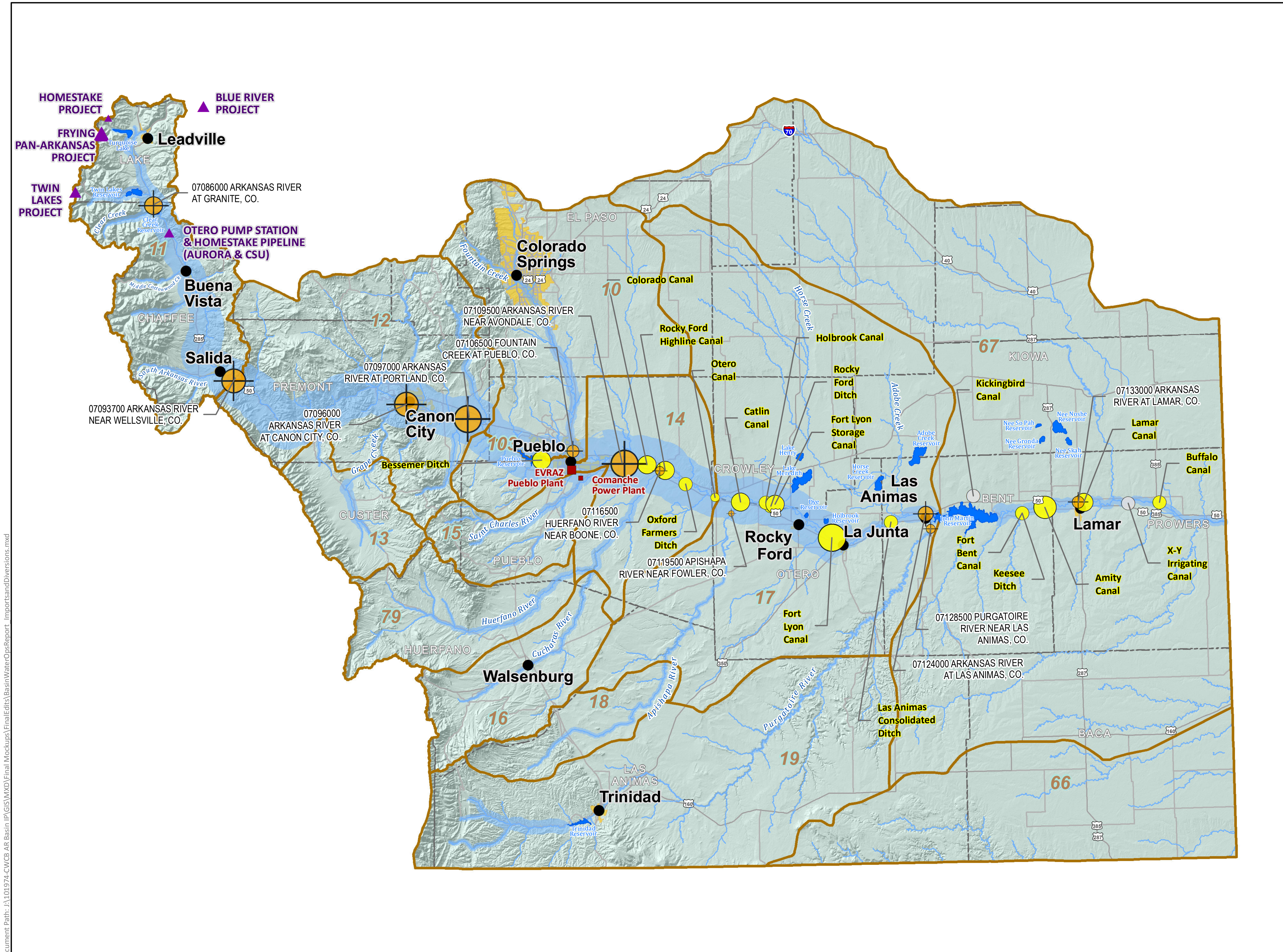


Figure 6
Imports and Diversions

AVERAGE YEAR [WR 2010]

Arkansas River Basin Implementation Plan

Streamflow - Width is proportional to annual flow volume

Water District

Major Imports and Diversions
Symbol size is proportional to annual flow (AFY)

< 1 000 ---------- > 500 000

Symbol Types

- Major Stream Gage
- Major Irrigation System Headgate
- Major Industrial Water User
- Major Transmountain System
- Major Irrigation System Headgate - No Data Available for this year

DRAFT 7/29/2014

Headgate diversions and gages: Historical Records (Hydrobase)
Streamflow widths: National Hydrography Dataset, USGS and Gage Records

0 20 40
Miles

CDM Smith

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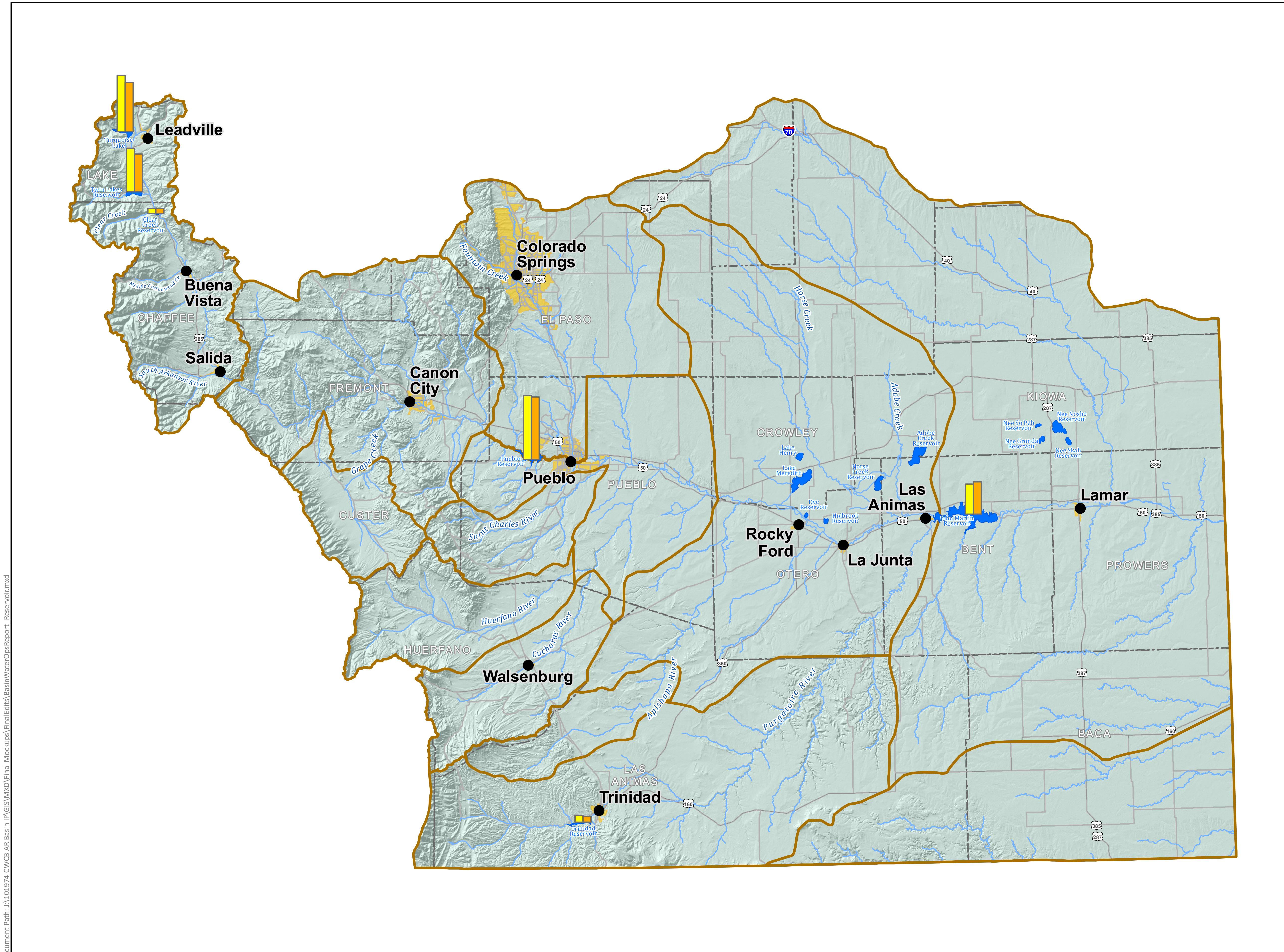
Colorado Water Conservation Board
Department of Natural Resources

Yampa/White, North Platte, South Platte, Colorado, Metro, Gunnison, Rio Grande, Southwest, Arkansas

Figure 7
Reservoir Storage and Release

WET YEAR [WR 2011]

Arkansas River Basin Implementation Plan



Water District

Reservoir Annual Flow (AFY)

49,000

Capture

Release

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0 20 40
Miles

CDM Smith

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Colorado Water Conservation Board
Department of Natural Resources

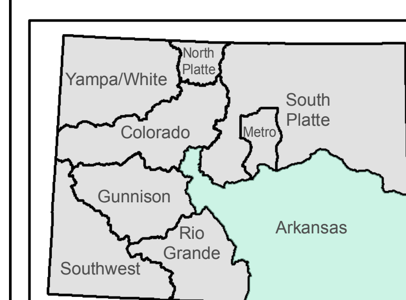
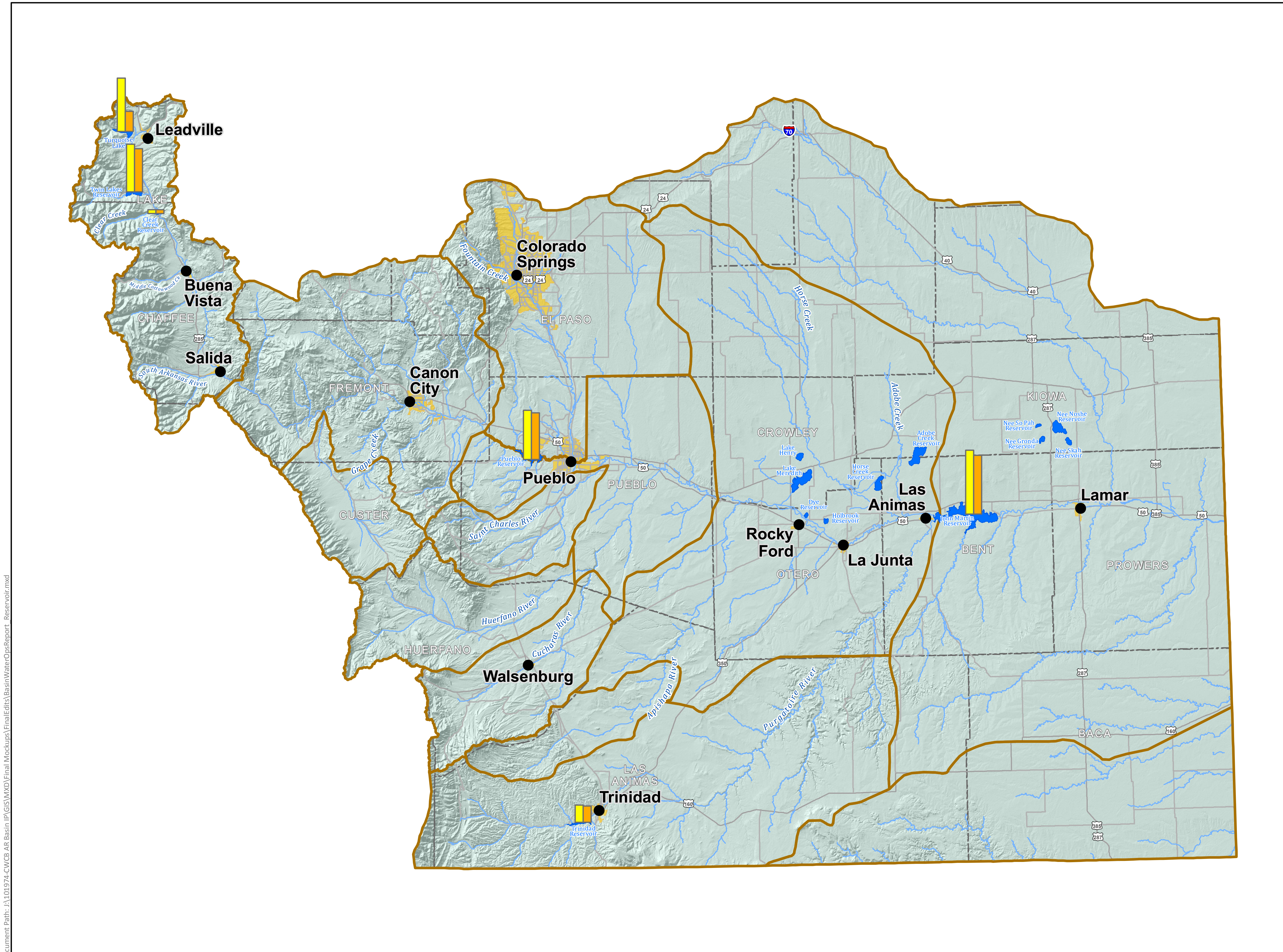


Figure 8
Reservoir Storage and Release

DRY YEAR [WR 2005]

Arkansas River Basin Implementation Plan



Water District

Reservoir Annual Flow (AFY)

39,000

Capture

Release

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0 20 40 Miles

CDM Smith

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Colorado Water Conservation Board
Department of Natural Resources

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Colorado
Metro
Gunnison
Rio Grande
Arkansas
Southwest

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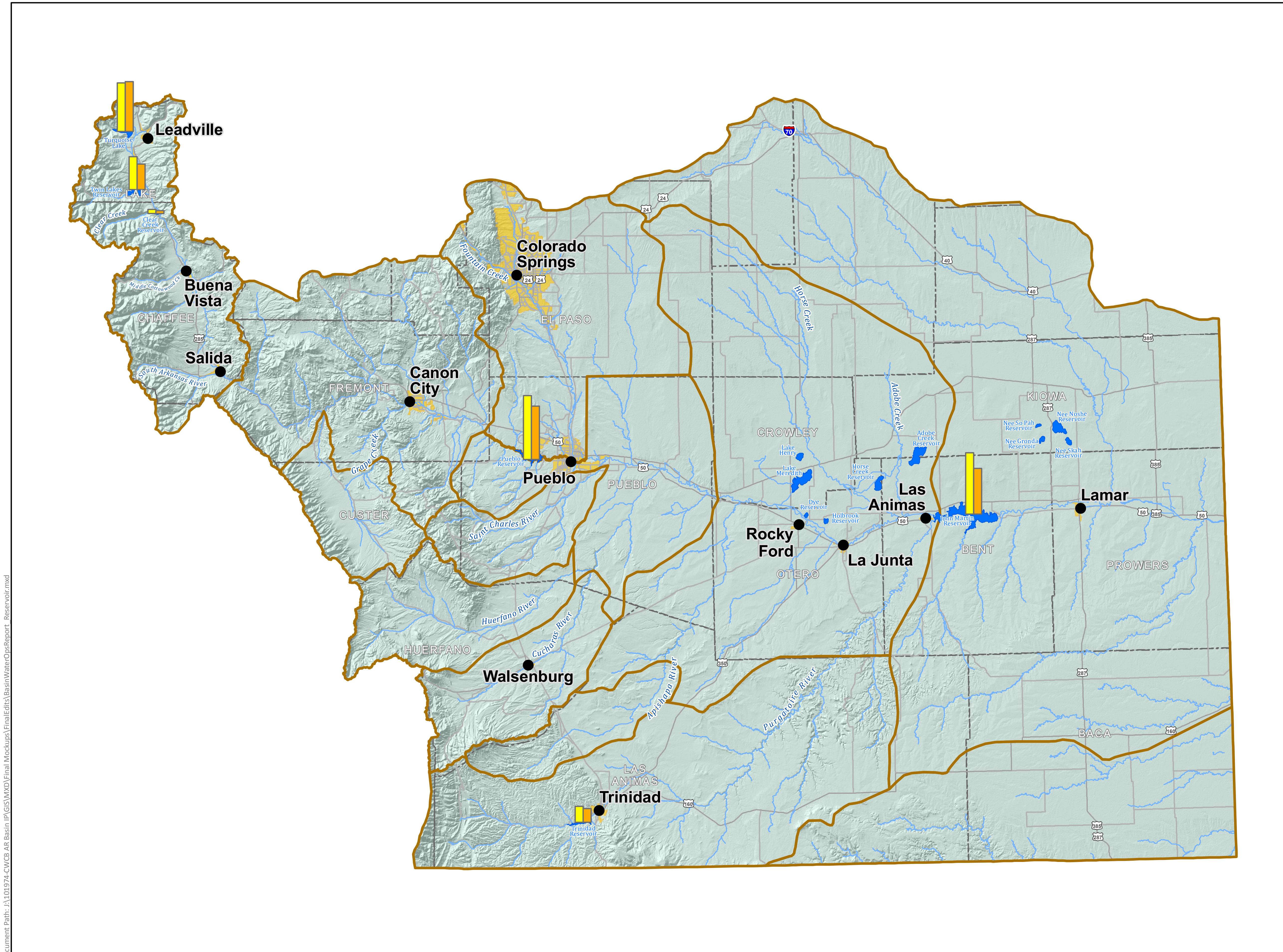

Figure 9
Reservoir Storage and Release

AVERAGE YEAR [WR 2010]

Arkansas River Basin Implementation Plan

Water District

Reservoir Annual Flow (AFY)

45,000

Capture

Release

DRAFT 7/29/2014

0 20 40
Miles

CDM Smith

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Colorado Water Conservation Board
Department of Natural Resources

Yampa/White
North Platte
South Platte
Colorado
Metro
Gunnison
Rio Grande
Arkansas
Southwest

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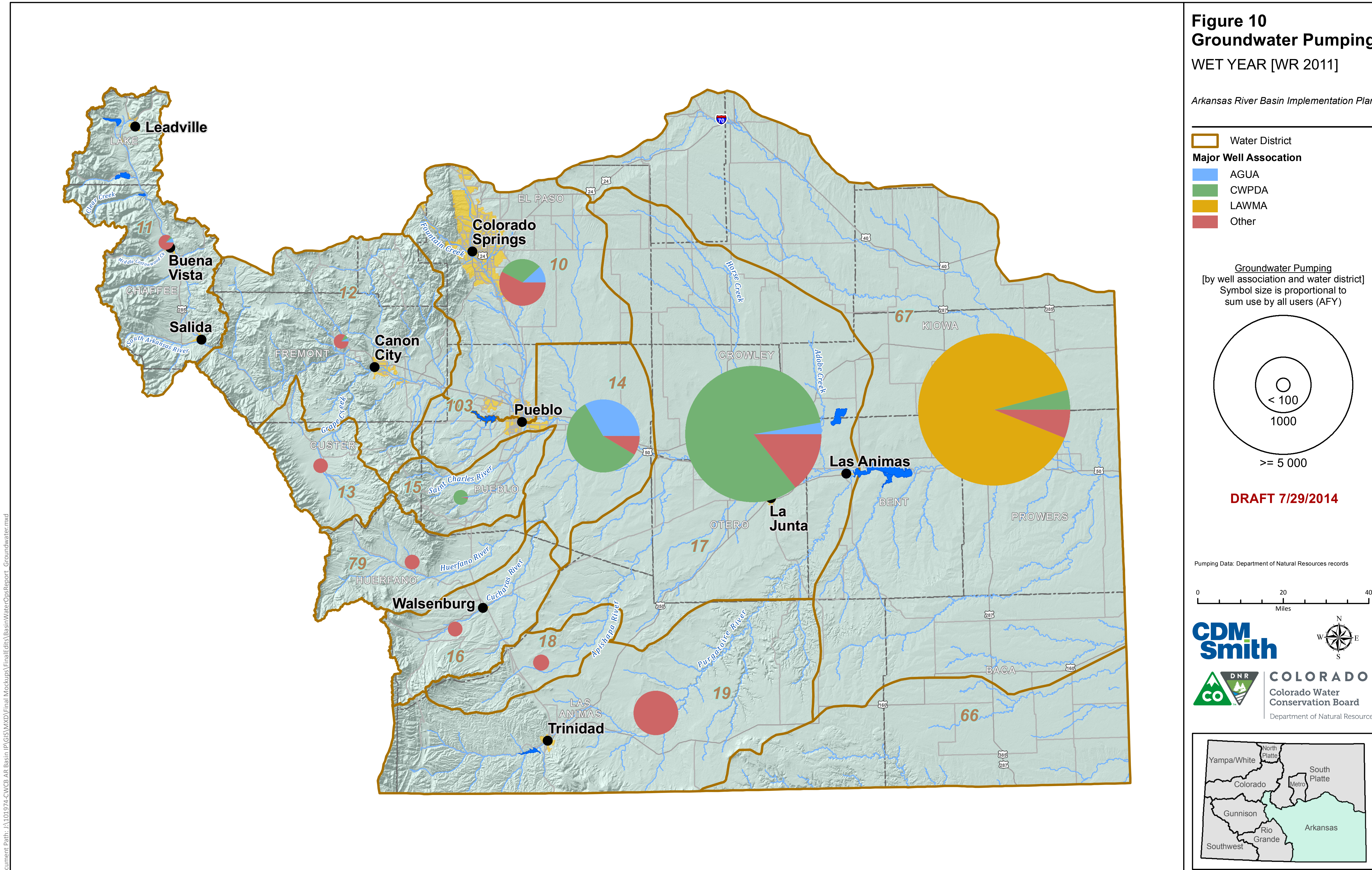

Figure 10
Groundwater Pumping
WET YEAR [WR 2011]

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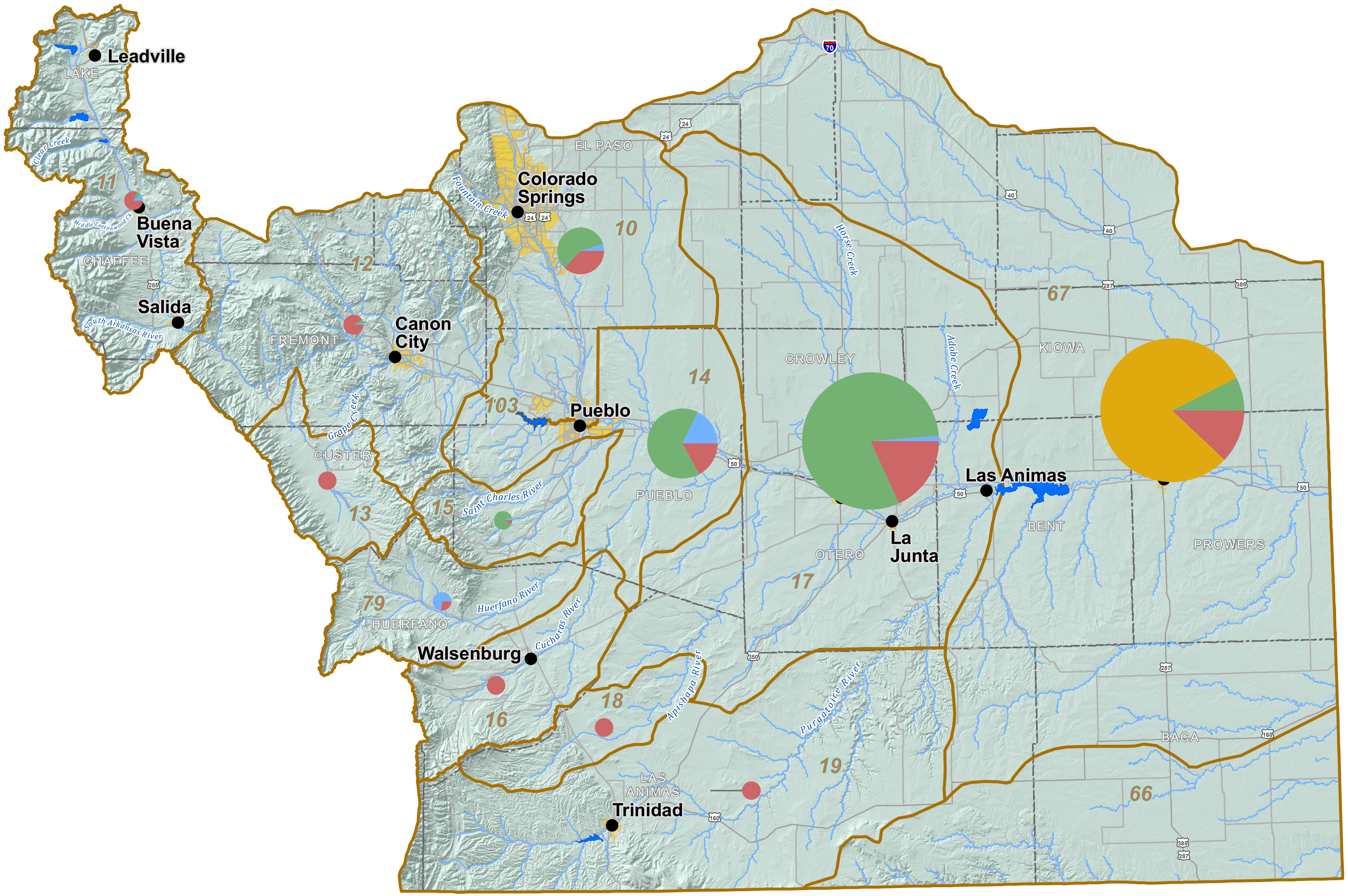


Figure 11
Groundwater Pumping

DRY YEAR [WR 2005]

Arkansas River Basin Implementation Plan

Water District

Major Well Assocation

- AGUA
- CWPDA
- LAWMA
- Other

Groundwater Pumping
[by well association and water district]
Symbol size is proportional to
sum use by all users (AFY)

< 100
1000
>= 5 000

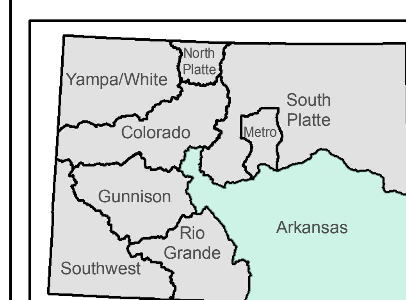
DRAFT 7/29/2014

Pumping Data: Department of Natural Resources records

0 20 40
Miles

CDM Smith

COLORADO
Colorado Water Conservation Board
Department of Natural Resources



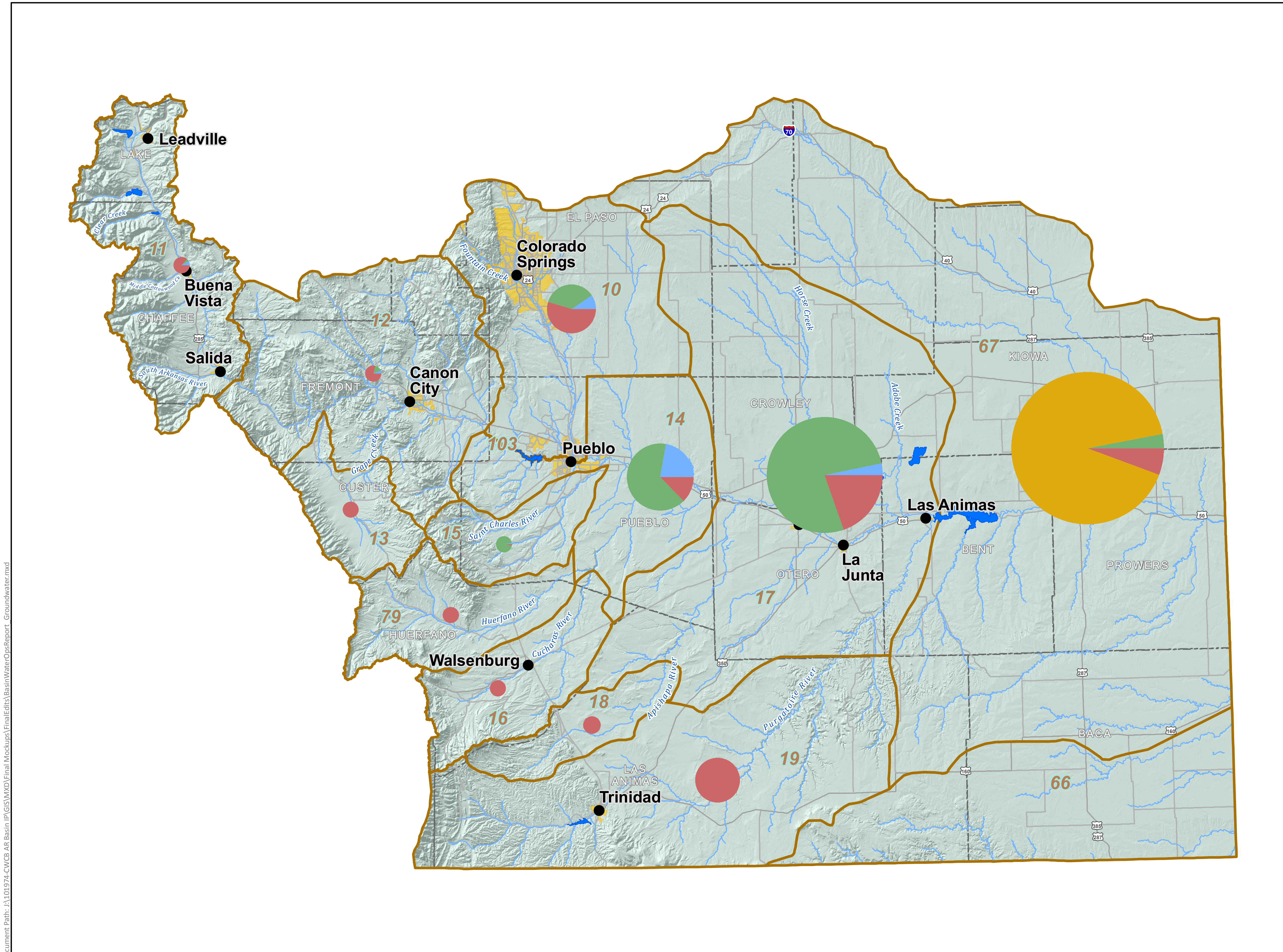


Figure 12
Groundwater Pumping

AVERAGE YEAR [WR 2010]

Arkansas River Basin Implementation Plan

Water District

Major Well Assocation

- AGUA
- CWPDA
- LAWMA
- Other

Groundwater Pumping
[by well association and water district]
Symbol size is proportional to
sum use by all users (AFY)

< 100
1000
>= 5 000

DRAFT 7/29/2014

Pumping Data: Department of Natural Resources records

0 20 40
Miles

CDM Smith

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Yampa/White
North Platte
South Platte
Metro
Colorado
Gunnison
Rio Grande
Arkansas
Southwest

Document Path: J:\101974-CWCB AR Basin IP\GIS\MXD\Final Mockups\FinalEdits\BasinWaterOpsReport_Groundwater.mxd

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Figures

Tables

3.2. Water Management and Administration in the Arkansas BIP

This report is an overview of the water administration in the Arkansas River Basin (Basin) and is intended to be part of the Basin Implementation Plan (BIP) currently under development by the Arkansas Basin Roundtable (Roundtable). This report will become or be integrated into Section 3 of the Arkansas Basin Implementation Plan (BIP).

3.2.1 Introduction

The purpose of this task is to provide a common understanding of water administration and Arkansas River Compact administration policies. This will aid the Roundtable with a better understanding how these policies impact water use in the Basin.

Water administration in the Basin can be grouped into the following topics:

- Arkansas River Compact Administration
- Surface Water Administration
- Groundwater Administration

This document is not intended to provide legal guidance or advice but to rather summarize the statutes, policies, and rules and regulations that impact water administration and use as it relates to water resource operations in the Basin.

3.2.2 Arkansas River Compact

Background

The history of litigation between Kansas and Colorado with respect to the flows of the Arkansas River extends back to early 1900s when Kansas sued Colorado in the U.S. Supreme Court in the case referred to as **Kansas v. Colorado** (1907). Kansas sought to have Supreme Court apportion the waters of the Arkansas River. The Supreme Court ruled that Kansas did not show that there was any economic damage to Kansas but did state that "there will come a time when Kansas may justly say there is no longer an equitable division of benefits and may rightfully call for relief." This decision did provide important guidance to all states sharing a river basin that there should be an equitable apportionment of the water supplies of that river.

In 1928 Colorado filed a complaint with the U.S. Supreme Court in a case referred to as **Colorado v. Kansas** (1943). This litigation was intended to settle a series of lawsuit filed by Kansas irrigators beginning in 1910 to attempt to adjudicate interstate priorities for waters of the Arkansas River. There were negotiations among the states with respect to a compact but no success was reached. The Special Master assigned to the case submitted his report to the Supreme Court in May of 1943 with recommendations. The Supreme Court did not adopt the Special Master's recommendations and found that:

- Colorado should not be subject to future litigation from Kansas irrigators.
- It denied Kansas demand for an apportionment of the water of the Arkansas River.
- The Supreme Court strongly advised the states to settle future disputes through negotiations of an interstate compact.

The states agreed to initiate compact negotiations in 1945 and appointed commissioners to represent each state. Congress in 1945 passed legislation granting both states the right to negotiate compact including the operations of John Martin Reservoir that was nearing completion. The reservoir was constructed by the Army Corps of Engineers and construction began on the dam in August of 1940. Hans Kramer, retired Brigadier General, was appointed as the federal representative. After intensive negotiations, the compact was signed on December 14, 1948. It was approved by both state legislatures and the U.S. Congress in 1949.

Arkansas River Compact Features and Administration

The Arkansas River Compact does not have a quantifiable allocation of water to either state unlike other compacts that Colorado entered into and have one of the following quantifiable features:

- A delivery obligation at the Stateline such as in the Rio Grande Compact or the La Plata River Compact.
- An allocation of consumptive use among the states as in the Colorado River Compacts and the Republican River Compact.
- The operation of a common water rights administration system across the Stateline such as the Costilla Creek compact and the South Platte River Compact.

Instead the Arkansas River Compact limited the future development (post compact) in Colorado and Kansas so as to not deplete the usable flow of the river above the Stateline to the detriment of precompact water rights in each state. The key provision is Article IV D. which states:

> This compact is not intended to impede or prevent future beneficial development of the Arkansas River basin in Colorado and Kansas by federal or state agencies, by private enterprise, or by combinations thereof, which may involve construction of dams, reservoirs and other works for the purposes of water utilization and control as well as the improved or prolonged functioning of existing works: Provided, that the waters of the Arkansas River shall not be materially depleted in usable quantity or availability for use to the water users in Colorado and Kansas under this compact by such future development or construction.

Thus, the compact is basically protecting existing development as of 1948 including John Martin Reservoir from any material depletion by post compact activities or development. At times of high flow when all precompact water rights and John Martin Reservoir are satisfied, it may be possible to divert under a post compact water right. This has only occurred five times since 1954.

The compact provides for the storage of water in John Martin Reservoir commencing on November 1 and continuing to March 31 of the following year and is referred to as winter storage. The water can be released at the rate of up to 750 cfs for Colorado users and up to 500 cfs for Kansas water users which is a 60/40 division of the water stored. The compact allows either state to call for water from storage beginning April 1. If the content of John Martin Reservoir is less than 20,000 ac-ft, the release rates are reduced to 600 cfs for Colorado water users and 400 cfs for Kansas water users.

Summer storage is also allowed in John Martin Reservoir provided Colorado is not administering water rights below John Martin Reservoir. Any summer stored water is to be released on the same 60/40 ratio as for winter stored water.

The compact is administered by a seven member compact administration with a non-voting federal representative appointed by the President acting as chair person and with three members appointed by the Governor of each respective state. Each state has only one vote on any compact action and thus to approve any action requires unanimous approval of the compact administration.

The states often would call for releases of winter stored water shortly after April 1 and the reservoir was often drawn down before the irrigation season was very far along. This "race" to use the water at the rate of releases set forth in the compact led to the compact administration amending the operations in 1980 by allocating the water stored in John Martin Reservoir based on volume with Colorado receiving 60 percent and Kansas 40 percent. The water could be released when any state desired and can be carried over if desired. Colorado ditches are allocated a fixed percentage of the Colorado allocation and have separate accounts in the reservoir. The amendment of the operations was accomplished by the compact administration approving the "Resolution Concerning an Operating Plan for John Martin Reservoir" on April 24, 1980 and is referred to as the 1980 Operating Plan. This change in operation allowed for better management and use of the waters stored in the reservoir. The Division Engineer for Water Division 2 is required to give an accounting of the operations under the plan no later than December 1 of each year.

The compact administration also approved a resolution in 1976 creating a permanent pool of 10,000 ac-ft for the purposes of fish, wildlife, and recreation in John Martin Reservoir. The pool is to be filled by Colorado water rights owned by the Colorado Division of Parks and Wildlife. The pool will be charged its prorata share of evaporation from the reservoir.

Post Compact Water Development

After the compact was signed, there was post compact development related to the construction of large capacity tributary wells along the Arkansas River as described in the Tributary Groundwater Section below. At that time, especially during the drought of the 1950s, it was not recognized that the construction of these wells would impact the flow of the Arkansas River. The number of wells constructed increased until the 1965 Ground Water Management Act as discussed in the Tributary Groundwater Section below. Unfortunately, the number of post compact wells in operation along the

Arkansas River was around 3000. The pumping of these wells were subject to the 1973 use rules until the 1996 amended use rules were adopted.

The Fry-Ark Project including Pueblo Reservoir became operational in 1975 with the completion of Pueblo Dam. The project was authorized to store water imported from the Colorado River Basin and to store water in the enlarged Turquoise Reservoir and the enlarged Twin Lakes Reservoir as well as Pueblo Reservoir. As described in the Winter Water Storage Section below, the Fry-Ark Project authorizing legislation included the Winter Water Storage Program, which involves the storage of precompact water rights in Pueblo Reservoir and other existing off-channel reservoirs.

Trinidad Reservoir was completed in 1977 and its primary purposes as set forth in the authorizing federal legislation were:

1. Control of floods originating above the reservoir for the benefit of the City of Trinidad and downstream reaches.
2. Optimum beneficial use of available water for irrigation and municipal and industrial use through:
   a) Transfer of the storage decree in the Model Reservoir for 20,000 ac-ft annually.
   b) Storage of flood flows which would otherwise spill from John Martin Reservoir
   c) Storage of winter flows that were historically diverted for winter irrigation of project lands.
3. Maintenance of a minimum pool for fishery and wildlife enhancement values.

Litigation with Kansas over Post Compact Development

In 1985, Kansas filed a request with the U.S. Supreme Court for permission to file a lawsuit against Colorado over compliance with the Arkansas River Compact and specifically the post compact development described previously. Kansas alleged that the operation of post compact wells, the Winter Water Storage Program, and the operation of Trinidad Reservoir had violated the compact. The Supreme Court granted Kansas' motion to file a complaint in March of 1986.

The trial was bifurcated into a liability phase and a remedy phase. The liability phase of the trial commenced on September 17, 1990 in front of Special Master Arthur Littleworth and concluded on December 16, 1992. The Special Master issued his report with recommendations to the Supreme Court in July of 1994. He recommended a finding that the increase of groundwater pumping in Colorado had caused serious depletions of usable Stateline flow in violation of Article IV-D of the compact. He also recommended a finding that Kansas did not prove that the operation of the Winter Water Storage Program had caused material depletions of Stateline flow. He also recommended dismissal of the claim concerning Trinidad Reservoir. Both states filed exceptions to the report and a hearing was held in front of the Supreme Court. The Supreme Court overruled the exceptions on May 15, 1995.

Subsequent hearings in front of the Special Master resulted in a final determination that the depletions to usable Stateline flow from 1950 through 1996 were 428,005 ac-ft. The economic damages to Kansas based on these depletions was also determined and found to be $34,615,146, which Colorado paid to Kansas on April 29, 2005.

As a result of the first report of the Special Master in July of 1994, the State Engineer adopted amended groundwater use rules in 1996 as described in the previous section. The Special Master was impressed with Colorado's efforts to come into compliance with the compact and so stated in his second report to the Supreme Court in 1997. Based on the opinions of Colorado's experts, the Special Master also recommended that compact compliance be determined using the H-I Model over a 10-year moving period to smooth out annual variations in the model's operation. The Supreme Court agreed with this recommendation and the first 10-year period was 1997 to 2006. The results of the model run for this period showed a credit for Colorado and each subsequent 10-year period has shown a credit and no depletions. For the period 2003 to 2012, the credit had grown to 58,708 ac-ft indicating that the amended use rules are in fact working as intended and that Colorado is in compliance with the compact.

Continuing to Comply with the Compact

Colorado has been vigilant in efforts to comply with the compact after the finding about post compact well development and the fiscal impact as a result of the damages awarded Kansas. The Irrigation Improvement Rules discussed in the section below are an example of this effort to not allow irrigation system improvements to cause an additional depletion to Stateline flows.

The storage of water in post compact reservoirs using post compact water rights continues to be closely monitored and prohibited by the Division Engineer. New reservoirs can only store water from transbasin sources or from changed precompact water rights that allow the water from these water rights to be fully consumed including return flows from a previous use such as municipal sewage effluent. Water from nontributary groundwater sources can also be stored in a new reservoir or an existing post compact reservoir.

3.2.3 Surface Water Administration

Surface water in the Basin is administered separately but in conjunction with groundwater to be in accordance with Colorado water law and compact administration. Colorado administers water rights according to the Doctrine of Prior Appropriation, first in time, first in right, which gives older senior water rights priority over newer junior water rights when water is not available to the senior water right.

Doctrine of Prior Administration

A water right in Colorado is a right to use, in accordance with its priority, a certain portion of the waters of the state by reason of appropriation. Appropriation is the application of a specified portion of the waters of the state to a beneficial use. A water right in Colorado arises by application of water to beneficial use and is confirmed by a Water Court decree, which determines the amount and priority of the water right for the purposes of administration by state water officials. The appropriation date (date of first use) of each water right generally establishes the "rank" or priority of the right, the first right (the senior right) having priority over those rights that are later in time (junior rights). There is an exception to this general principle if a water right was not adjudicated in the first possible adjudication, it will have a lower priority than any water right adjudicated in the prior adjudication even if its appropriation date is older than any other water right in the prior adjudication. Therefore, the priority of a water right is based on the date of first use and the date of adjudication. Decrees for diversions for direct use are approved as a rate in cubic feet per second (cfs); decrees for storage rights are approved as a volume in acre-feet (ac-ft). Water rights are administered by the State Engineer, division engineers, and water commissioners based on the priority of each water right in accordance with the decrees of the Colorado courts and applicable laws, including interstate compacts.

Streamflow Data

In order to administer surface water in Colorado and the Basin, data on streamflow is required in order to make administrative decisions regarding specific surface water diversions that are allowed to divert water according to their priority.

Data on water availability is obtained via several different methods and stored in a centralized water resources database, HydroBase. Streamflows are obtained and recorded at numerous locations within the Basin to assist the water commissioners and division engineer in administering water rights within the Basin. The Hydrography and Satellite Monitoring branch of the Division of Water Resources (DWR) operates and maintains many key stream gages that are at specific locations to support water rights administration. In addition, the U.S. Geological Survey (USGS) operates and maintains other stream gages in conjunction with cooperators that are also used by the DWR to monitor streamflow at other locations within the Basin.

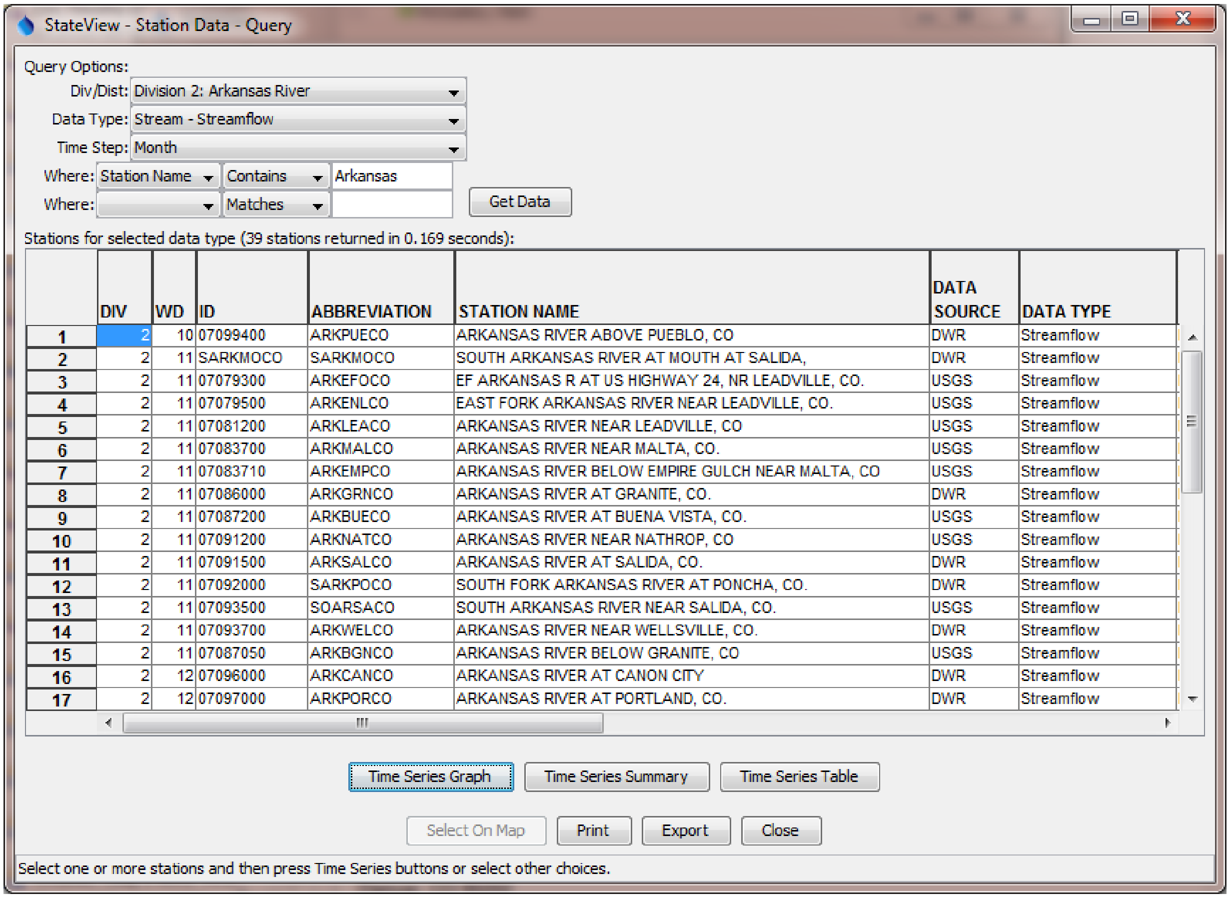
Colorado is the only state in the U.S. that operates its own hydrographic program in order to have the stream gages it needs for water rights administration and also to not have to rely on the USGS Stream gaging program for data. This saves the DWR funds by not having to pay the USGS for operating the gages since the USGS costs would be higher than what it costs the state to operate its stream gaging program.

HydroBase

The DWR and Colorado Water Conservation Board (CWCB) maintain a central database of water resources data within the State of Colorado called HydroBase. HydroBase contains data on streamflow, diversions, storage, and water rights. It is maintained by DWR and is publically available on the state website. HydroBase is updated annually after the irrigation season ends on October 31.

HydroBase also contains conditional and decreed water rights that can be queried using several various parameters to identify water rights.

Figure 3.2.1 - Screenshot of HydroBase Streamflows (via StateView)

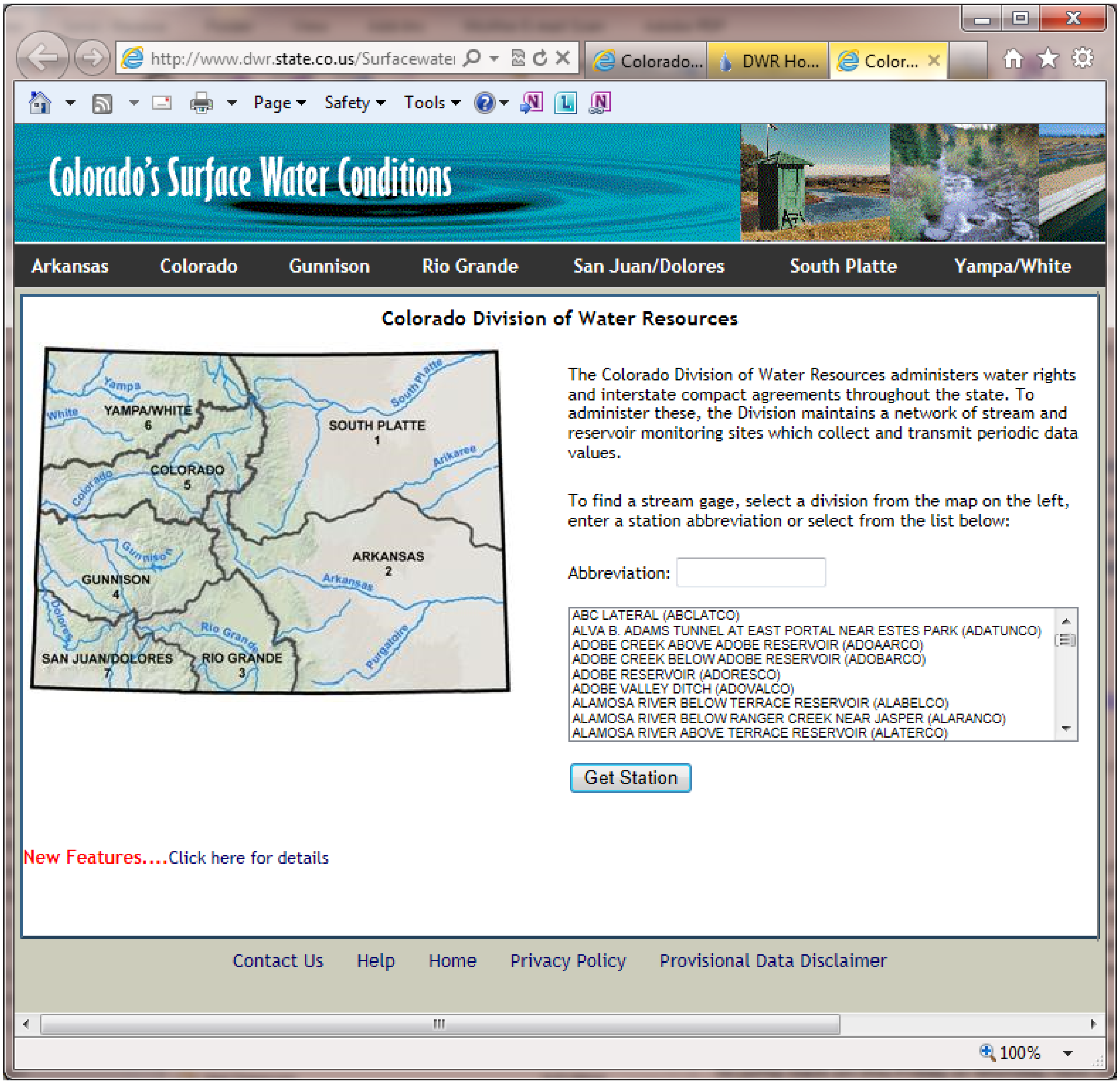


	DIV	WD	ID	ABBREVIATION	STATION NAME	DATA SOURCE	DATA TYPE
1	2	10	07099400	ARKPUECO	ARKANSAS RIVER ABOVE PUEBLO, CO	DWR	Streamflow
2	2	11	SARKMOCO	SARKMOCO	SOUTH ARKANSAS RIVER AT MOUTH AT SALIDA,	DWR	Streamflow
3	2	11	07079300	ARKEFOCO	EF ARKANSAS R AT US HIGHWAY 24, NR LEADVILLE, CO.	USGS	Streamflow
4	2	11	07079500	ARKENLCO	EAST FORK ARKANSAS RIVER NEAR LEADVILLE, CO.	USGS	Streamflow
5	2	11	07081200	ARKLEACO	ARKANSAS RIVER NEAR LEADVILLE, CO	USGS	Streamflow
6	2	11	07083700	ARKMALCO	ARKANSAS RIVER NEAR MALTA, CO.	USGS	Streamflow
7	2	11	07083710	ARKEMPCO	ARKANSAS RIVER BELOW EMPIRE GULCH NEAR MALTA, CO	USGS	Streamflow
8	2	11	07086000	ARKGRNCO	ARKANSAS RIVER AT GRANITE, CO.	DWR	Streamflow
9	2	11	07087200	ARKBUECO	ARKANSAS RIVER AT BUENA VISTA, CO.	USGS	Streamflow
10	2	11	07091200	ARKNATCO	ARKANSAS RIVER NEAR NATHROP, CO	USGS	Streamflow
11	2	11	07091500	ARKSALCO	ARKANSAS RIVER AT SALIDA, CO.	DWR	Streamflow
12	2	11	07092000	SARKPOCO	SOUTH FORK ARKANSAS RIVER AT PONCHA, CO.	DWR	Streamflow
13	2	11	07093500	SOARSACO	SOUTH ARKANSAS RIVER NEAR SALIDA, CO.	USGS	Streamflow
14	2	11	07093700	ARKWELCO	ARKANSAS RIVER NEAR WELLSVILLE, CO.	DWR	Streamflow
15	2	11	07087050	ARKBGNCO	ARKANSAS RIVER BELOW GRANITE, CO	USGS	Streamflow
16	2	12	07096000	ARKCANCO	ARKANSAS RIVER AT CANON CITY	DWR	Streamflow
17	2	12	07097000	ARKPORCO	ARKANSAS RIVER AT PORTLAND, CO.	DWR	Streamflow

Satellite Monitoring System

Another important function of administration is having accurate, timely and reliable data on streamflow. The Satellite Monitoring System (SMS), operated by the Hydrography and Satellite Monitoring branch, provides near real-time gaging station data on streamflow, reservoirs and selected canal diversions at approximately 240 locations in the Basin. Most of this data is reported every hour so it is truly near real time. This near real-time data can be retrieved via the DWR's Surface Water Conditions page (http://www.dwr.state.co.us/Surfacewater/default.aspx), Figure 3.2.2.

Figure 3.2.2 - Screenshot of DWR's Surface Water Conditions



Water Rights Administration

The primary utility of the Colorado's SMS is for water rights administration. The availability of real-time data from a network of key gaging stations in each major river basin in Colorado provides an overview of the hydrologic conditions of the basin that was previously not available. By evaluating real-time data for upstream stations, downstream flow conditions can typically be predicted 24 to 48 hours in advance. This becomes an essential planning tool in the hands of the Division Engineers and Water Commissioners. The "river call" can be adjusted more precisely to satisfy as many water rights as possible, even if just for short duration flow peaks caused by precipitation events. Access to real-time data makes it possible to adjust the "river call" to match dynamic hydrologic conditions. If additional water supplies are available in a basin, more junior rights can be satisfied. On the other hand, if water supplies decrease, then water use can be curtailed to protect senior rights.

The administration of water rights in Colorado is becoming increasingly more complex due to increased demands, implementation of augmentation plans, water exchanges, transbasin diversions, and minimum stream flow requirements. For example, the number of water rights in Colorado has increased from 102,028 in 1982 to over 173,000 in 2007. Increasing numbers of water rights has continued to the present. Water rights transfers approved by the water courts are becoming increasingly complex. This is especially evident where agricultural water rights are transferred to municipal use.

There is considerable interest in monitoring transbasin diversions, both by western slope water users and the eastern slope entities diverting the water. Transbasin diversion water is administered differently than water originating in the basin. In general, this water may be claimed for reuse by the diverter until it is totally consumed. Forty transbasin diversions are monitored by the SMS.

Water exchanges between water users or between specific locations are becoming increasingly frequent. These exchanges can provide for more effective utilization of available water resources in high demand river basins, but can be difficult to administer. The satellite-linked monitoring system has proven to be an integral component in monitoring and accounting of these exchanges.

Many municipalities and major irrigation companies have reservoir storage rights. Generally, these entities can call for release of stored water on demand. The Division Engineer must be able to delineate the natural flow from the storage release while in the stream. He/she then must track the release and ensure that the proper delivery is made. The SMS has demonstrated to be effective in this area.

The utility of the SMS in the administration of interstate compacts is an especially important application. Data collected from over 20 gage stations operated by both the Colorado DWR and the USGS are incorporated in the statewide monitoring network and utilized for the effective administration of interstate compacts.

The majority of the large, senior water rights in Colorado belong to irrigation companies. These rights are often the calling right in the administration of a water district. The direct diversion rights exercised can affect significantly the hydrology of the river. Dozens of major irrigation diversions are monitored by the system.

Instream flow water rights have been appropriated by the CWCB to provide minimum instream flows (ISF) in critical stream reaches around the state. These ISF water rights are junior water rights and cannot prevent a senior water right from reducing the flow below the minimum amount appropriated; however, these ISF water rights can protect a stream reach from diversions by junior water rights or from a reach being impacted by a change in use of a senior water right. The availability of real-time data is essential in ensuring that these minimum stream flows are protected to the extent of the law.

Hydrologic Records Development

Specialized software programs provide for the processing of raw hydrologic data on a real-time basis. Conversions such as stage-discharge relationships and shift applications are performed on a real-time basis as the data transmissions are received. Mean daily values are computed automatically each day for the previous day. Data values that fall outside of user defined normal or expected ranges are flagged appropriately. Flagged data values are not utilized in computing mean daily values. Missing values can be added and invalid data values corrected by the respective hydrographer for that station using data editing functions.

Data can be retrieved and displayed in various formats including the standardized USGS-Water Resources Division annual report format adopted by the Colorado DWR for publication purposes. An advantage of real-time hydrologic data collection is in being able to monitor the station for ongoing valid data collection. If a sensor or recorder fails, the hydrographer is immediately aware of the problem and can take corrective action before losing a significant amount of data.

It is essential to understand that real-time records can be different from the final record for a given station. This can be the result of editing raw data values because of sensor calibration errors, sensor malfunctions, analog-to-digital conversion errors, or parity errors. The entering of more current rating tables and shifts can modify discharge conversions. Corrections to the data are sometimes necessary to compensate for hydrologic effects such as icing. Human error can also result in invalid data. The final record for those gaging stations operated by nonstate entities, such as the USGS-Water Resources Division, is the responsibility of that entity. Modifications to the real-time records for these stations are accepted by the State of Colorado.

The Hydrography Branch develops historic streamflow records in coordination with other state and federal entities and the water user community. At the conclusion of each water year, the State Engineer's Office compiles streamflow information and measurements conducted throughout the year for publication. Published streamflow records describe the mean daily discharge, the instantaneous maximum, lowest mean discharge, and monthly/ annual volumetric totals for a specific location on a river or stream. These annual streamflow records are computed using two critical sources of information: streamflow measurements made throughout the water year to calibrate the stage-discharge relationship at a specific site, and the electronic record of stream stage collected by the satellite monitoring system. Using these data, a continuous record of streamflow for the water year is computed. Streamflow records undergo a rigorous data quality control/quality assurance program to ensure the product is accurate. The DWR Hydrographic program computes and publishes over 240 streamflow, reservoir, and canal diversion records annually in the Basin. Published historical streamflow data are extremely valuable in support of water resources planning and management decision-making, assessment of current conditions and comparisons with historical flow data, and hydrologic modeling.

Water Resources Accounting

Currently, the satellite-linked monitoring system is being utilized for accounting for the Colorado River Decision Support System (CRDSS), the Colorado-Big Thompson Project, the Dolores Project, and the Fryingpan-Arkansas (Fry-Ark) Project Winter Water Storage Program among others around the state. The ability to input real-time data into these accounting programs allows for current and ongoing tabulations.

Dam Safety

Dam safety monitoring has developed in recent years into a major issue. Numerous onsite parameters are of interest to the State Engineer in assessing stability of a dam. At this time, the system monitors reservoir inflow, water surface elevation, and reservoir release or outflow at more than 50 reservoirs in Colorado. These data provide a basis for evaluating current operating conditions as compared to specific operating instructions. The installation and operation of additional sensor types could provide essential data on internal hydraulic pressure, vertical and horizontal movement, and seepage rates.

Exchanges

Water exchanges (exchanges) are an important component of surface water administration and water management. Exchanges allow a water user/provider to move water upstream to a point of diversion or reservoir. A water exchange is accomplished by diverting water at one point in a river basin and replacing that water with a like quantity released from a reservoir or from a source that can legally be used for this purpose, which could include transbasin diversions, transbasin diversion return flows, or fully consumable water from a change in use of senior irrigation water rights.

An exchange has a priority among other exchanges based on the date it was first implemented and can be adjudicated by the water court to establish a priority for administration with other exchanges that may be occurring in a reach of the river. Exchanges cannot operate if injury to other water rights would occur and the Division Engineer and water commissioners must carefully administer exchanges to prevent injury.

An example of a simple exchange would be the operations under the Holbrook Canal located on the north side of the Arkansas River near Manzanola. The Holbrook Canal has two reservoirs—Dye and Holbrook Reservoir—that are filled with water from the canal and are located downgradient from the canal so water cannot be released to serve lands under the canal. The reservoir water is released to the Arkansas River to meet the demands of senior downstream water rights and a like amount of water is diverted (exchanged) upstream at the Holbrook Canal headgate to irrigate lands under the canal. The Colorado Canal also has exchanged water from Lake Meredith to its headgate to allow the stored water to be used to serve the lands under the canal.

An example of a more complex exchange is where transbasin return flows from the Colorado Springs wastewater treatment plant in Fountain Creek at the confluence of the Arkansas River are exchanged upstream to Pueblo Reservoir. This water is not native water to the Basin and can be legally reused to complete extinction so it becomes the source of water for the exchange by having this quantity of water flow downstream to meet a senior demand and a like amount of water is stored in Pueblo Reservoir by exchange. Again the Division Engineer and water commissioners must carefully administer the exchange to prevent injury to other water rights.

There are several exchanges of water from the Arkansas River below Pueblo Reservoir upstream to storage in Pueblo Reservoir or even higher upstream to Twin Lakes Reservoir, Turquoise Reservoir, Clear Creek Reservoir, or to the Otero Pumping Plant near Buena Vista for diversion from the Arkansas River by Aurora or Colorado Springs. These exchanges are all decreed by the water court and are operated by Colorado Springs Utility, the Pueblo Board of Water Works, Aurora Water as well as other utilities to a smaller degree. Table 3.2.1 (Table 2, AVC FEIS, Appendix D.1) provides an example of the number and priorities of exchanges from the Arkansas River below Pueblo Reservoir to the reservoir.

Table 3.2.1 - Major Arkansas River Exchange Priorities into Pueblo Reservoir

<table>
<tr><th>Priority</th><th>Beneficiary</th><th>Amount</th><th>Case</th><th>Priority Date</th></tr>
<tr><td>1</td><td>Southeastern</td><td>(1)</td><td>B42135, 88CW143, 84CW56</td><td>2/10/1939</td></tr>
<tr><td>2</td><td>Board of Water Works Pueblo</td><td>27 cfs</td><td rowspan="10">83CW18, 84CW62, 84CW63, 84CW64, 84CW35, 84CW202, 84CW203, 84CW177, 84CW178</td><td rowspan="10">6/5/1985</td></tr>
<tr><td>3</td><td>Colorado Canal Company Agricultural Entities</td><td>100 cfs</td></tr>
<tr><td rowspan="2">4</td><td>Board of Water Works Pueblo</td><td>50 cfs</td></tr>
<tr><td>Colorado Canal Companies</td><td>50 cfs</td></tr>
<tr><td>5</td><td>Colorado Canal Companies</td><td>50 cfs</td></tr>
<tr><td>6</td><td>Colorado Springs</td><td>77 cfs minus Board of Water Works of Pueblo Exchange under #2 and #4</td></tr>
<tr><td>7</td><td>City of Aurora</td><td>Applicable Maximum Rate of Flow Allowed by Decree in 83CW18</td></tr>
<tr><td>8</td><td>Colorado Springs</td><td>100 cfs minus Colorado Springs Exchange under #6</td></tr>
<tr><td rowspan="2">9</td><td>Colorado Canal Companies</td><td>1/2 of remaining exchange potential up to 756 cfs</td></tr>
<tr><td>Colorado Springs</td><td>1/2 of remaining exchange potential minus Rocky Ford I under #9</td></tr>
</table>

Priority	Beneficiary	Amount	Case	Priority Date
	City of Aurora	Up to 40 cfs of 1/2, but not to exceed 500 ac-ft annually; thereafter 25% of 1/2 up to an additional 500 ac-ft annually		
10	Colorado Springs	William Creek Reservoir		
11	Pueblo West	6.0 cfs (measured return flows)	85CW134A	12/31/1985
12	City of Aurora (Rocky Ford II)	Applicable Maximum Rate of Flow Allowed by Decree in 99CW169)	99CW169	12/28/1999
13	City of Pueblo	(2)	01CW160	5/15/2000
	City of Fountain	60 cfs	01CW108, 01CW146	(4)
	Southeastern	50 cfs (3)	01CW151	(4)
	Pueblo West	100 cfs	01CW152	(4)
14	Aurora – Rocky Ford Highline	500 cfs	05CW105	(4)
15	Southeastern	Varies	06CW8	(4)
	Restoration of Yield Storage – Holbrook Reservoir	2,000 cfs	06CW120	(4)
16	Super Ditch	Varies	10CW4	(4)
17	Other currently undecreed exchanges, including return flows originating from nontributary groundwater	(5)	(5)	(5)

Notes:
(1) Measured Municipal Fry-Ark Return Flows generated and re-purchased by the same entity.
(2) See discussion on Pueblo Flow Management Program in below sections.
(3) Non-measured Municipal and Agricultural Fry-Ark Return Flows.
(4) Priority yet to be determined.
(5) No water rights application or decree.

Reservoir Storage

Reservoir storage plays an important role in meeting Colorado's water supply needs. Colorado is a headwaters state, meaning that all the water supplies Colorado has falls in the form of precipitation (rain or snow). The timing of runoff plays a key role in water resources planning. To mitigate the runoff pattern (70 percent of annual runoff volume occurring in 3 months) to better match water supply needs both within a year and inter year, many reservoirs have been constructed within the state. Reservoirs have been constructed by various entities and for a variety of purposes including water supply, power generation, recreation, and flood protection.

Pursuant to section 37-87-101, C.R.S., the right to store water for later use is recognized as a beneficial use of water under the Colorado statutes. The structure must be operated in such a manner as to not cause material injury to other water users. Water in Colorado at a time of demand can only be stored when there is a water right to store the water. Storage water rights are obtained in a similar process to direct flow rights and assigned a priority so that they can be administered according to the prior appropriation system.

One Fill Rule

Water may either be stored under a water right under the priority system or in some situations contractually—for instance a user may be able to store reusable water in a reservoir. The one fill rule concerns the storage of water under the priority system. Under Colorado law, a water user may store water whenever the water is physically available, its water right is in-priority, and the decree for the water right has not been filled. Under Colorado Supreme Court decisions, a user is entitled to only one filling of a reservoir water right in any one year unless a user has a water right that provides for a refill and/or additional storage or free river conditions exist (i.e., no downstream shortage of water to meet the demands of all users for their decreed water rights including storage in John Martin Reservoir pursuant to the Arkansas River compact).

Carryover

Generally, any water remaining in a reservoir at the end of the seasonal year is called "carryover water," and is credited to the next year's fill. This will limit the amount of new water to be put into storage during next year's seasonal year. For example, if a reservoir's decreed and physical capacity is 100,000 ac-ft and at the end of seasonal year 1 it contains 60,000 ac-ft, then the carryover would be 60,000 ac-ft for the next year, seasonal year 2. In this situation, the Division Engineer or Water Commissioner would limit the amount the owner could divert and store in seasonal year 2 to 40,000 ac-ft because the 100,000 ac-ft water right is filled once the 40,000 ac-ft is stored. The 40,000 ac-ft limit would exist even if the owner released water from storage during seasonal year 2 and created additional capacity. In this situation, this additional capacity can only be refilled under free river conditions since no other storage rights exist.

Decreed versus Physical Capacity

Given the large investment required for reservoir construction, a potential reservoir owner generally receives a decree for a conditional water right to store an amount of water prior to construction. Upon completion of the reservoir, the actual physical capacity of the reservoir may be different from the decreed capacity. This raises the question of whether the physical capacity or the decreed capacity controls the administration of the amount of water that can be stored. If the physical capacity is less than the decreed capacity, then the allowed amount of fill will be based upon the physical capacity rather than the decreed capacity. For example, when a reservoir is physically full at 50,000 ac-ft and has a decreed capacity of 60,000 ac-ft, then the reservoir has reached its one fill and cannot come back in later in the season when space becomes available to fill the additional 10,000 ac-ft. The difference between the decreed capacity and the lower physical capacity is subject to abandonment (or if conditional[1], to cancellation for failure to prove diligence)[2] unless the reservoir owner shows intent to make subsequent modifications to enlarge the reservoir to the originally decreed capacity [3].

When physical capacity is greater than decreed capacity, a fill is based upon the decreed capacity. To use the additional capacity, the reservoir owner must adjudicate a new water right for the difference, use other foreign water legally available for storage in the reservoir, or hope to fill the difference under free river conditions.

Storable Inflow

Storable inflow is the amount of water that is physically and legally available for storage in a reservoir under a particular water right. After the beginning of the seasonal year, all storable inflow must be accounted against the storage right in order to protect other water users, whether or not the reservoir owner actually stores the water. This assures junior water right users that they will be able to divert water in the amount and time that they could have if the senior storage right had filled with all water available to it under its storage priority. For example, if a reservoir operator with a decree to store 20,000 ac-ft of water chooses to bypass 5,000 ac-ft of water that they would otherwise have been able to store in-priority; the Division Engineer considers the bypassed water "storable inflow." Accordingly, the Division Engineer would credit the bypassed water toward the fill of the reservoir and would consider the storage right to be filled when the reservoir physically contains 15,000 ac-ft of water stored under the storage right.

Refill Rights

Some reservoirs in the Basin operate under decrees that provide for refill rights. A refill right typically has a later priority than the original storage right. However, if the reservoir owner applied for a refill right in the original application, the owner may have been given a right to store under the same priority of the original appropriation after the reservoir achieves its first fill and capacity becomes available. Available capacity for a refill right in a reservoir is created by evaporative and seepage losses in addition to actual storage releases.

Paper Fill, Including Bookover

As discussed below, a paper fill is an accounting mechanism whereby storable inflow is charged against a storage water right either because the reservoir owner elected not to physically divert or store water

[1] A conditional water right is one in which the amount claimed in the decree has not been put to a beneficial use.
[2] Diligence is the process of showing progress towards putting the conditional water right to beneficial use. Evidence is presented to the Water Court on the progress made during the current diligence period.
[3] Decreed capacity is the specified storage capacity in the water court decree.

under that right or a junior upstream reservoir diverted the storable inflow out of priority. Some examples of paper fill are described below, followed by a discussion of some of the exceptions to the general rule. These are not meant to be exhaustive on this issue, but should provide an understanding of the most typical situations.

1. A reservoir may have multiple rights. For example, it may have a senior storage right and a junior storage right for additional decreed uses. If water is stored under the junior right before the senior right is filled, then a paper fill for the amount stored and credited under the junior right will also be charged against the senior storage water right, to the extent that it remains unfilled. Once the senior right is filled (either physically or on paper), the junior right may continue to store under its own priority unless it is (or until it becomes) filled.
2. A paper fill is charged against a water storage right when a reservoir cannot be filled to its decreed capacity because of a flood control limitation on storage (unless flood control is a decreed beneficial use) or because of a State Engineer storage restriction on the dam[4].
3. A paper fill is charged if sedimentation has occurred limiting the reservoir's physical capacity.
4. A paper fill is charged when actual storage in the reservoir includes foreign water that limits the capacity of the reservoir to fill under a senior priority unless the owner of the senior priority books over the foreign water in the reservoir to the senior right at the rate that the senior right would have filled the space taken up by the foreign water.
5. A paper fill is charged for any exchange on natural flow into the reservoir for foreign water. For example, assume an on-stream reservoir user exchanges 20 cfs of foreign water into the reservoir by making release of a substitute supply downstream at the same time the user is entitled to fill the reservoir in priority. In this example, the reservoir would be paper filled for the 20 cfs or approximately 40 ac-ft each day the exchange occurred.

Evaporation

Reservoirs are categorized based on their location from a natural stream as either on-channel or off-channel. When a reservoir is constructed on a natural stream bed (on-channel) it causes an increase in losses to the stream system due to the increase in free water surface area of the stream. When an on-channel reservoir is in-priority and filling, the operator does not have to pay back the stream for this increased loss. However when the reservoir is not filling in priority, the operator is required to release stored water to offset the amount of this increased loss to assure that the total natural flow is passed through the reservoir as if the reservoir did not exist. Usually, the release for this loss is accomplished by lowering the reservoir stage to correspond to the calculated net depletion amount. If daily administration is not practical because of the limited size of a reservoir surface, releases for this loss are often aggregated and made on a monthly rather than daily basis. If more than one water right is in a reservoir or the reservoir contains foreign water, the reservoir owner may specify which type(s) of water to release to account for evaporation.

[4] According to the 2012 State Engineers Dam Safety Report, there are 20 dams in the Basin with restrictions.

When predicting the amount of future evaporation to be replaced for an on-channel reservoir, the average gross evaporation (free water surface) must be calculated based upon average evaporation atlases in National Oceanic and Atmospheric Association (NOAA) Technical Report NWS 33 and the maximum surface area of the reservoir (unless otherwise decreed). The total gross evaporation estimate from NOAA shall be distributed to all months. The monthly distributions for elevations are shown in Table 3.2.2.

Table 3.2.2 - Monthly Distribution of Gross Evaporation.

Month	Gross Evaporation as Percent (below 6500 feet)	Gross Evaporation as Percent (above 6500 feet)
Jan	3.0%	1.0%
Feb	3.5%	3.0%
Mar	5.5%	6.0%
Apr	9.0%	9.0%
May	12.0%	12.5%
Jun	14.5%	15.5%
Jul	15.0%	16.0%
Aug	13.5%	13.0%
Sep	10.0%	11.0%
Oct	7.0%	7.5%
Nov	4.0%	4.0%
Dec	3.0%	1.5%

For some reservoirs, the Division Engineer may require that the owner install a weather station with an evaporation pan in order to obtain more accurate estimates of evaporation. The reservoir evaporation may be reduced by the amount of effective precipitation occurring on that day. The effective precipitation is the precipitation that would not have contributed to streamflow had the reservoir not been constructed. This reduction of gross evaporation reduces the amount of water released to compensate for the evaporation from the on-channel reservoir.

Seepage

As soon as water stored in a reservoir or in the process of being delivered by a ditch seeps through the bottom or sides of the structure, it is considered waters of the state subject to the prior appropriation doctrine. This applies to water that cannot be "re-used" as well as fully-consumable water that is no longer under the dominion and control of the user. A reservoir owner may not recapture seepage water from a reservoir as part of the original storage right unless specifically allowed by decree and may not recapture fully consumable water without dominion and control accounting approved by the division engineer. An appropriator of seepage water cannot require or demand that the seepage continue as the reservoir or ditch owner is generally allowed to make improvements that may eliminate or reduce the seepage.

Winter Water Storage Program

The Winter Water Storage Program became a reality as a result of the completion of Pueblo Reservoir in 1975. The program had been in the conceptual stage since the 1930s when the Fryingpan – Arkansas Project was envisioned.

The agricultural users have some of the most senior rights on the river. In the wintertime, they were able to continue diverting water to their fields as long as there was water in the river available to their water rights in priority. The concept was that although crops needed little or no irrigation during winter months water could be stored in the soil underlying fields. This soil moisture content was important for spring planting and winter wheat. This concept was in place from the 1880s to 1976 when Pueblo Reservoir became available for storing inflows to the reservoir outside the irrigation season. Winter irrigation also prevented junior off-channel reservoirs from diverting in the winter by placing a call on the river.

The concept of Winter Water Storage Program is that there now is an on-channel reservoir to store water to be released later in the growing season allowing for better water management by the farming and ranching communities in the Lower Arkansas Valley. The need for a process of fairly diverting and dividing the amount of Winter Water Storage Program was negotiated among water users and resulted in the 1987 Decree (84CW179) officially recognizing the Winter Water Storage Program. The Winter Water Storage Program is administered by the Division 2 office of the Division of Water Resources.

The Winter Water Storage Program operates from 00 00:00 hours on November 15 of each year to 24:00 hours on March 14 the following spring. Currently, the Division Engineer requires 100 cfs to be passed through Pueblo Reservoir and down the river above the City of Pueblo when possible. Pursuant to the decree, the River Call is artificially set at March 1, 1910 during the Winter Water Storage Program allowing non-participants to divert water during the program period, provided they hold water rights senior to that date and they will not injure any other water users having senior priorities. There are also some further constraints and modifications in additional agreements and stipulations.

Storage is maintained at Pueblo Reservoir via an agreement with the United States Bureau of Reclamation. Additional, off-channel storage is allowed in reservoirs as agreed upon including water users above Pueblo Reservoir. This is also identified in the accounting in the section below. Overall, water is stored and released as prescribed by the decree entered in 84CW179.

The flow of the Arkansas River, including the Winter Water Storage Program, is subject to the Arkansas River Compact of 1948. The U.S. Army Corps of Engineers built John Martin Reservoir on the Arkansas River beginning in 1943 with completion in October 1948 for conservation and flood control purposes. The States of Colorado and Kansas agreed to a federally authorized compact regarding flows on the

Arkansas River in 1948. The Winter Water Storage Program allows storage of some water in John Martin Reservoir and the Compact Administration has approved resolutions permitting use of John Martin for this purpose. The Winter Water Storage Program is operated in compliance with these resolutions and the compact. The winter water allocation for the Winter Water Storage Program is shown in Tables 3.2.3-3.2.5.

Table 3.2.3 - Winter Water Storage Program First 100,000 ac-ft.

From 0:00 hours on Nov 15 to 24:00 hours on Mar 14
Direct Flow Participants
Receive 28.8% of the First 100,000 ac-ft stored

	Percent of the First 28.8% Stored	Percent of the Overall First 100,000 ac-ft
Bessemer	21.50%	6.19%
Highline	28.87%	8.31%
Oxford	6.96%	2.00%
Catlin	31.72%	9.14%
LA Consolidated	9.57%	2.76%
Riverside	0.46%	0.13%
West Pueblo	0.92%	0.26%
Total	100.00%	28.80%

Off Channel Storage Participants
Receive 71.2% of the First 100,000 ac-ft stored

	Percent of the First 71.2% Stored	Percent of the Overall First 100,000 ac-ft
Colorado Canal System	15.01%	10.69%
Holbrook	11.97%	8.52%
Fort Lyon	19.42%	13.83%
Amity	19.42%	13.83%
Total	100.00%	71.20%

Table 3.2.4 - Winter Water Storage Program Next 3,106 ac-ft.

Next 3,106 ac-ft Stored

Amity	2750 ac-ft
Holbrook	356 ac-ft

Table 3.2.5 - Winter Water Storage Program Water over 103,106 ac-ft.

Any Storage over 103,106 ac-ft
Direct Flow Participants
Receive 25.0% of any water over 103,106 ac-ft

	Percent of the First 25% Stored Over 103,106 ac-ft	Percent of the Overall Water Over 103,106 ac-ft
Bessemer	21.50%	5.38%
Highline	28.87%	7.22%
Oxford	6.96%	1.74%
Catlin	31.72%	7.93%
LA Consolidated	9.57%	2.39%
Riverside	0.46%	0.12%
West Pueblo	0.92%	0.23%
Total	100.00%	25.00%

Off Channel Storage Participants
Receive 75.0% of any water over 103,106 ac-ft

	Percent of the First 75% Stored Over 103,106 ac-ft	Percent of the Overall Water Over 103,106 ac-ft
Colorado Canal System	17.07%	12.80%
Holbrook	14.05%	10.54%
Fort Lyon	50.88%	38.16%
Amity	18.00%	13.50%
Total	100.00%	75.00%

Irrigation Improvement Rules

On September 30, 2009 the State Engineer filed the Compact Rules Governing Improvements to Surface Water Irrigation Systems in Basin ("Irrigation Improvement Rules" or "Rules") in the Division 2 Water Court. The Irrigation Improvement Rules are designed to allow improvements to the efficiency of irrigation systems in the Basin while ensuring compliance with the Arkansas River Compact ("Compact"),

§ 37-69-101, C.R.S. (2009). The Rules became effective on January 1, 2011. The rules apply to sprinkler and drip systems installed on or after October 1, 1999.

The State Engineer determined that the improvements to surface water irrigation systems, such as sprinklers and drip systems that replace flood and furrow irrigation, or canal-lining that reduce seepage, have the potential to materially deplete the usable waters of the Arkansas River in violation of the Compact and specifically Article IV-D. The Rules provide a process, referred to as a Compact Compliance Plan, for water users who have or will improve their irrigation systems that will deplete the usable waters of the Arkansas River to maintain historical seepage and return flows using other water sources. The Compact Compliance Plan must be approved annually by the Division Engineer.

3.2.4 Groundwater Administration

Groundwater is a key component of water supplies in Colorado and the Basin. Groundwater is used for municipal, agricultural, industrial, and other uses. Groundwater in Colorado is presumed to be tributary unless shown to be otherwise. Groundwater that is nontributary is water from aquifers that have minimal or no connection with surface waters as described below.

Colorado's' prior appropriation system regulates tributary groundwater. Groundwater other than tributary is defined by Colorado statutes for three additional categories— designated, nontributary, and Denver Basin groundwater.

Groundwater administration in the Basin can be grouped into the following topics:

- Tributary Groundwater
- Nontributary Groundwater
- Denver Basin Groundwater
- Designated Groundwater Basins

Tributary Groundwater

Tributary groundwater is hydraulically connected to a surface stream or alluvium and cannot be appropriated without a well permit from the State Engineer who must find that water is available for appropriation without causing injury to other water rights. If there will be injury to other water rights, the applicant must obtain approval from the water court of a plan for augmentation to replace out-of-priority depletions resulting from the pumping of a well. Since the Arkansas River is over appropriated, no tributary well permits can be issued for non-exempt uses without a plan for augmentation. Exempt uses include household use only wells in a single family dwelling or domestic wells on parcels of land greater than 35 acres and both types of wells must have pumps with a capacity of 15 gallons per minute (gpm) or less.

Tributary well development began in the early 1900s and the number of irrigation wells increased dramatically during the drought of the early 1950s when turbine pump technology along with the availability of electrical power from Rural Electric Associations. The number of large capacity wells increased until the 1965 Ground Water Management Act was approved by the legislature. This legislation focused primarily on the authority of the Colorado Ground Water Commission but did have a provision in section 37-90-137 CRS addressing permits to construct wells outside of designated groundwater basins. This section required that the State Engineer issue a well permit before construction of a well and that there had to be a finding that the use of well would not materially injure vested water rights. This State Engineer began restricting the issuance of well permits in over appropriated basins including the Basin.

In 1969 the legislature approved the Water Right and Determination Act dealing with all water rights including tributary groundwater. The 1969 Act came about in part from the complaints by senior surface water rights in both the Arkansas and South Platte River basins that tributary irrigation wells were reducing stream flow and that the water supply in the streams were declining. The Legislature in 1968 authorized two studies by engineering firms to evaluate the impact of the rapid development of wells. Both studies found that there was a correlation with declining stream flow and well development. The 1969 Act required all tributary large capacity wells to file for adjudication by July 1, 1972 with the new Division Water Courts created by the act. The 1969 Act further required the State Engineer to administer the wells once adjudicated in the priority system. Furthermore, the State Engineer could promulgate rules to assist in the administration of tributary wells.

In1973, the State Engineer promulgated rules for the Basin governing the use of tributary wells. These rules limited pumping to three days per week; Monday, Tuesday, and Wednesday. The 3/7 operational period could modified for different days of pumping if approved by the Division Engineer so long as the pumping was restricted to 3 days. The 1973 Rules were not opposed by the water users. They were not supported by increased staffing and were not effectively enforced.

In 1974, the State Engineer attempted to amend the rules to provide for curtailing wells 5 days per week in 1974, 6 days in 1975, and completely in 1976. These rules were challenged and a trial was held in the Division 2 water court. The outcome was that the court decided that the new rules should not be implemented because there had not been sufficient time to evaluate the effectiveness of the 1973 rules. The decision was appealed by the State Engineer to the Supreme Court which sustained the water court disapproval (Kuiper v. Atchison, Topeka, and Santa Fe, June, 1978). The 1973 rules remained in effect until they were amended in 1996 as discussed below.

1994 Measurement Rules and Regulations

As a result of the litigation with Kansas over the Arkansas River Compact that began in 1985 (Kansas v. Colorado, No. 105 original) when the U. S. Supreme Court granted Kansas the right to sue Colorado over the administration of the compact, Colorado had to begin a more stringent administration of tributary wells in the Basin. There was a need to have accurate well pumping records so that depletions by the tributary wells could be computed using computer models.

In March 1994, the Colorado State Engineers Office (SEO) adopted "Rules Governing the Measurement of Tributary Ground Water Diversions Located in the Arkansas River Basin" (Office of the State Engineer, 1994); these initial rules were amended in February 1996 (Office of the State Engineer, 1996) and again in November 2005 (Office of the State Engineer, 2005). The amended rules require users of wells that divert tributary ground water to annually report the water pumped monthly by each well.

The 1994 measurement rules require all tributary wells (except exempt wells) to be measured by a totalizing flow meter, the power conversion coefficient method or report as inactive (not being used). Exempt wells are wells that are exempt from water rights administration and are not administered under the priority system. In most cases, exempt well permits limit the pumping rates to less than 15 gpm (Guide to Colorado Well Permits, Water Rights and Water Administration; DWR September 2012). Examples of exempt wells include: household use only, domestic and livestock wells, pre-1972 domestic and livestock wells, monitoring and observation wells, and fire protection wells.

Annual Reporting of the monthly water amounts pumped for the period November 1 to October 31 from wells within the Basin meeting the criteria must be reported to the Division Engineer no later than January 31 of the following year.

Totalizing flow meters are required to be re-verified in the field to be in accurate working condition under the supervision of state certified well tester every 4 years. The power conversion coefficient must be re-verified every 2 years. The legislature supported the implementation of these rules by authorizing 4.5 FTEs to enforce the rules.

1996 Ground Water Use Rules and Regulations

In 1996, the original 1973 Rules were amended, and are referred to as the 1996 Ground Water Use Rules. These rules apply to all wells except:

- Exempt wells permitted under 37-92-602 C.R.S.
- Wells located within a designated groundwater basin
- Decreed or permitted non-tributary wells
- Exposure of groundwater in gravel mining operations
- Wells withdrawing from the Denver Basin, Dakota or Cheyenne aquifers

These rules were opposed and a trial was held in 1996 in the Division 2 water court. The outcome was that Judge Anderson upheld the rules and they were promulgated and effective in 1996. The legislature also supported the rulemaking by authorizing 9.5 FTE (Full Time Employees) to enforce the rules.

All wells subject to the rules are required to replace depletions to senior water rights and to Stateline flow. The rules have standard well head depletion factors based on the irrigation method so that the stream depletion can be computed using a computer model jointly developed by both states which is referred to as the H-I Model.

The rules require monthly reporting of well pumping so that the depletions associated with the previous month's pumping as well as the pumping for the prior 240 months can be computed and replaced in the current month. There are few if any river basins anywhere in the world that have tributary groundwater administered on such a near real time basis. When combined with the real time administration of surface water using the SMS, the Basin may be the only basin of this size so administered anywhere.

The rules in Rule 14 allow the State Engineer to approve annual replacement plans for well users that do not have permanent water rights that can be included in a plan for augmentation approved by the water court. The three main well augmentation associations in the Basin—Colorado Water Protective and Development Association (CWPDA), Arkansas Groundwater Users Association (AGUA) and Lower Arkansas Water Management Association (LAWMA)—all operate to some extent with leased water for replacing well depletions and therefore have a need to use the replacement plan rather than water court approved augmentation plans. Although LAWMA does have decreed augmentation plans using changed senior irrigation rights it purchased. In 2013, the State Engineer approved 12 replacement plans under Rule 14. In 2014, 11 replacement plans were approved.

Augmentation Plans

Augmentation plans are a key part of managing Colorado's water resources. In the 1969 act, the General Assembly created the concept of an augmentation plan. An augmentation plan is a court-approved plan designed to protect senior water rights, while allowing junior water rights to divert water out-of-priority and avoid State Engineer curtailment orders.

Augmentation plans allow for out-of-priority diversions by replacing water that junior water right users consume (stream depletions). The replacement water must meet the needs of senior water rights holders at the time, place, quantity and suitable quality they would expect absent the out-of-priority diversions. For example, this would allow a junior water user to pump a tributary groundwater well, even when a river call exists on the stream by providing augmentation or replacement water to the calling water right. The depletions impacting the stream at a time of call, even if from pumping effects in prior years, must be replaced and this often requires complex accounting of pumping, consumptive use of the pumped water, and the computation of the amount and time of stream depletions.

Augmentation water can come from a variety of legally available sources and is provided in a variety of means. An augmentation plan identifies structures, diversions, beneficial uses, timing, and amount of depletions to be replaced. It also identifies how and when the replacement water will be supplied and how the augmentation plan will be operated. Some augmentation plans use stored water to replace diversions. Others use senior water rights whose use is changed to include augmentation. This has been done in the Lower Arkansas River basin below John Martin Reservoir by LAWMA.

Substitute Water Supply Plans

The State Engineer is allowed to approve substitute water supply plans, under certain circumstances, while an augmentation plan application is pending in water court. A notice of a request to approve the substitute water supply plan needs to be provided to all interested parties, so they can provide comments to the SEO.

Substitute water supply plans allow temporary out-of-priority diversions if sufficient replacement water can be provided to senior water rights to offset depletions. Substitute water Supply Plans are approved by the State Engineer for a defined period. Substitute water supply plans differ from Augmentation plans, which are long-term and must be approved by the water courts. In the Basin approximately 50 to 100 are approved per year.

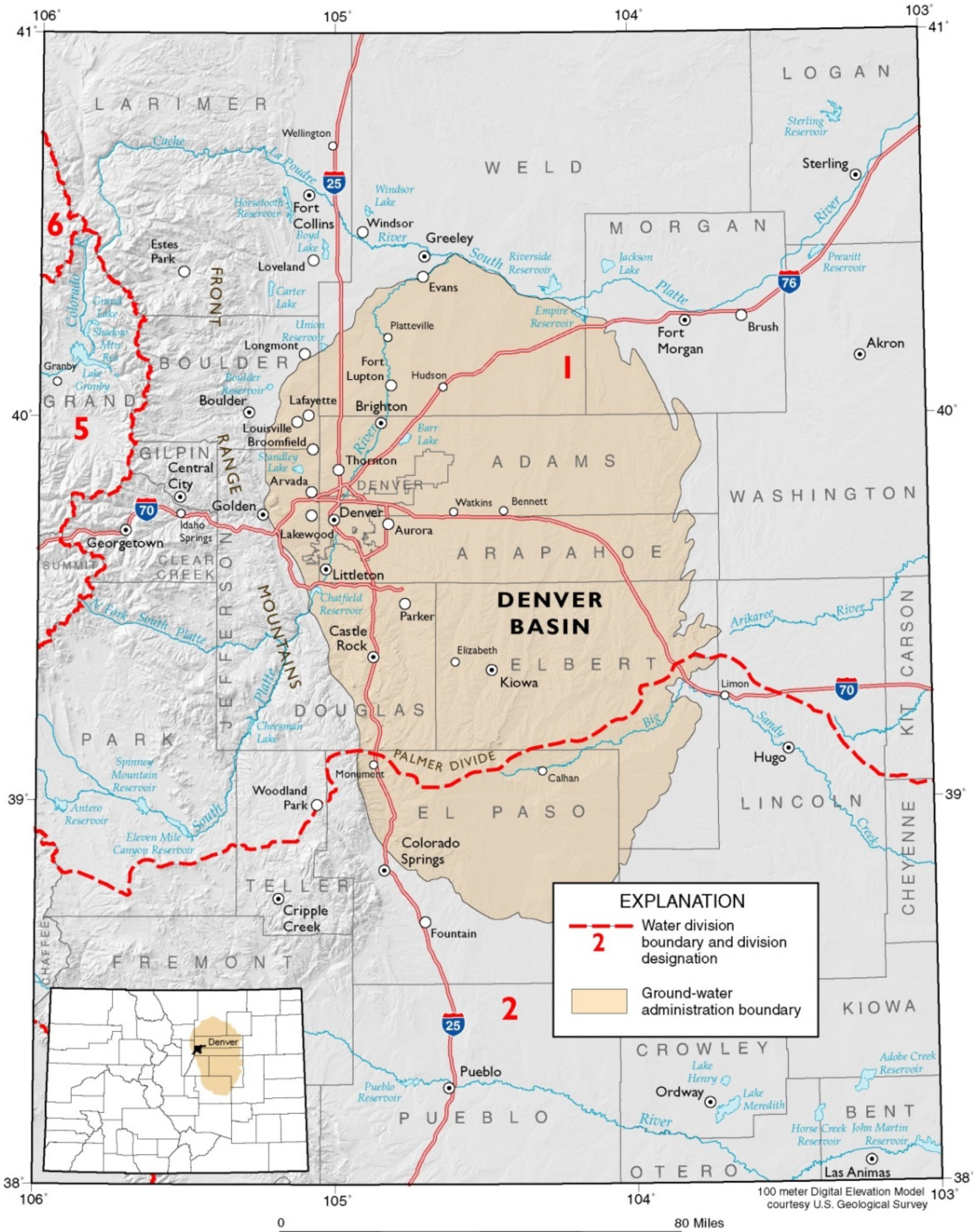
After review, the State Engineer will define the term and conditions of the plan to assure that the operation of the plan will replace all the out-of-priority depletions in time, location, and amount to prevent injury to other water rights.

Nontributary Groundwater including the Denver Basin

The northern portion of the Basin overlies the southern portion of the Denver Basin aquifers in northern El Paso and southern Elbert Counties, Figure 3.2.3. Some water providers in this area rely on the Denver Basin aquifers for their water supplies. These aquifers contain both nontributary and not nontributary[5] groundwater. Withdrawing groundwater from the Denver Basin must comply with the Denver Basin Rules as discussed below and the Denver Basin is shown on Figure 3.2.3.

[5] Not nontributary aquifers in the Denver Basin are those that do not meet the definition of nontributary and that are more than one mile from the point of contact with the stream its alluvium.

Figure 3.2.3 - Denver Basin Extent (Source: CGS – Water Atlas image download)



In 1985, complex legislation commonly known as Senate Bill 5 was enacted to address the allocation and use of the Denver Basin aquifers, as well as other nontributary groundwater aquifers statewide. The rules for the groundwater withdrawal from the Denver Basin aquifers are commonly referred to as the "Denver Basin Rules."

By enacting this legislation, the General Assembly established a policy that it was acceptable to mine the Denver Basin aquifers by withdrawing more water than was being recharged by precipitation. These statutes clarified that nontributary groundwater is groundwater "the withdrawal of which will not, within 100 years, deplete the flow of a natural stream at an annual rate greater than 1/10th of one percent of the annual rate of withdrawal." This definition applies to all nontributary aquifers, including the Denver Basin. For parts of the Denver Basin not within a designated groundwater basin, the water court has the jurisdiction to enter decrees for the use of groundwater. Groundwater withdrawals from the Denver Basin and all nontributary aquifers are limited so as to provide for a 100 year aquifer life, allowing the annual pumping of 1/100th of the available water in the aquifer by the overlying land owner, municipality, or service district.

The Denver Basin rules implement the provisions of section 37-90-137 CRS pertaining to the Denver Basin. The Rules include maps of the four aquifers in the basin: Laramie- Fox Hills, Arapahoe, Denver, and Dawson depicting the areas that are nontributary. In these areas, well permits can be granted by the State Engineer without the need for an augmentation plan. The nontributary water can be reused but 2 percent of the water pumped must not be consumed by the user.

For portions of the Denver basin aquifers that are not nontributary and more than one mile from the point of contact of the aquifer with a stream or its alluvium, the statutes require that a water court approved plan for augmentation be in place to replace 4 percent of the amount of water annual withdrawn before the well permit is approved.

For portions of the Denver Basin aquifers within one mile of the contact of the aquifer with a stream or its alluvium, the augmentation plan must replace actual depletions with the assumption that the hydrostatic pressure in the aquifer has been lowered to the top of the aquifer.

In parts of the Basin, the Dakota formation underlies some areas and depending on the conditions, some of the Dakota formation contains groundwater that meets the definition of nontributary groundwater. The remainder of the formation would contain tributary groundwater and new appropriations would not be approved without a water court approved plan for augmentation.

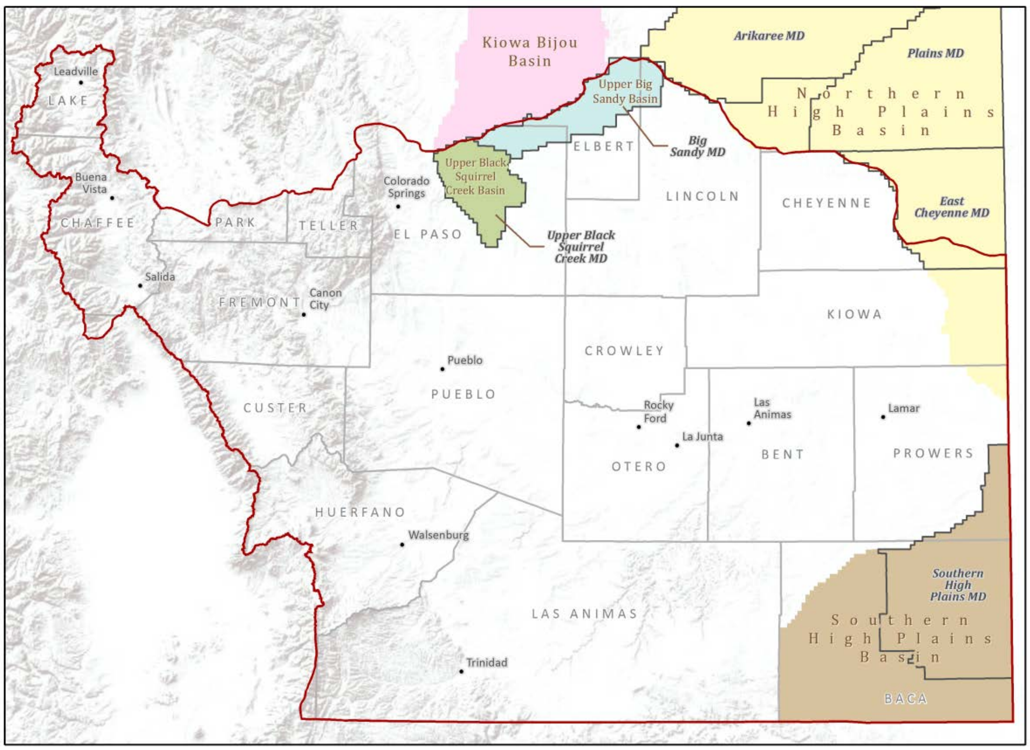
<u>*Designated Groundwater Basins*</u>

In the Basin there are four designated groundwater basins, Figure 3.2.4.

The designated groundwater basins in the Basin are:

- Upper Big Sandy
- Upper Black Squirrel Creek
- Southern High Plans
- Northern High Plans (small portion)

Figure 3.2.4 - Designated Basins



Administration of the designated groundwater basins is under the jurisdiction of the Colorado Ground Water Commission and is not administered by the State Engineer. The State Engineer provides technical and staff support to the Ground Water Commission. The General Assembly has granted the Ground Water Commission authority under Title 37, Article 90 of the Colorado Revised Statues (Ground Water Management Act) to grant water rights and issue large capacity well permits. Small capacity wells are administered by the State Engineer. Small capacity wells are intended for domestic use, livestock, and small commercial operations. These wells are limited to a maximum pumping rate of 15 gpm and no more than one acre of lawn and garden irrigation (Guide to Colorado Well Permits, Water Rights and Water Administration, Sept 2012).

Designated groundwater is groundwater that in its natural course would not be available to and required for the fulfillment of decreed surface rights, or groundwater in areas not adjacent to a continuously flowing natural steam wherein groundwater withdrawals have constituted the principal water usage for at least 15 years. It is applicable to the groundwater underlying the eight "designated basin" areas created by the Colorado Groundwater Commission, located on Colorado's eastern plains. See Figure 3.2.4.

Thirteen Ground Water Management Districts (GWMDs) have been created pursuant to local elections and state statutes. The GWMDs are authorized to adopt additional rules and regulations to assist in administration and management of groundwater within their district.

The GWMD rules for GWMDs in the Basin can be found on the Colorado DWR website:

- Upper Big Sandy - http://water.state.co.us/DWRIPub/Documents/UpperBigSandy.pdf
- Upper Black Squirrel Creek - http://water.state.co.us/DWRIPub/Documents/UBSCRules.pdf
- Southern High Plains - http://water.state.co.us/DWRIPub/Documents/SouthernHighPlains.pdf
- Northern High Plains - http://water.state.co.us/DWRIPub/Documents/EastCheyenne.pdf

These rules and regulations approved by the specific GWMDs include items such as: rules for the removal of groundwater from the district, well spacing, annual appropriations, land to be irrigated and compliance.

Produced Nontributary Groundwater from Oil & Gas Operations

The Colorado DWR has recently promulgated rules for produced nontributary groundwater from oil and gas operations. These rules were made final in the "Produced Nontributary Ground Water Rules (2 CCR 402-17). The purpose of these rules is to assist the State Engineer with the administration of dewatering of geologic formations by withdrawing nontributary groundwater to facilitate mining of oil and natural gas.

Groundwater in the State of Colorado is legally presumed to be "tributary or hydrologically connected to the surface water system requiring administration within the prior appropriation system in conjunction with surface rights, unless it is demonstrated to be nontributary groundwater in accordance with the law. As part of these rules, Rule 17.7.D. identifies geographically delineated areas under which groundwater in specified formations is nontributary for the limited purpose of the Rule. These maps are available on the DWR website (water.state.co.us).

One can submit a petition for a Determination of Nontributary Groundwater if the area and formation has not been previously determined to be nontributary. This requires the demonstration by the use of a numerical groundwater model or alternate methodology that the groundwater being produced is nontributary.

These rules do not apply to any aquifer or portion thereof that contains designated groundwater and is located within the boundaries of a designated groundwater basin.

In addition, tributary produced groundwater from oil and gas operations are required to have a well permit and operate in accordance with a plan for augmentation or substitute water supply plan that replaces depletions to affected streams.

3.2.5 Summary and Challenges

Water rights administration is complex, but particularly so in the Basin, where the interstate compact with the State of Kansas, and subsequent lawsuits, have put additional requirements on both water users and the Division of Water Resources. The level of scrutiny for changes in any attribute of a historic water rights, including timing, replacement of return flows, and place of use, make water rights administration particularly difficult, and represent a challenge to meeting the needs of the basin for both consumptive and nonconsumptive uses.

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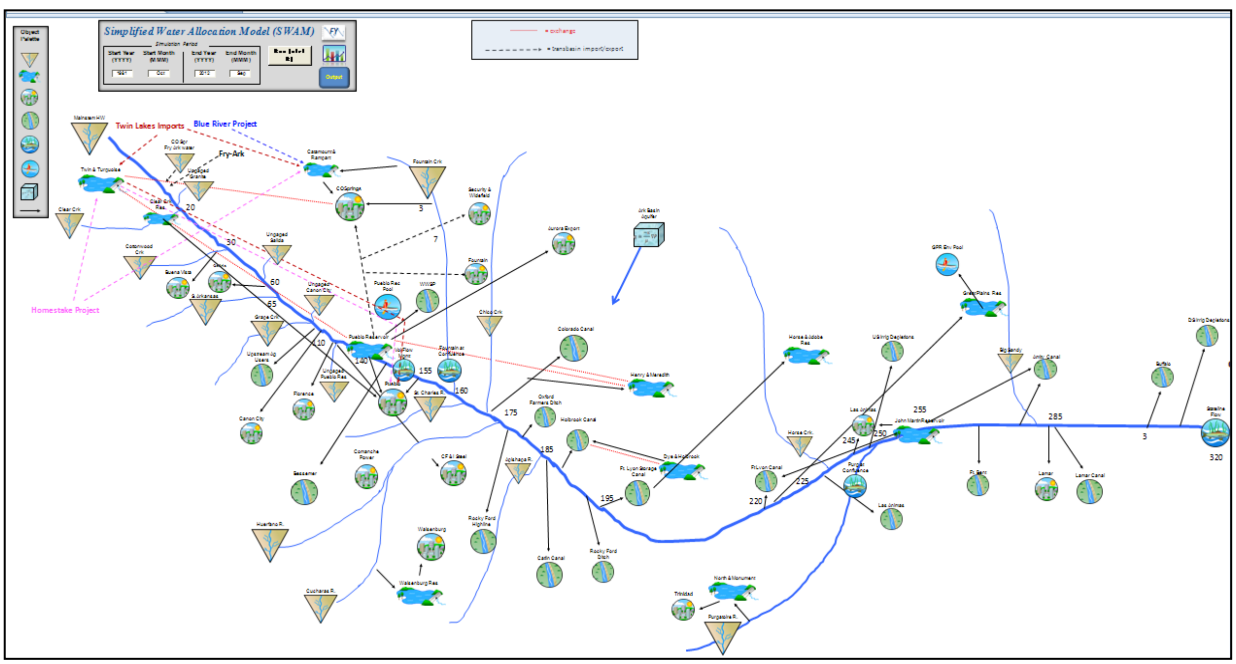
3.3 Water Allocation Planning Model Documentation

3.3.1 Overview

A water allocation model has been developed for the Arkansas River Basin (Figure 3.3.1) to support the Basin Implementation Plan (BIP). The model spatial domain extends from the Arkansas River at Leadville flow gage in the western headwaters to the Colorado-Kansas state line in the east. It includes all major tributaries, agricultural ditch diversions, M&I water users, and transbasin water imports. All other significant inflows and withdrawals in the basin have been represented implicitly in the model in aggregated form. The model is designed for large-scale planning studies and, more specifically, the quantification of water shortages in the basin as a result of increasing future demands. It is not designed to be a river administration or operational support tool, nor is it intended to replicate the Arkansas Basin Decision Support System (ArkDSS) that has recently completed a Feasibility Study. Consequently, there are intentional simplifications in the model, compared to the ArkDSS, to maintain its ease of use and transparency for coarser resolution planning. These simplifications include: a monthly timestep, aggregated agricultural diversions, simplified reservoir operations and accounting, and simplified representation and inclusion of water exchange and augmentation plans. That being said, the key drivers of water availability in the basin, including native hydrology, major water uses and return flows, the water rights priority system, groundwater pumping with surface returns and stream depletions, and transbasin imports, are all explicitly represented in the model. Lastly, the model is well supported by a calibration/verification exercise based on recent (1982 – 2012) river gage data.

Figure 3.3.1 - Arkansas River BIP Water Allocation Model



3.3.2 Modeling Platform

The Arkansas Basin planning model was developed using CDM Smith's Simplified Water Allocation Model (SWAM). SWAM was originally developed in 2009 to address an identified need for a networked, generalized water allocation modeling tool that could be easily and simply applied for planning studies by a wide range of end users. It has been extensively modified and enhanced since that inception. SWAM is designed to be intuitive in its use and streamlined in functionality and data requirements, while still maintaining the key elements of water allocation modeling.

SWAM is not intended to replace more complex water allocation modeling software. It is not well-suited for either operational support or water rights administration modeling. There are key constraints in the model with respect to the number of simulated water user nodes and the level of complexity available for simulating reservoir operations. Rather, SWAM was designed to complement these more complex tools by providing for efficient planning-level analyses of water supply systems. It is best suited for either analysis of focused networks or coarser resolution basin-level studies.

Like most water allocation models, SWAM calculates physically and legally available water, diversions, storage, consumption, and return flows at user-defined nodes in a networked river system. Both municipal and agricultural demands can be specified and/or calculated in the model. Legal availability of water is calculated based on prioritized water rights, downstream physical availability, and specified return flow percentages. Additional features in SWAM include easily-parameterized M&I conservation and reuse programs, agricultural land transfers, groundwater pumping, water user exchange agreements, and transbasin diversion projects. Multiple layers of complexity are available as options in SWAM to allow for easy development of a range of systems, from the very simple to the more complex.

SWAM operates on a monthly timestep over an extended continuous simulation period intended to capture a range of hydrologic conditions. The program is coded in Visual Basic object-oriented code with a Microsoft *Excel*-based interface.

3.3.3 Model Construction

Model Simulation Period

The Arkansas Basin model simulates the water years 1982 – 2012. This historical period is known to include all of the current major basin operations, storage and diversion structures, and transbasin imports and is inclusive of the critical drought of the early 2000s. It is also consistent with the simulation period utilized for the SDS modeling performed as part of that project's EIS (MWH 2007).

Tributary Objects

Tributary objects are used in SWAM to establish native flows throughout the basin. In addition to a mainstem headwater flow, multiple tributaries are included in the model in a dendritic network. These model objects are parameterized with a monthly flow time series and spatial location identifiers (e.g., confluence location). Gaged flow records were used, to the extent possible, to quantify native flows in the basin. Gages used for this purpose in the model are located above major basin operations and generally represent unimpaired flows. As described below, flow contributions from a number of ungaged sub-basins were also included in the model developed using statistical estimation techniques and adjusted as part of the model calibration process. Standard hydrologic statistical methods were also employed to extend or augment gaged records, as necessary.

The following tributaries, with full or partial gaged flow records, are explicitly included in the model:

- Mainstem Headwater;
- Clear Creek;
- Cottonwood Creek;
- S. Arkansas River;
- Grape Creek;
- Fountain Creek and local runoff;
- St. Charles River;
- Chico Creek;
- Huerfano River;
- Cucharas River;
- Apishapa River;
- Horse Creek;
- Purgatoire River;
- Big Sandy Creek.

In some cases, tributary reaches are explicitly simulated in the model and include surface water user nodes along the extent of the reach. These tributary objects are parameterized with upstream (headwater) gaged flows and, in some cases, reach gains and losses (quantified as part of the calibration process) (Table 3.3.1). In other cases, the tributaries merely serve as point inflows to the mainstem river and are therefore parameterized using flow rates measured near the mainstem confluence. For both types of tributary objects, monthly flow records for the simulation period were either obtained directly from USGS gage records or were estimated using well-known statistical techniques, including area-weighting with a surrogate gage and the MOVE.2 record-filling method.

Table 3.3.1 - Summary of Model Tributary Objects

Tributary Object	Representative USGS Flow Gage	Drainage Area (mi^2)	Available Period of Gage Record	Statistical Extension or Record-Filling Method	Calibration Gain/Loss Factor (unitless)[1]	Mean Annual Flow (AFY)[2]
Mainstem Headwater	Arkansas River nr Leadville (07081200)	99	Oct '81 – Sep '83; May '90 – Sep '12	MOVE.2 (with 07086000 reference gage)	1	55,000
Clear Creek at Clear Crk Reservoir	Clear Creek ab Clear Crk Reservoir (07086500)	67	Oct '81 – Sep '12	none	1	49,000
S. Arkansas River at Mouth	Grape Creek nr Westcliffe (07095000) (surrogate)	201	Oct '81 – Sep '12	area-weighting, surrogate gage	1	16,000
Grape Creek at Mouth	Grape Creek nr Westcliffe (07095000)	541	Oct '81 – Sep '12	area-weighting, down to confluence	1	43,000
Fountain Crk & Local Runoff	Fountain Creek nr CO Springs (07103700) + Estimated Local Runoff[3]	102 (+ local runoff drainage)	Oct '81 – Sep '12	none	1	77,000
St. Charles River at Mouth	St. Charles River at Vineland (07108900)	474	Oct '81 – Sep '12	none	1	28,000
Chico Creek at Mouth	Chico Creek nr Avondale (07110500)	864	Mar '39 – Sep '46	mean monthly flows	30	2,500
Huerfano River Headwater	Huerfano River at Manzanola (07111000)	73	Oct '81 – Sep '87; Oct '94 – Sep '12	MOVE.2 (with 07124200 reference gage)	3.5	52,000
Cucharas River Headwater	Cucharas River ab Walsenburg (07114000)	56	Oct '81 – Sep '87; Oct '94 – Sep '12	MOVE.2 (with 07124200 reference gage)	1	16,000
Apishapa River at Mouth	Apishapa at Fowler (07119500)	1074	Oct '81 – Sep '12	none	1	12,000
Horse Creek at Mouth	Horse Creek nr Las Animas (07123675)	1403	Oct '79 – Sep '93	mean monthly flows	1	9,000
Purgatoire River Headwater	Purgatoire ab Madrid (07124200)	505	Oct '81 – Sep '12	none	0.85	52,000
Big Sandy Creek at Mouth	Big Sandy nr Lamar (07134100)	65	Jul '95 – Sep '12	mean monthly flows	0.75	12,000
Ungaged Above Granite	NA	350	NA	area-weighting (with 07086500 reference gage)	0.75	253,000
Ungaged Below Granite, Above Salida	NA	600	NA	area-weighting (with 07091015 reference gage)	0.75	240,000
Ungaged Below Salida, Above Canon	NA	1120	NA	area-weighting (with 07095000 reference gage)	0.75	88,000

Tributary Object	Representative USGS Flow Gage	Drainage Area (mi^2)	Available Period of Gage Record	Statistical Extension or Record-Filling Method	Calibration Gain/Loss Factor (unitless)[1]	Mean Annual Flow (AFY) [2]
City						
Ungaged Below Canon City, Above Pueblo Reservoir	NA	1400	NA	area-weighting (with 07099060 reference gage)	0.75	110,000

1 Factor applied to estimated flow to represent reach gains or losses down to the confluence, quantified as part of calibration process

2 Flow at initial point of application in model, prior to gains or losses

3 Estimated as part of calibration process

For the Fountain Creek sub-basin, upstream of Colorado Springs, stream gage data were augmented with estimates of additional flow into Colorado Springs local reservoir system. This runoff is known to be a significant source of supply for the city and is not captured in the Fountain Creek gage data. The flow augmentation was achieved by applying a uniform factor to the Fountain Creek near Colorado Springs gage data, quantified as part of the calibration process. This process was guided by downstream Fountain Creek gaged flows (Fountain Creek at Pueblo, see Section 3.3.4) and independent estimates of local runoff for Colorado Springs (Colorado Springs Water Tour document).

In addition to the individual tributaries listed above, a number of ungaged tributaries were included in the model in aggregate form. Flows for these ungaged areas were estimated using area-weighting techniques applied to surrogate gages. Adjustments were made to the flow estimates as part of the calibration process (described in Section 3.3.4). The focus of this analysis was on the ungaged headwater regions of the basin where contributions from snowmelt are likely significant. As can be seen in Table 3.3.1, these ungaged headwater tributaries constitute well over half of the total native flow in the basin as simulated in the model.

Reservoirs

The following major reservoirs are included in the model:

- Twin and Turquoise Aggregate Reservoir (offline);
- Clear Creek Reservoir (online);
- Pueblo Reservoir (online);
- Catamount and Rampart Aggregate Reservoir (offline);
- Walsenburg Reservoir (offline);
- Henry and Meredith Aggregate Reservoir (offline);
- Dye and Holbrook Aggregate Reservoir (offline);
- Horse and Adobe Aggregate Reservoir (offline);
- North and Monument Aggregate Reservoir (offline);
- John Martin Reservoir (online);

- Great Plains Aggregate Reservoir (offline).

Reservoirs are parameterized according to total storage capacity, user accounts, simplified release and operational rules, and evaporation rates (Table 3.3.2). Inflows and withdrawals from the reservoirs are dictated by activity associated with the individual water user accounts in each reservoir. Offline reservoirs divert water for storage according to physical and legal availability for individual user accounts. Online reservoirs hold inflow only to the extent legally allowed according to user account water rights and downstream senior calls. For online reservoirs, excess water not held in individual accounts, and not called by downstream users, is stored in flood control pools. The storage capacity of these pools is calculated as the difference between total user account storage and the total physical storage of the reservoir. Releases from flood control pools are defined by user-input outflow-capacity tables.

Table 3.3.2 - Modeled Reservoirs

Reservoir Name	Total Storage Capacity (AF)	Sources of Water	User Accounts	Evaporation Losses (Apr – Sep)	Prescribed Release Rules
Twin & Turquoise Aggregate	269,000	Transbasin imports	Colorado Springs, City of Pueblo	0.14 – 0.28 in d^{-1}	none
Clear Creek Reservoir	11,400	Clear Creek	City of Pueblo	1% per month	none
Pueblo Reservoir	330,000	Arkansas R. mainstem	City of Pueblo, Colorado Springs, City of Fountain, Lamar, Security & Widefield, Bessemer Ditch, Aggregate Upstream Ag Users, Aurora Export	0.14 – 0.28 in d^{-1}	flood control pool: 0 – 5000 AFM (0 – 100% capacity)
Catamount and Rampart Aggregate	60,000	Fountain Creek, transbasin imports	Colorado Springs	1% per month	none
Walsenburg Reservoir	843	Cucharas River	Walsenburg	1% per month	none
Henry and Meredith Aggregate	49,000	Arkansas R. mainstem	CO Canal	1% per month	none
Dye and Holbrook Aggregate	50,000	Arkansas R. mainstem	Holbrook Aggregate Canal	1% per month	none
Horse and Adobe Aggregate	200,000	Arkansas R. mainstem	Fort Lyon Storage Canal	1% per month	none
North and Monument Aggregate	5700	Purgatoire R.	City of Trinidad	1% per month	none
John Martin Reservoir	450,000	Arkansas R. mainstem	Las Animas Ditch, Ft. Lyon Canal, Ft. Bent Canal	0.1 – 0.3 in d^{-1}	flood control pool: 0 – 70,000 AFM (0 – 100% capacity)
Aggregate Great Plains Reservoir	70,000	Arkansas R. mainstem	GPR environmental pool	1% per month	none

In the current model, reservoir bathymetry is defined by simplified area-capacity curves where such information is available. Monthly mean evaporation rates (inches per day) have been specified in the model based on regional values reported in the literature. In the absence of reservoir bathymetric information (smaller reservoirs only), 1 percent volumetric evaporative losses are assumed for the months of April – October, with no evaporation during the winter months.

Two nonconsumptive environmental pools are also included in the model, associated with Pueblo and the Aggregate Great Plains Reservoir. These model objects designate minimum storage levels that are maintained, to the extent possible, given physical and legal availability of water. Environmental pools are assigned a water right appropriation date in the same manner as consumptive users. This water right determines the ability of the object to divert and store water. The only losses from the environmental pools are evaporative. The Pueblo environmental pool is set at 30,000 AF with a relatively senior appropriation date of 1/1/1900. The Great Plains Reservoir environmental pool is set at 21,000 AF with a largely junior appropriation date of 1/1/1990 (i.e., it only fills during wet years).

M&I Users

The following M&I water users are explicitly included in the Arkansas Basin SWAM model:

- Colorado Springs;
- Pueblo;
- Buena Vista;
- Salida;
- Canon City;
- Florence;
- Security and Widefield;
- Fountain;
- CF&I Steel;
- Walsenburg;
- Trinidad;
- Las Animas;
- Lamar;
- Aurora Export.

Each M&I user is parameterized according to spatial location (diversions and return flows), current demand estimates, representative water rights appropriation dates, diversion rights, and source water portfolio details (including direct diversions, storage accounts, transbasin imports, and groundwater pumping) (Table 3.3.3). M&I users in SWAM can have multiple sources of supply used to satisfy a single set of demands, in order of user-defined preferences. Sources of supply can include: direct surface diversions, surface diversions via storage accounts, and groundwater pumping.

Table 3.3.3 - Summary of M&I Water User Objects

Name	Total Demand (AFY)	Modeled Sources of Supply	Modeled Storage Accounts
Colorado Springs	116,000	• Groundwater (implicit in model) • Direct Fountain Creek + local runoff, • Storage Fountain Creek + local runoff • Transbasin with Pueblo Res. storage (Fry-Ark) • Transbasin with Catamount & Rampart storage (Blue River, Twin Lakes, and Homestake) • Exchange of transbasin return flows (to Pueblo Res.) • Exchange of Colorado Canal and Lake Meredith water (to Pueblo Res.)	• Catamount & Rampart (60,000 AF) • Twin & Turquoise (47,000 AF) • Pueblo (17,000 AF) • Henry & Meredith (27,000 AF)
City of Pueblo	40,000	• Direct mainstem • Storage Clear Creek • Transbasin with Twin & Turquoise storage (Twin Lakes and Homestake) • Transbasin with Pueblo Res. storage (Fry Ark) • Exchange of transbasin return flows (to Pueblo Res.)	• Clear Creek Res. (11,400 AF) • Twin & Turquois (17,600 AF) • Pueblo Res. (10,000 AF)
Buena Vista	900	• Direct Cottonwood Creek • Groundwater	none
Salida	3000	• Direct mainstem • Groundwater	none
Canon City	7200	• Direct mainstem	none
Florence	2800	• Direct mainstem	none
Security and Widefield	9000	• Groundwater • Transbasin with Pueblo Res. storage (Fry-Ark)	• Pueblo (1000 AF)
Fountain	5200	• Groundwater • Transbasin with Pueblo Res. storage (Fry-Ark)	• Pueblo (5000 AF)
CF&I Steel	4100	• Direct mainstem	none
Walsenburg	1000	• Storage Cucharas Riv.	• Walsenburg Res. (840 AF)
Trinidad	5100	• Storage Purgatoire Riv.	• North & Monument (5700 AF)
Las Animas	1000	• Groundwater	none
Lamar	2750	• Groundwater • Transbasin with Pueblo Res. storage (Fry-Ark)	• Pueblo (1400 AF)
Aurora Export	17,500	• Storage mainstem	• Pueblo (10,000 AF)

The model calculates both legally and physically available flow at each surface water diversion point associated with M&I water user objects. Legal availability is calculated in SWAM using the same algorithm (Modified Direct Solution Algorithm) utilized in the State of Colorado DSS and considers downstream senior calls, return flows, and diversion rights. In SWAM, the actual diverted amount is calculated as a function of physical and legal availability and demand. Monthly M&I demands are set in the model, based on the best available information, to approximately represent current demands. Monthly demand patterns are defined in the model based on model default values that follow patterns typical of M&I usage in Colorado. Water user storage accounts are assigned a "parent" reservoir, a total account capacity, and water rights (diversion and storage rights). The model attempts to maintain a full storage account, to the extent physically and legally allowable, by imparting a diversion demand on the source river in the same way that direct diversion demands are imparted. For all M&I users in the model, a uniform return flow monthly pattern is assumed based on typical indoor vs. outdoor usage patterns and consumptive use portions associated with each. No time lags have been included for return flows in this monthly timestep model.

Note that neither stream depletions nor surface water augmentation plans are explicitly included in the model M&I object portfolios, as the combination of the two represents a zero net change in the surface water budget. Also note that exchange agreements allowing the Cities of Colorado Springs and Pueblo to use their transbasin import water to extinction are included in the portfolios for these two model objects, parameterized with appropriate decree priority dates. An exchange agreement between Colorado Springs and Colorado Canal, with storage in Henry & Meredith Aggregate Reservoir, is also included as part of the water supply portfolio for the city. See *Exchanges and Flow Management Programs* for further details on modeled exchanges.

Agricultural Users

The following irrigation ditches are explicitly included in the model:

- Colorado Canal;
- Bessemer Ditch;
- Las Animas Ditch;
- Fort Lyon Canal;
- Rocky Ford Highline;
- Catlin Canal;
- Lamar Canal;
- Buffalo Canal;
- Holbrook Canal;
- Amity Canal;
- Ft. Lyon Storage Canal;
- Oxford Farmers Ditch;
- Ft. Bent Canal;
- Rocky Ford Ditch;
- Upstream Aggregate Ditch (aggregation of all ditches upstream of Pueblo Res.).

The major ditches listed above comprise approximately two-thirds of the total agricultural diversion in the basin. The remaining diversions, achieved with smaller ditches and canals, were assigned, in aggregate, to the major users in the model based on relative proximity to the major diversion location.

In this way, approximately 100 percent of the reported total agricultural water use is included in the model but at a coarser spatial resolution than in actual operation.

As with M&I users, agricultural users are parameterized in the model according to spatial location, demands, water rights, and source water details (Table 3.3.4). In the current model, agricultural user demands are set based on reported historical headgate diversions averaged over the simulation period (1982 – 2012). Monthly-varying average diversion volumes, calculated using the full dataset, are used to characterize the seasonality in water use. Diversions are assumed to all occur from the mainstem of the Arkansas River. Aggregate storage accounts are included, where appropriate, based on available information (e.g., HydroBase diversion records, see *Data Sources*. For aggregate diversions where a significant portion of the diverted water is transmitted to storage prior to use, a single storage account was assigned to one of the simulated reservoirs (Table 3.3.4). Storage account capacities were initially roughly estimated based on available data with subsequent minor adjustments as part of the calibration process. These accounts are intended to represent lumped storage available to the various diversions, and are used to overcome seasonal constraints associated with available river diversion water.

Table 3.3.4 - Summary of Aggregate Agricultural Water User Objects

Name	Total Demand (AFY)	Representative Priority Date	Storage Accounts
Colorado Canal	147,000	6/9/1890	Henry & Meredith (49,000 AF)
Bessemer Ditch	124,000	5/1/1887	Pueblo (10,000 AF)
Las Animas Ditch	124,000	3/13/1888	John Martin (5000 AF)
Fort Lyon Canal	240,000	3/1/1887	John Martin (20,000 AF)
Rocky Ford Highline	81,000	3/7/1884	none
Catlin Canal	102,000	12/3/1884	none
Lamar Canal	60,000	7/16/1890	none
Buffalo Canal	53,000	10/1/1895	none
Holbrook Canal	48,000	10/10/1903	Dye & Holbrook (30,000 AF)
Amity Canal	91,000	4/1/1893	none
Ft. Lyon Storage Canal	75,000	3/1/1910	Horse & Adobe (200,000)
Oxford Farmers Ditch	55,000	2/26/1887	none
Ft. Bent Canal	40,000	12/31/1900	John Martin (20,000 AF)
Rocky Ford Ditch	31,000	5/15/1874	none
Upstream Aggregate Ditch	303,000	5/2/1887	Pueblo (10,000 AF)

Representative water rights appropriation dates are assigned to each of the major users listed above based on the date listed for the largest diversion right associated with the ditch or canal. A uniform return flow percentage (43 percent) is assumed for all agricultural users based on average historical efficiencies reported for the basin (SDS report). Return flows are not lagged and are assumed to return to the river at single specified downstream locations, assigned based on visual assessment of the mapped irrigation areas associated with each major ditch.

Transbasin Imports

Imported transbasin water is included in the model as a major source of supply for many of the M&I water users described above. Transbasin imports are simulated in the model as steady monthly inflows to the river basin. Imports are made available to their corresponding water users by either direct transmittal to water user storage accounts or via mainstem conveyance. As an example of the latter, Fry-Ark water utilized by Colorado Springs, Pueblo, and downstream agricultural users is modeled as a steady point inflow to the mainstem river at the top of the system (above Clear Creek confluence). This water flows down the mainstem and a portion is captured and stored in accounts in Pueblo Reservoir, where it is available for use by Colorado Springs and Pueblo. The Fry-Ark water owned by downstream agricultural water users is transported further downstream to aggregate agricultural diversions, as dictated by downstream water rights. In other cases, transbasin imports are simulated with a direct transmittal to a specified water user storage account (e.g., Colorado Springs Homestake, Twin Lakes, and Blue River imports).

Major transbasin imports explicitly represented in the model, and their associated water users, are listed below (and summarized in Table 3.3.5):

- Homestake (Colorado Springs, Pueblo);
- Blue River (Colorado Springs);
- Twin Lakes (Colorado Springs, Pueblo);
- Fry-Ark (Colorado Springs, Pueblo, City of Fountain, Security & Widefield, Lamar, downstream agricultural users).

Table 3.3.5 - Summary of Modeled Transbasin Import Water.

Name	End Users	Modeled Storage	Modeled Yield (AFY)
Homestake	Colorado Springs, Pueblo	Catamount & Rampart (CO Springs), Twin & Turquoise (Pueblo)	15,500 (CO Springs) 12,000 (Pueblo)
Blue River	Colorado Springs	Catamount & Rampart (CO Springs)	8,000 (CO Springs)
Twin Lakes	Colorado Springs, Pueblo	Catamount & Rampart (CO Springs), Twin & Turquoise (Pueblo)	29,000 (CO Springs) 12,000 (Pueblo)
Fry-Ark	Colorado Springs, Pueblo, Fountain, Security & Widefield, Lamar, downstream ag users	Pueblo Reservoir (CO Springs, Pueblo, Fountain, Security & Widefield, Lamar)	14,500 (CO Springs) 5000 (Pueblo) 10,000 (Fountain) 10,000 (Security & Widefield) 1400 (Lamar) 32,000 (downstream ag users)

Exchanges and Flow Management Programs

Water exchanges in the Arkansas River Basin involve diversion and water use at one location offset by a simultaneous release of an equivalent volume at a different location. For the basin as a whole, a zero net change in river flows is realized. However, exchanges do impact the spatial distribution and timing of flows within the basin. Exchanges can also represent an important element of individual water supply portfolios in the basin. For this planning-level model, only a select number of key exchanges were explicitly included in the model (Table 3.3.6):

- Colorado Springs transbasin return flows;
- City of Pueblo transbasin return flows;
- Colorado Springs – Colorado Canal exchange;
- Aurora – Rocky Ford exchange;
- Winter Water Storage Program (WWSP).

Table 3.3.6 - Summary of Modeled Exchanges

Name	Water Users Involved	Storage	Exchange Quantity (AFY)[1]	Water Right Priority Date
CO Springs transbasin return flows	CO Springs	Twin & Turquoise	37,000	6/5/1985
Pueblo transbasin return flows	City of Pueblo	Pueblo Res.	17,000	6/5/1985
CO Springs – Colorado Canal	CO Springs, Colorado Canal	Henry & Meredith, Pueblo Res.	1200	6/5/1985 (CO Springs), 6/10/1890 (CO Canal)
Aurora-Rocky Ford	Aurora Export	Pueblo Res.	5500	6/5/1985
Winter Water Storage Program	Multiple downstream ag users	Pueblo Res.	50,000	1/1/1885

[1] Average annual volume exchanged in current model, as calculated as a function of demand and physical and legal availability

The first two listed exchanges capture the ability of these cities to use their transbasin import water (excluding Fry-Ark) to extinction. Both are represented in the model with additional senior diversion rights set equal to their modeled, monthly-variable return flows from transbasin project water yields. For the Colorado Springs model object, water is diverted under this exchange from the mainstem headwaters and stored in Twin & Turquoise Aggregate Reservoir for as-needed use. For the Pueblo object, return flow exchange water is diverted at Pueblo Reservoir and stored in a Pueblo account for as-needed use.

The Colorado Springs – Colorado Canal exchange involves the use of Colorado Springs shares in Colorado Canal diversion water and Henry & Meredith Aggregate Reservoir storage. In the model, SWAM's water exchange functionality is utilized, within the Colorado Springs water supply portfolio (see Table 3.3.3), to divert and store downstream mainstem water in Henry & Meredith. This water is released, as needed, to offset upstream city diversions at Pueblo Reservoir.

The Aurora – Rocky Ford exchange is represented in the model using the Aurora Export M&I water user noted above (Table 3.3.6). This model object includes a seasonal diversion of water just above Pueblo Reservoir with diversion rights set according to the Rocky Ford Exchange agreement (Mar – Oct water rights). Water is diverted to a storage account in Pueblo Reservoir (10,000 AF) and then utilized with typical M&I seasonal usage patterns with zero return flows (i.e., an export from the basin). While the exchange with Rocky Ford ditch is not explicitly simulated in this model, it is assumed that ample flow is available at the Rock Ford diversion point to allow for the upstream diversion.

The WWSP is represented in the model with a winter-only diversion (Nov – Mar) just upstream of Pueblo Reservoir and storage in the reservoir. The stored water is then fully released during the growing season months (Apr – Sep) for use by downstream agricultural users. In other words, downstream agricultural users are able to divert additional water during the growing season equal to the amount of WWSP stored water released from Pueblo Reservoir. The total annual WWSP diversion is set in the model at 50,000 AFY based on recent historical recorded totals (Reclamation, 2013).

Lastly, the Arkansas River Flow Management program is represented in the model with an instream flow object located on the mainstem just downstream of Pueblo Reservoir. Target flows for this object vary monthly, ranging from 100 cfs (Dec – Feb) to 500 cfs (Jun and Jul), based on recreation and fishery needs during low flow years (Flow Management Program May 2004 Exhibit 1, commonly known as the "6-party IGA."). These instream flow targets are prioritized with a decree date of 6/4/1985, which makes them just senior to the municipal exchange programs described above. In other words, if minimum downstream flow requirements are not met then the municipal exchanges described above are not allowed. The Arkansas River Flow Management object does not impact the ability of more senior water user objects to divert water.

Groundwater Pumping

A single groundwater aquifer is included in the model to provide water for M&I user pumping. Pumping in the model is currently unconstrained by groundwater hydrology (high recharge rate, no aquifer depletion). M&I groundwater supplies are included in the water user supply portfolios as appropriate. Agricultural (irrigation) groundwater pumping is not included in the model, as only surface water agricultural demands and diversions are simulated. Return flows from irrigation groundwater pumping are assumed to be negligible for the planning analysis performed here.

Groundwater pumping in the basin is known to result in significant depletions of river flow. In the model, stream depletions are represented with fully consumptive agricultural diversion objects at two different lumped locations, upstream and downstream of John Martin Reservoir. The total depletion amount is set in the model as 41,500 AFY (29,600 upstream, 11,900 downstream) based on 2014 Rule 14 plans for LAWMA for the downstream of John Martin Reservoir and from AGWUA and CWPDA above John Martin Reservoir. Water rights priority dates for the two lumped depletion objects are set such that they are junior to all other agricultural diversions.

Data Sources

Data sources used to parameterize the model elements described above are summarized in Table 3.3.7. Detailed descriptions of these data sources are provided elsewhere.

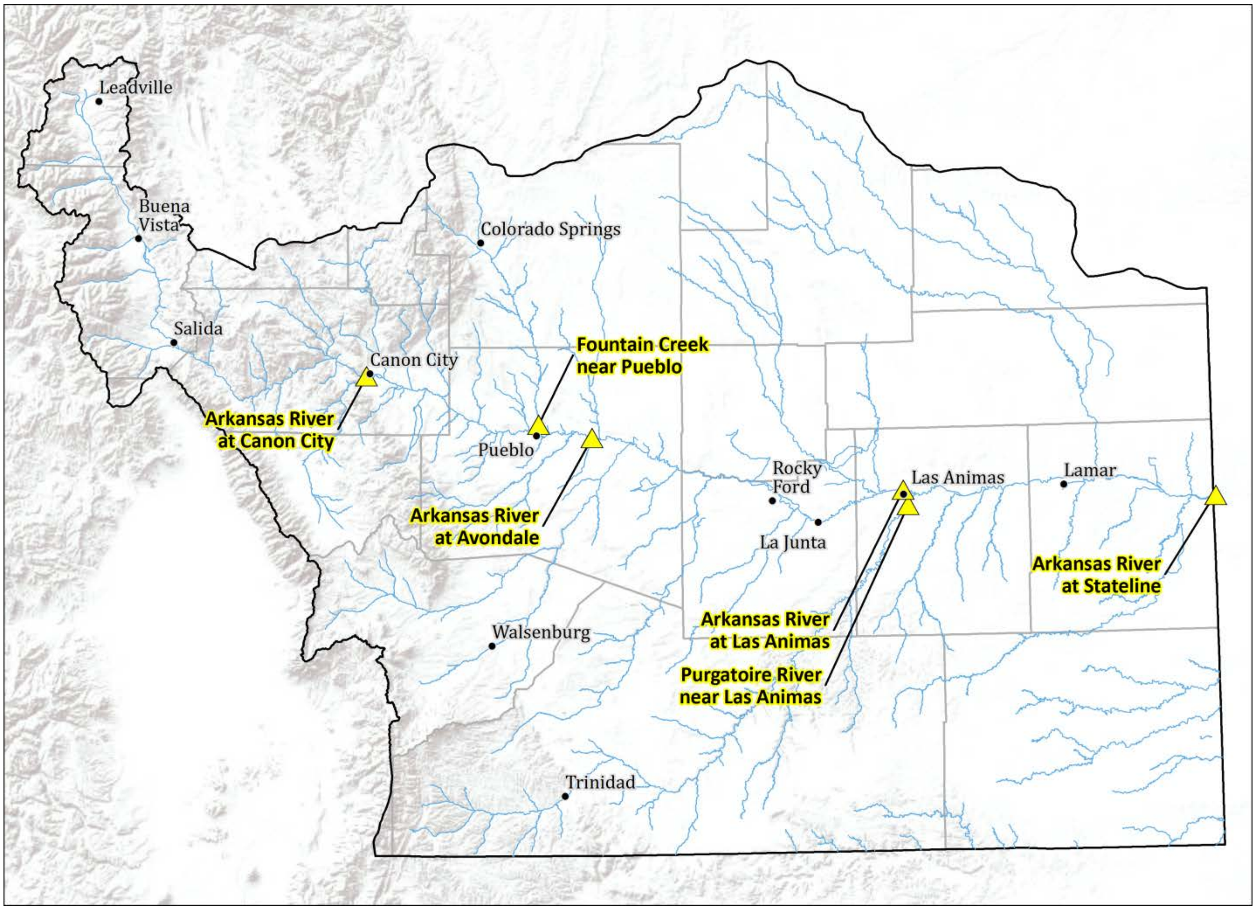
Table 3.3.7 - Summary of Data Sources.

Model Parameter	Data Sources
Tributary object monthly flows	USGS flow gages, statistical extension methods, GIS drainage area calculations
Reservoir bathymetry	AVC EIS Report (Reclamation 2013)
Reservoir capacities	Abbott Report (USGS 1985)
Reservoir evaporation rates	Western Regional Climate Center (http://www.wrcc.dri.edu/)
Online reservoir outflow curves	calibration
M&I water user demands	Abbott Report (USGS 1985); CO Springs SDS Report (MWH 2007)
M&I source water details	Abbott Report (USGS 1985); ArkDSS Feasibility Study (Brown and Caldwell 2011); CO Springs Water Tour Document, Fry Ark Return Flows and Exchanges Report (MWH 2008); City of Fountain Online Bulletin (www.fountaincolorado.org); City of Security Conservation Plan (WaterMatters 2011); Buena Vista – Salida Groundwater report (USGS 2005); Aurora Water Supply Fact Book (Aurora Water 2011); phone interviews (small cities)
M&I water rights and appropriation dates	Division 2 Line Diagrams (SE CO Water Conservancy District); Abbott Report (USGS 1985); AVC EIS Report (Reclamation 2013)
Ag canal aggregation	GIS mapping of diversion location, HydroBase data: lat/long location, historical annual diversion amounts
Ag user demands	HydroBase diversion records (1982 – 2012)
Ag user storage details	HydroBase (storage flags)
Ag user diversion appropriation dates	HydroBase (assigned based on appropriation date of largest individual diversion within aggregation)
Transbasin project details (yields, storage, ownership)	HydroBase, Abbott Report (USGS 1985); Fry Ark Report (MWH 2008); CO Springs Water Tour Document; CO Springs SDS Report (MWH 2007)
Major exchange program details	AVC EIS Report, Appendix D (Reclamation 2013); Division 2 Line Diagrams (SE CO Water Conservancy District); ArkDSS Feasibility Study (Brown and Caldwell 2011)

3.3.4 Model Calibration

The objective of any model calibration process is to lend confidence to model predictions of future conditions by demonstrating, and refining, the model's ability to replicate past conditions. For this study, the calibration exercise sought to achieve adequate model representation of mainstem flow at selected key downstream locations (Figure 3.3.2), as a function of upstream headwater and tributary inputs and basin operations and water use. Calibration points were selected based on available flow gage records and to achieve sufficient spatial coverage to allow for a spatial assessment of model performance. Calibration performance metrics include: annual average flow, monthly average flow, monthly flow percentiles, major reservoir storage, and water user shortages. These metrics provide insight into the model's ability to simulate, respectively: the overall basin water budget, seasonality in flow and water use, flow variability (including extreme events), reservoir flow regulation and operations, and individual water user supply and demand characterization. Calibration adjustment parameters were primarily ungaged flow gains/losses and online reservoir outflow-capacity curves. Uncertainty associated with both sets of parameters is considered relatively high, and, therefore, calibration adjustments are deemed appropriate. The calibration exercise was supported by USGS flow gage records and reported monthly reservoir storage levels for the simulation period (1982 – 2013).

Figure 3.3.2 - Arkansas River Model Flow Calibration Locations



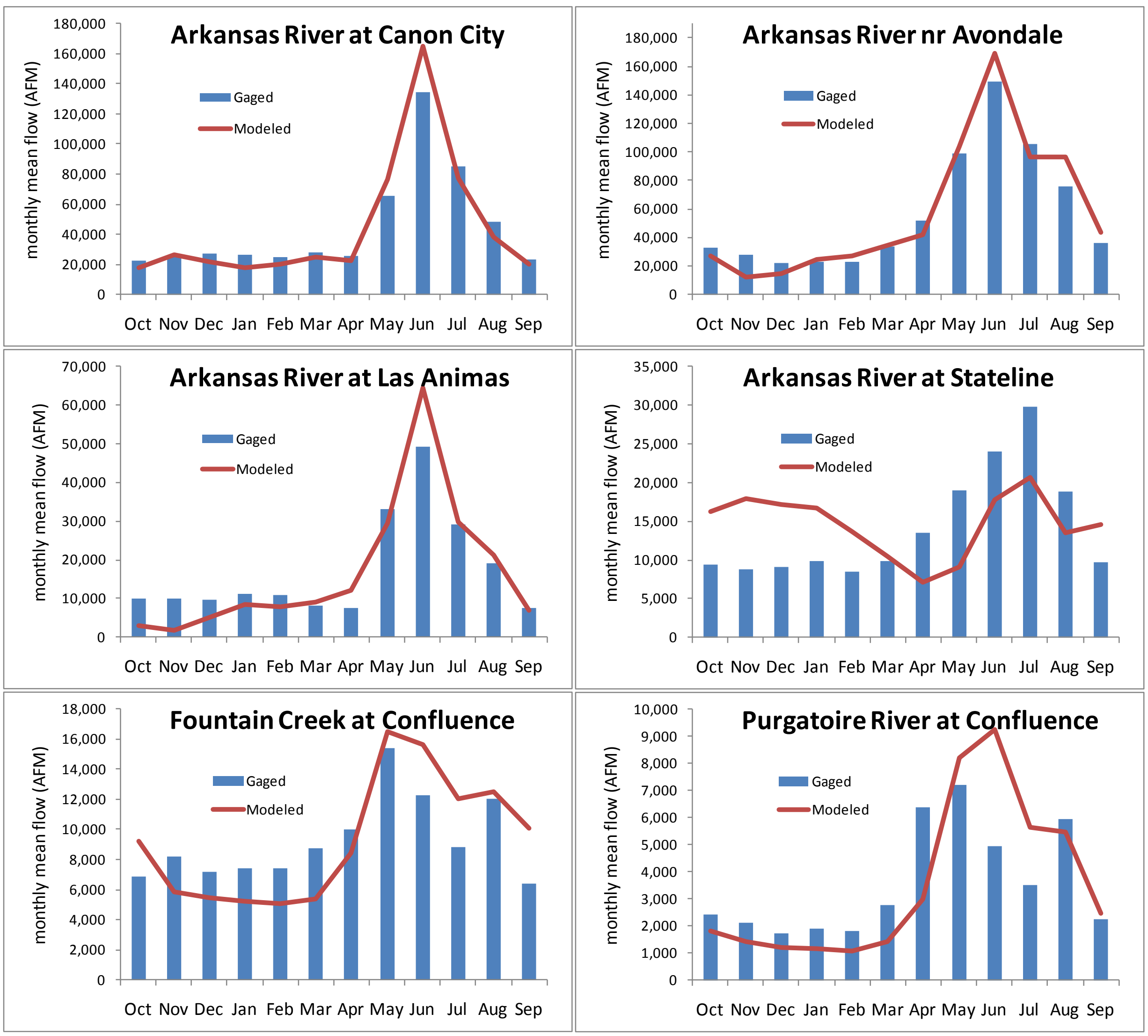
Calibration results are summarized in Table 3.3.8 and Figures 3.3.3 – 3.3.6. As shown, a good agreement between modeled and measured metrics is achieved. Differences between modeled and measured annual flows are all less than 5 percent. Monthly patterns of simulated stream flow generally match the patterns observed in the gage data. Similarly, percentile plots indicate that the model does an excellent job of capturing the range of monthly flow variability observed at multiple locations throughout the basin. Monthly storage values in the two major reservoirs, Pueblo and John Martin, are also well-represented by the model. Lastly, model predictions of agricultural shortages for the simulation period meet expectation. Since agricultural diversions in the model are parameterized based on average recorded diversion volumes for the period of record (but with variable hydrology), the predicted small, and infrequent, shortages (0 – 12 percent of the average demand) appear appropriate. For M&I water users, the model predicts that current demands are able to be met with the modeled supply portfolios throughout the simulation period (minor exception in Buena Vista).

Results of this exercise lend confidence to the use of the model for simulating future scenarios.

Table 3.3.8 - Preliminary Calibration Results

Gage Location	Mean Measured Flow (AFY)	Mean Modeled Flow (AFY)	Percent Difference
Arkansas River at Canon City	535,000	528,000	-1%
Arkansas River at Avondale	680,000	692,000	2%
Arkansas River at Las Animas	205,000	199,000	-3%
Arkansas River at Stateline	171,000	175,000	2%
Fountain Creek nr Pueblo	111,000	111,000	0%
Purgatoire River nr Las Animas	43,000	42,000	-2%

Figure 3.3.3 - Model Calibration Results, Mean Monthly Flows



CDM Smith

Figure 3.3.4 - Model Calibration Results, Monthly Flow Percentiles

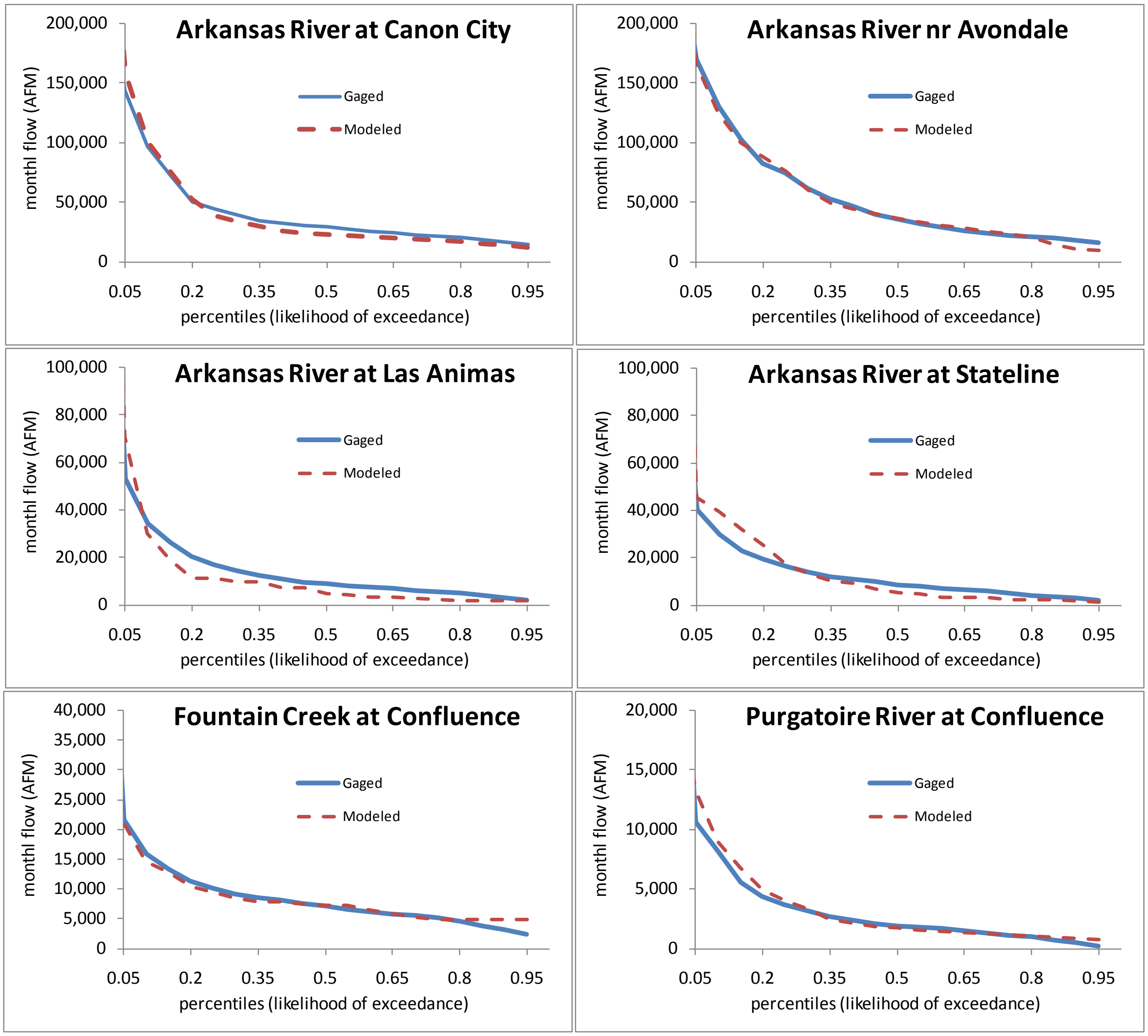


Figure 3.3.5 - Model Calibration Results, Reservoir Storage

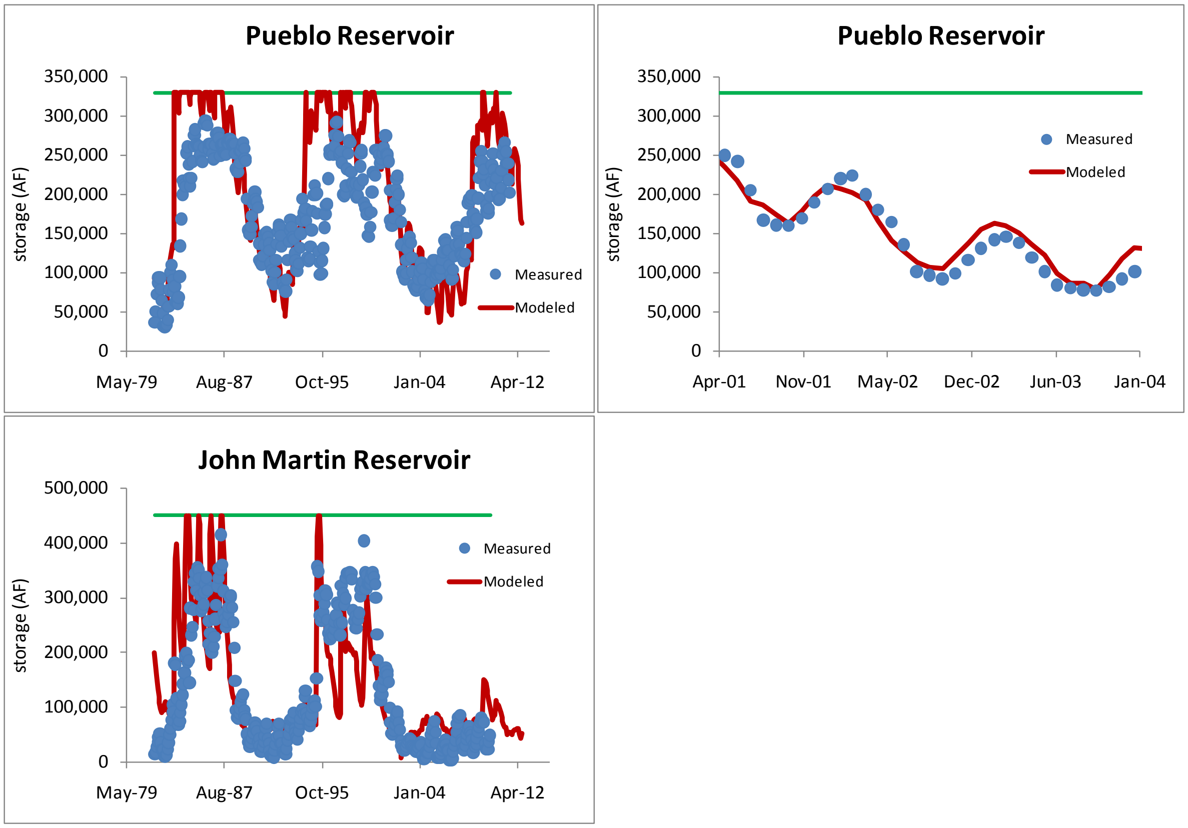
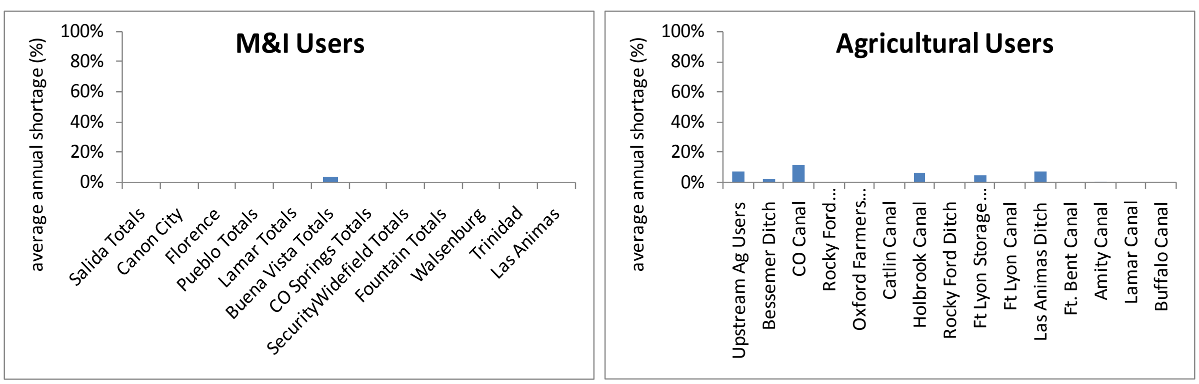


Figure 3.3.6 - Model Calibration Results, Water User Shortages



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3.4 Current and Future Shortage Analysis (Work in Progress)

3.4.1 Overview

The primary goal of this analysis is to assess water supply availability for a future planning horizon (2050) in the Arkansas River Basin. The Arkansas River Basin Model (discussed in Section 3.3) will be modified and used to analyze basin water availability and water user shortages.

The shortage analysis model will be based on the Arkansas River Basin Model and will simulate native flows, reservoir storage, water user demands, return flows, exchange agreements, and transbasin projects across a network of key locations, or nodes, in the basin. The model will be modified to simulate a range of hydrologic conditions subject to future demands. Model output will include physical availability of water (streamflows), legal availability of water (to identify legal constraints), reservoir storage levels, diversions, return flows, and water supply shortfalls. Output will be provided for locations throughout the basin on a monthly timestep.

As noted in Section 3.3, model simplifications are required to provide useful and practical simulations of basin water resources within constraints imposed by data, budget, and schedule limitations. These simplifications include aggregation of water use nodes and/or simplified representation of legal exchange agreements or operating rules. Simplifications made for the calibrated model will be carried forward into the shortage analysis model.

Note, it is anticipated that this current and future shortage analysis will be completed after the submission of the DRAFT Arkansas BIP to the CWCB. As a result, the following sections describe in further detail the shortage analysis approach, key assumptions, and data sources concerning hydrology, demands, and basin operations. This approach describes a single scenario; however, additional scenarios may be evaluated per the direction of the Arkansas Basin Roundtable.

3.4.2 Hydrology

A historical hydrology from 1982 – 2012 will be utilized for the shortage analysis. This 30-year hydrology data set will be the same as the calibrated model described in Section 3.3. The period between 1982 and 2012 includes a range of both wet and dry hydrologic conditions. Additional detail on the selected study period's variability can be found in Section 3.1.

3.4.3 Demands

M&I Demand

Future demand conditions will based on a "high growth" scenario developed as part of SWSI 2010 and will include passive conservation (see Section 4.2 and Appendix H of SWSI 2010). The SWSI 2010 projections were made at the county level; however, the Arkansas Basin Model explicitly includes individual M&I users represented as model objects (see Section 3.3 for more detail). The discrepancy in spatial representation of M&I water use requires a more generalized approach to future demand allocation. Specifically, each M&I water user model object will be assigned to a single county. For those M&I water user model objects that have representative service areas in multiple counties, a dominant county will be assigned based on the county with the largest proportion of water use for that M&I water user. The increase in county level M&I water demand from existing levels to 2050 (i.e., "delta demand") will be assigned to each existing M&I water user model object based on the proportion of existing water use represented by the M&I water user in that county. In other words, existing demands (as described in Section 3.3) will be increased so that total water demand represented in the model will be equal to that projected in the 2050 High Growth with passive conservation scenario described in SWSI 2010. This approach, while general, maintains an approximation of the spatial distribution of the projected growth. This results in an increase of basin-wide M&I demand from 215,550 AFY to 352,000 AFY, or an increase of 63 percent.

Crop Irrigation Demand

Similar to M&I demand, agricultural demands will be based on a 2050 planning horizon as projected by SWSI 2010. The SWSI 2010 crop irrigation demand projections were made at the DWR administrative water district level. Future agriculture water demand will be based on existing irrigation water requirement (IWR) estimates from SWSI 2010 except reduced to reflect estimates of planned agricultural to municipal water right transfers identified on the Identified Project and Processes list (approximately 7,000 acres) and estimates of land use conversion resulting from urbanization (approximately 2,500 acres). The SWSI 2010 agricultural projections also included unidentified agricultural to municipal transfers as a means to meet the projected 2050 M&I gap. In the Arkansas Basin "meeting the gap" through unplanned agricultural to M&I transfers resulted in an additional loss of approximately 45,000 irrigated acres by 2050. These unidentified transfers will not be included in the BIP shortage analysis. The above approach results in a reduction of acreage from 428,000 acres to 418,500; or 2.2 percent.

Agricultural demand projections in SWSI 2010 for crop irrigation are based on an IWR application rate of 2.32 AF/acre, which results in an estimated IWR in 2050 of just under 970,000 AFY (not including unplanned transfers). This represents a decrease in demand of 25,000 AFY compared to existing IWR levels of 995,000 AFY.

The Arkansas Basin Model requires input of headgate demand (or diversions). To convert SWSI 2010 estimates of IWR to estimated future headgate demand for the purposes of this shortage analysis a historical return flow factor (i.e., 43 percent) and historical canal loss factor (i.e., 20 percent) will be used. The equation for headgate demand is shown below.

$$\boldsymbol{Agricultural\ Headgate\ Demand} = \frac{\boldsymbol{Irrigation\ Water\ Requirement}}{(\mathbf{1} - \boldsymbol{Return\ Flow\ Factor}) * (\mathbf{1} - \boldsymbol{Canal\ Loss\ Factor})}$$

Similar to M&I demands, agricultural demands will be aggregated to the associated water user model objects. Specifically, aggregated water user model objects (as described in Section 3.3) will be assigned to a specific DWR administrative water district. For those aggregated model objects that have representative irrigated lands in multiple water districts, a dominant water district will be assigned based on the water district with the largest proportion of water use for the aggregated agricultural water user. Existing headgate demands will be modified so that total water demand represented in the model will be equal to that projected in SWSI 2010 for 2050 (not including unplanned transfer from agricultural to municipal). This approach will maintain an approximation of the spatial distribution of the projected agriculture water demand. The above approach results in a decrease of basin-wide headgate demand of 2,182,000 AFY to 2,120,000 AFY.

Return Flows

Return flows will be modeled based on typical return flow factors associated with each demand sector. For agricultural demands, the same return flow factor that is utilized to determine headgate demand will be input into the model to maintain consistency with the irrigation water requirement projections from SWSI 2010.

3.4.4 Basin Operations and Identified Projects and Processes

Basin Operations will remain largely unchanged in the shortage analysis model. Existing transbasin imports and exports will be assumed to remain constant, as described in Section 3.3. In addition, the four explicitly modeled exchanges will remain unchanged. Basin operations will be modified as needed to incorporate two large water supply projects currently under development and planning in the Arkansas Basin. These two projects are the Southern Delivery System (SDS) and the Arkansas Valley Conduit (AVC).

3.4.5 Shortage Analysis

Section to be completed after shortage analysis, which is currently ongoing.

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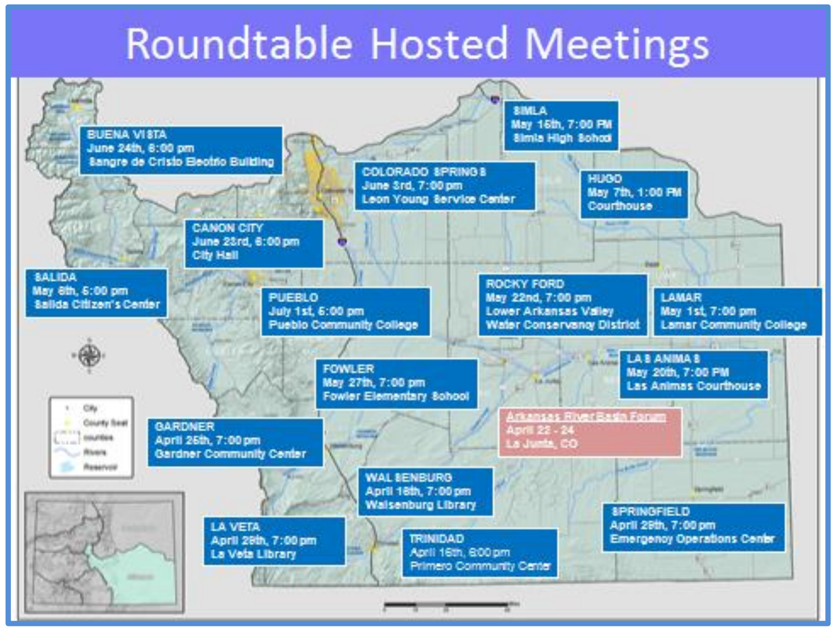
4.1. Education, Participation & Outreach

4.1.1 Introduction

Education, Participation and Outreach have been on-going in the Arkansas Basin Roundtable since its inception. The Public Education Public Outreach (PEPO) liaison attends meetings of both the Roundtable and the Executive Committee. Scholarships from PEPO funds have been made available to cover roundtable member's travel cost to statewide roundtable events. The Roundtable has also funded two topical conferences through Water Supply Reserve Account grants: 1) A two-day conference on Alluvial Aquifer Storage and Recovery held in 2007 in collaboration with the American Groundwater Trust, and; 2) A seminar in 2013 entitled *Valuing Colorado's Agriculture: A Workshop for Water Policy Makers.* The Workshop was organized by the Water Institute at Colorado State University in partnership with the Colorado Agricultural Water Alliance.



However, the Governor's call to action in May, 2013 prompted the Roundtable to take its education and public outreach to a higher level, by pursuing multiple outreach strategies. At the March, 2014 Roundtable meeting, members were given a diskette entitled "Charge to Roundtable Members." The diskette contained historic documents prepared by and for the Roundtable, maps, Colorado Water Conservation Board guidance documents and information about Colorado's Water Plan. The Chair of the Roundtable provided a memorandum asking the members to organize meetings within their local area, offering a draft powerpoint presentation, agenda and an input form, requesting that basin residents offer their perspective on addressing the needs of the Arkansas Basin.

The Executive Committee reached out to the premier watershed event in the basin, the annual Arkansas River Basin Forum. In a series of coordination meetings with the PEPO team, and supported by CWCB staff, the Forum agreed to focus its three-day program on the Arkansas Basin Implementation Plan and Colorado's Water Plan. In the meantime, the PEPO group established a website, arkansasbasin.com, drafted public service announcements and began to promote interest in the process in local media.

4.1.2 Outreach Initiative

The Arkansas Roundtable's Outreach Initiative was coordinated by the PEPO team and the Nonconsumptive Needs subcontractor, CH2MHIll. The rationale was that many citizen's first impressions of "water" are based on their recreational uses of water. The presentations included reference to all topic areas, but the draw was recreation and the environment. The presentation included a request for completion of an input form and information on how to find the website.

Individual roundtable members organized the local meeting, with conservancy districts, utilities, non-profits and government agencies supporting the effort, usually through free venues and refreshments donated in-kind. As Figure XXX reveals, the meetings covered all geographic areas of the Arkansas Basin. The materials, powerpoint side show and blank input form are included in Appendix XXX. The over 100 Input Forms received are collated by sub-region and included in a separate section of the appendices for this Section 4.1. Overall, the Outreach Initiative was a great success.

4.1.3 Arkansas River Basin Forum

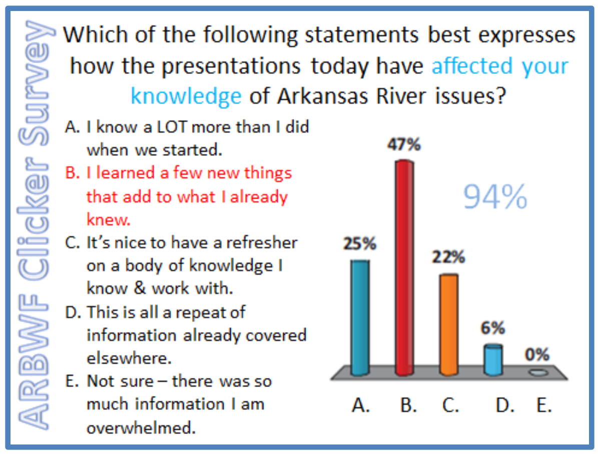
Holding its first event in 1995, the Arkansas River Basin Forum is closing in on its second full decade of bringing diverse water interests together for a fruitful dialogue. The Forum's website provides an excellent summary of both its objectives and the congruence with the Roundtable's education and outreach efforts.

The 2014 Forum was held at Otero Junior College in La Junta, Colorado on April 23-25th. The Keynote Speaker was James Ecklund, Executive Director of the Colorado Water Conservation Board, who articulated the purpose and rationale for Colorado's Water Plan. The agenda for the Forum is included as Appendix XXX. One session panel focused on other basin Roundtables, moderated by the Director of Compact Negotiations John Stulp, and included participation by the South Platte, Gunnison, Rio Grande and Colorado Basin Roundtables. Members of the Arkansas Roundtable Executive Committee presented in a panel entitled "How Did We Get Here?" followed by a panel made up of the team drafting the Basin Implementation Plan, entitled "Where Do We Go Next?"

At the conclusion of the Forum presentations, attendees were asked to participate in a survey session using clicker technology to provide feedback on the draft elements of the Basin Implementation Plan. The results of the survey are included as Appendix XXX. Three quarters of respondents stated they either knew " a LOT more" or "a few new things" as a result of the event. The entire program was recorded and is available on-line through a link on arkansasbasin.com or the Forum's website, www.arbwr.org.

Forum Objectives

- *The Arkansas River Basin Water Forum serves as a conduit for information about the Arkansas River Basin in Colorado, and for issues related to water allocation and management.*
- *The objective of the Forum is to promote open dialogue among water users and the general public, thereby creating a greater understanding of Colorado water law, beneficial water use, and principles of water conservation.*
- *Through this dialogue, the Forum seeks to find common ground between the primary water users in the basin. The Forum particularly targets agricultural, municipal, industrial, environmental, recreational, and governmental interests in the basin.*
- *The Forum is a friendly, constructive medium where individuals and organizations are able to explain their views and engage in open dialogue with other water users in the basin.*



4.1.4 Public Education, Public Outreach (PEPO) work plan

In 2014, the Public Education, Participation and Outreach Workgroup (PEPO) of the Arkansas Basin Roundtable began working in coordination with Roundtable members to reach out to citizens and stakeholders within the Arkansas Basin. Members of the PEPO developed and continue to maintain the website.

Looking toward 2015, PEPO has various strategies and actions designed to achieve critical priorities within the Basin. PEPO aims to define target audiences for continued engagement during the finalization of the Arkansas Roundtable's BIP. PEPO plans to participate in the 2015 Arkansas River Basin Water Forum as well as participate in the August 29th Water Resource Review Committee hearing in the City of Pueblo. Summarizing the Arkansas Basin Implementation Plan in clear and concise language is crucial to continued education and collaboration with a variety of participants within the Arkansas Basin. PEPO will invite targeted audience members to attend public outreach meetings at which feedback from targeted groups and general public will be collected. A review of the input will be received from outreach activities and be incorporated in the refinement process as deemed appropriate by the Arkansas Basin Roundtable. Through these various methods of reaching out to public, PEPO will encourage productive partnerships among community leaders, media outlets, and active citizen groups to support collaboration across the basin.

4.1.5 Public Meetings held April – July, 2014

A total of 17 public meetings were held around the Arkansas Basin. The schedule, attendance rosters and a typical presentation are included in Appendix XXX. Over 100 Input Forms were generated. These have been logged and sorted by sub-region and are included in Appendix XXX. In response to the statement " *The Arkansas Basin needs: ____________,"* the input ranged from detailed spreadsheets of potential projects generated by a state agency to individual comments like:

- *"The Plan should have a conveyance efficiency component. All municipal distribution systems a) Leak, b) are aging, and c)need funding to address both."*
- *"Maintaining the same level of water quality that we enjoy now. I strongly believe that more storage capacity should be developed. Continued pro-active management and effective wastewater treatment; Permits for construction of new storage capacity should be facilitated instead of tied up in bureaucratic red tape."*
- *"Reuse/conservation projects; Joint/shared infrastructure projects; New water supply projects."*
- *"Watershed health."*
- *"The upper lake (western) of Twin Lakes is a dust bowl where barren land is exposed when the lakes are low….. this is an eyesore."*
- *"Meet non-irrigation water requirements which occur outside of incorporated municipalities. Such needs were generally ignored by SWSI."*
- *"Wildland fire mitigation and fuel removal at headwaters area of Cucharas River."*
- *"Improve conservation education efforts of Front Range residents—watering lawns—incentives to reduce lawns in suburbia—incentives for xeriscaping for developers not to install such massive lawns. Start grassroots—kids to parents."*
- *"Consistent water rights administration with transparent exchanges (of the paperwork variety)."*
- *"The Arkansas Basin is over-appropriated and based on that we should do everything possible to keep water rights in the basin."*
- *"1. Storm water management on Fountain Creek; 2. Improved Water Administration Tools; 3. Preserve the irrigated agricultural economy of the Arkansas Valley."*
- *"Nonconsumptive – Tamarisk removal for waterways, repair of headgate by Colorado Parks and Wildlife at Two Buttes Reservoir; Consumptive – Irrigation reality – less water intensive crops for future over time; possible aquifer recharge research; ability to participate in rotational fallowing; more public education to condition of water supply (decreasing availability); recognition that farmers are best equipped to determine value of water that they use; oil & gas – produced water – Baca Co. has salt water which would be beneficial if used on gravel roads."*

Overall, the Outreach initiative was a great success, but the information must be processed and understood. The Roundtable is committed to that effort[1].

4.1.6 Summary and Challenges

The monthly meetings of the Arkansas Basin Roundtable are open and each session includes an opportunity for public comment. Decision making, including financial support of grant requests, is by consensus. As public awareness of both Colorado's Water Plan and the Arkansas Basin Implementation plan increase, the Roundtable may be challenged by the volume of public input. However, the combination of an on-going partnership with the Arkansas River Basin Forum, an enthusiastic PEPO team and the sincerity of its individual members means the Roundtable will remain adequate to the task of education, participation and outreach to the citizens of the Arkansas Basin.

[1] See Section 5 for greater detail

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Figures

Appendices

4.2. Watershed Health

4.2.1. Introduction

The Watershed Health section was added to the BIP scope of work at the July 2013 CWCB meeting at the suggestion of CWCB member Travis Smith. At the time, fires in the Rio Grande Valley threatened the Rio Grande Reservoir, highlighting the critical relationship between watershed health and key water supply infrastructure. Additionally, the experiences of the Rio Grande Valley during the West Fork Complex fire demonstrated the importance of effective partnerships between communities before, during, and after events that impact watershed health. Inclusion of the watershed health in the BIP scope of work was an acknowledgement about the importance of broad, landscape-level perspectives when considering water supply management into the future. Watershed health is closely linked with nonconsumptive values and plays a major role in meeting M&I and agricultural water supply gaps.

Watershed health data was not included in SWSI 2010 efforts. However, in preparing the watershed health section of the BIP, the Arkansas Basin Roundtable approached the subject with first-hand experience from the 2012 Waldo Canyon Fire and subsequent post-fire flooding. In discussion with Colorado Springs Utilities, a decision was made to approach this topic through a facilitated dialogue with state, federal, and non-governmental representatives with expertise in forest and watershed management. The goal was to capture experiences and lessons learned from Front Range communities about fires, floods, and the interconnected relationship between watershed health and water supplies in the Arkansas Basin and beyond. The Watershed Health Working Group (Working Group) was scoped and funded through a Water Supply Reserve Account grant with an in-kind contribution from Colorado Springs Utilities. The Working Group brought together basin roundtable members, representatives from federal and state natural resource agencies, NGO stakeholders, and local government officials. This interbasin, interagency collaborative group had a limited timeframe and was focused on identifying priorities, strategies, and next steps to manage watershed health for the protection of water resources. The group also worked on strategies to improve communication and collaboration between entities responding to watershed health-related threats and events.

4.2.2. Scope of Work and Schedule

The vision for a Watershed Health Working Group had the following goals: 1) invite state, federal, and non-governmental organizations to actively participate in the process of formulating watershed health plans; 2) capture the experience of stakeholders and consumptive water users from the past decade of fire suppression and post-fire mitigation and recovery in Colorado; 3) develop an action plan to guide the next steps of the Arkansas Basin in future watershed health management activities; 4) develop a series of "how-to" documents to guide stakeholders statewide through the life cycle of a threat or emergency event with impacts to watershed health; and 5) develop a series of maps with input from the Watershed Health Working Group, key stakeholders, and the public that illustrated watershed health values and threats in the Arkansas Basin.

Five Working Group meetings, ranging from three to five hours in length, were held in Pueblo and Colorado Springs between February and July 2014. Additionally, in May 2014, the Working Group hosted a webinar that featured presentations from speakers with expertise in planning for and responding to wildfire and post-fire flooding events.

Early meetings focused on developing definitions and methodologies for assessing watershed health and identifying key partners. Work then shifted to identifying key values and threats associated with watershed health and identifying data sources to inform future assessments. Mapping exercises were held at the group's third meeting to identify key values and threats related to watershed health in the Arkansas Basin. The webinar, held in May, was focused on gathering information about planning strategies and lessons learned from individuals with experience in managing wildfire and post-fire flooding events. The group's June meeting was primarily dedicated to development of a Watershed Health Action Plan for the Arkansas Basin and a series of "how-to" documents for stakeholders dealing with watershed health threats statewide. The July meeting focused on refining and finalizing the Arkansas Basin action plan and "how-to" documents for inclusion in the draft BIP.

See Appendix 4.2.A to read summaries from all of the Working Group meetings. Appendix 4.2.B is the summary of the May webinar.

4.2.3. Outreach

Outreach was fundamental to the process. The Arkansas Basin Roundtable extended invitations for participation to multiple parties.

4.2.3.1 Outreach to Other basins

The Arkansas Basin Roundtable initiated a Water Supply Reserve Account grant application to fund the Working Group process. Due to the relevance of the topic for all of the state's watersheds, the leadership of the Arkansas Roundtable reached out to the chairs of all nine basin roundtables via email to inform them of the creation and scope of work of the Working Group and to invite them to participate. Additionally, in-person presentations were made to the Metro and South Platte Basin Roundtables, as these basins have experiences with the impacts of wildfire and watershed health on water supply that are similar to those in the Arkansas Basin.

In addition to members of the Arkansas Basin Roundtable, members from the South Platte, Metro, and Rio Grande Basin Roundtables have participated in meetings. The webinar benefitted greatly from presentations by water providers and NGO leaders from the Arkansas, South Platte, Metro, and Rio Grande Basins, and participants in the webinar represented these basins as well as the Colorado and Gunnison. Additionally, members from several basin roundtables expressed support for the Working Group and requested to be kept informed of the group's progress. The technical contractors of several basin BIPs have been either participating in or tracking the Working Group's progress to determine whether and how the group's work can inform the Watershed Health chapters of their respective BIPs. "How-to" documents prepared by the Working Group will be shared with chairs and BIP contractors of all of the basin roundtables in July 2014 for their consideration as they consider revisions and/or additions to their draft BIPs.

4.2.3.2 Outreach to Federal, State and Non-Governmental Organization (NGO) Partners

Representatives from more than 40 state, federal, and nongovernmental organizations participated at some level in Watershed Health Working Group. Some individuals actively participated in the Working Group meetings and/or the webinar, while others were considered "interested parties" who did not regularly attend meetings but contributed information to the group or stayed abreast of the process through emailed documentation. The US Forest Service, the Natural Resources Conservation Service, the US Army Corps of Engineers, and the Bureau of Land Management have been particularly engaged in meetings and in the webinar, bringing critical knowledge, experience, and perspectives to the group's discussions.

At the state level, the Colorado Water Conservation Board, the Colorado Department of Natural Resources and Colorado Parks and Wildlife have also actively participated, sharing their ideas and perspectives with the group. The Colorado State Forest Service and the Colorado Division of Fire Prevention and Control provided critical information to the Working Group's understanding of how to plan for and respond to wildfires using tools and protocols developed at the state level. Additionally, members of the Colorado Legislature have expressed an interest in the efforts of the Working Group and have invited a presentation on the outputs and outcomes of the process before the Water Resources Review Committee in August 2014.

From the nongovernmental sector, the Working Group benefitted greatly from contributions of time and wisdom from several groups, particularly the Coalition for the Upper South Platte and the National Forest Foundation. Representatives from these groups have provided helpful information in meetings and on the webinar to advance the Working Group's understanding of how these and other groups can assist in planning, response, and recovery related to wildfires.

See Appendix 4.2.C for a complete list of entities and agencies that have participated or been interested parties to the Working Group's efforts.

4.2.4. Learning in the Process

The Watershed Health Working Group has learned a tremendous amount in a short period of time. The overarching lesson has been that there is a lot the group does not know, and there is a lot of work still to be done to ensure proper planning and protection of values in the watershed. This overarching lesson can be broken down into more focused lessons in two topic areas: 1) values, threats, and action planning, and 2) event life cycle, associated tools, and collaboration. The lessons learned in each of these topic areas are described below.

Values, Threats, and Action Planning

The Working Group was aware from its inception that there are many values that merit protection and/or restoration in the Arkansas Basin. These values can have either direct or indirect impacts on water supplies for both consumptive and nonconsumptive uses. Key values identified by the Working Group during their early meetings are shown in meeting summaries in Appendix 4.2.A and included water supply infrastructure, human safety and property, agriculture and prime farmland, ecosystem resilience, and wildlife habitat (both as an intrinsic value and as an important part of recreation economies), as well as transportation, energy, power, and communication infrastructure. In a breakout session at the Statewide Basin Roundtable Summit in March of 2014, a diverse group of more than 30 participants helped calibrate the process by brainstorming the types of values that could or should be protected in a given watershed. Some of the commonly cited values in this group included diversion structures and other infrastructure for ensuring the quantity and quality of water supplies, agricultural lands, wildlife habitat and riparian vegetation, oil and gas wells and other energy-related infrastructure, and terrestrial and aquatic recreation. The session participants also identified multiple threats to these values, particularly wildfire, post-fire floods and associated impacts, and invasive species (insects and plants).[1]

Building on this work, the group's GIS mapping expert developed a methodology to inform the creation of base maps to assist with further value identification. Water supply and water quality were conceptualized as a nexus for the watershed health values represented in the maps. Water supply was categorized further to represent values for municipal and industrial (M&I) entities, agriculture, the environment, and recreation. Maps were generated for each of these categories. Threats to watersheds were also considered in the following categories: catastrophic fire, flooding (pre- and post-fire), contamination/degradation, insects, and disease. A separate map was generated to represent these threats. Data sources for the maps included the Colorado Wildfire Risk Assessment Portal (CO-WRAP), Federal Emergency Management Agency (FEMA) floodplain maps, Colorado Department of Public Health and Environment (CDPHE) source water protection data, state stream impairment data, Natural Resource Conservation Service (NRCS) land use data, and forest insect and disease data from the Colorado State Forest Service (CSFS). A focus was placed on State of Colorado data sources.[2]

The Working Group then identified specific points on the maps where water supply values, environmental and recreation values, and agricultural values exist. For each value, the group indicated whether those values are at risk, what the source of the risk was, and how the risk was identified. In April 2014, participants at the Arkansas Basin Water Forum were invited to identify additional values, as were members of the Arkansas Basin Roundtable at their meeting in June 2014. These maps and the associated value information are a work in progress and will be finalized at the July 2014 Working Group

[1] The complete list of values and threats identified at the Statewide Summit is available in Appendix 4.2.D.
[2] The full methodology for the mapping exercise is available in Appendix 4.2.E.

meeting as the starting point for a broader stakeholder process to identify additional values (see below).[3]

Although the mapping exercise is not yet complete and may not yield complete results until later in 2014, it has already become clear to the Working Group that while important values are located throughout the Arkansas River watershed, areas identified as high risk for fire as well as important water supply points are concentrated in the middle and upper reaches of the watershed. Furthermore, these same reaches have a high correlation between the increasing jurisdiction of federal lands and decreasing size of population centers. This underscores the importance of working with federal partners to mitigate fire risk as well as encouraging collaboration and data sharing between rural communities to build resource capacity to address forest management on a regional scale. Post-wildfire flooding in the middle and upper reaches of the Arkansas River watershed has the potential to cause severe impacts to literally cascade down through the rest of the watershed. Lower Arkansas Basin watershed issues will change dynamically depending on upstream impacts to the watershed, such as fire, land use, and pollutants. Further assessment on landscape condition, biological diversity, disturbance regimes, and hydrology could help fully understand the linkages between watershed health and water supply as well as inform management strategies to protect functioning water supply watersheds.

Participants at the breakout group discussion of the March 2014 Statewide Basin Roundtable Summit identified barriers to protecting key watershed values and partners to help overcome those barriers. Building on this work, the Working Group developed an action plan outlining steps that need to happen in the short, medium, and long terms to plan to protect and restore watershed health in the Arkansas Basin. The action plan includes tasks related to collaboration, assessing current conditions, planning for fire and flood, and preliminary project implementation to foster resilience in the watershed. Early steps focus on creating one or more collaborative stakeholder groups (depending on desired scale and scope) to pick up where the Working Group left off in value identification, with specific actions related to gathering input and guidance from diverse leaders throughout the watershed on how create and frame an effective collaborative group. Additionally, there are many action items related to gathering data to inform planning efforts for fire and flood, as the Working Group learned that while there is a great deal of data available in the Arkansas Basin and statewide, the available data sets are not all in the same place, not all of the data is compatible, available data is often too old to be helpful, and many necessary data sets do not exist at all or do not exist at the scale necessary to be useful. Related action items involve reaching out to water providers, ditch companies, watershed groups, and state and federal agencies to request data, to get input into data layers, and/or to solicit cooperation in future planning efforts. Finally, there are action items related to developing plans to protect high-value assets and resources in the watershed from threats like fire and flood and pursuing new projects with diverse partners to advance watershed health and other interests.

[3] The complete set of values maps and associated tables that further describe the value points on the maps are available in Appendices 4.2.F and 4.2.G.

The Working Group believes that the tasks outlined in the action plan can and should be initiated and led by collaborative groups in the watershed--groups through which water providers, agricultural producers, environmental advocates, and local, state, and federal agencies bring their respective expertise and experience to a shared commitment to protect and enhance watershed health in the Arkansas Basin.[4] The Working Group also hopes that other basin roundtables and collaborative groups can use the action plan as a starting place for their own efforts to develop a path toward better understanding, planning, and implementation for healthy and resilient watersheds.

Event Life Cycle, Associated Tools, and Collaboration

At the first meeting of the Working Group, representatives from several state and federal agencies told the group about the existence of multiple tools, processes, and procedures that exist to help with planning and response to wildfire. Other members of the Working Group expressed interest in learning more about the tools and procedures that currently exist, but it was difficult to remember them and to distinguish one from the other across multiple discussions in multiple meetings. The May webinar aimed to address this problem: the goal of the webinar was to provide high-level overviews of multiple tools and processes all at once so participants could see them next to one another, begin to differentiate between them and, most importantly, to understand how they fit together.

Figure 4.2.4-1 outlines what the Working Group identified as the Watershed Health and Emergency Event Life Cycle. Overall, the Working Group determined that there is typically a precipitating event that should trigger a *Collaborative Dialogue with Community and Key Stakeholders* (more on this below). In the Arkansas Basin, the BIP process was the precipitating event, but a fire could also serve as a precipitating event, as could a simple invitation to collaborate by an entity interested in getting ahead of a potential threat or event. The collaborative group should include municipalities, counties, fire protection districts, federal agencies, state agencies, nongovernmental organizations, educators, and other entities or individuals as appropriate; precise membership and representation should be tailored to the specific watershed.

No matter how it begins, the collaborative dialogue is the venue in which additional identification of values and threats and pre-event planning should occur through state-level tools like the Colorado Wildfire Risk Assessment Portal (CO-WRAP) and the development of Community Wildfire Protection Plans (CWPPs). Values and plans that emerge from these collaborative processes can help get critical values to protect highlighted in the US Forest Service's Wildland Fire Decision Support System (WFDSS) and ensure that the USFS fire-fighting efforts understand local priorities. These and other types of *Condition Assessment and Data Gathering*, *Coordinated Planning and Event/Threat*, *Resilience Initiatives*

[4] The action plan is available in Appendix 4.2.H. Appendix 4.2.I is a blank action planning document to assist other groups interested in undertaking a similar exercise.

and Pre-Event Mitigation are important efforts that need to occur prior to a wildfire or other event, and they need to occur at the community level.[5]

If and when an event occurs, a series of response protocols are initiated at the local, state, and federal levels. The Working Group learned through the May webinar that unless a person is aware of them before an event occurs, these protocols can be unclear, hard to follow, and overwhelming. Based on information provided during the webinar from the Colorado Division of Fire Prevention and Control, Graphic 4.2.4-2 was developed to assist communities in understanding and preparing for wildfire response from a variety of agencies. Graphic 4.2.4-2 indicates that fire response progresses from the local to county to state to federal authorities, depending on the type of land that is burning and the scale of the event.[6]

As the event life cycle continues (e.g., after a wildfire has been extinguished), a new type of work begins and must be again driven by the community through the stakeholder collaborative process. The stakeholder group can and should help identify, fund, and implement *Immediate Post-Event Mitigation* efforts, *Mid-Term Event Mitigation* efforts, and *Watershed Restoration and Sustainability Initiatives.*

[5] Appendix 4.2.J is a table that provides more detail on the tools that can be used in each stage of the event life cycle and processes that have occurred during each stage as well.

[6] Appendix 4.2.K is a version of Graphic 4.2.4-2 that includes space for communities to write down the names and contact information for the key contacts at each level of fire-response authority.

Figure 4.2.4-1. Watershed Health and Emergency Event Life Cycle

Once these initiatives are underway, communities should continue to assess conditions, review values and threats, and revise plans through their stakeholder collaborative dialogues. The event life cycle never ends, because values and priorities shift and threats change. The most important component of the event life cycle is that the community stays engaged in order to stay ahead.

At meetings and during the webinar, the Working Group heard one message louder than any other: watersheds with an existing stakeholder collaboration fare better before, during, and after an event than those without such a group. These watersheds have the relationships, the trust, the networks, and the skills to mobilize people and funding better and faster than those watersheds without collaborative groups. This message was volunteered through Working Group meetings from a variety of people who work in different types of entities around the state, including local water providers, state water program staff from multiple departments, federal agency staff working in multiple capacities, and local watershed coordination leaders. These periodic but important statements led to an invitation to several speakers to address collaboration and stakeholder engagement during the webinar. One after another, webinar presenters consistently reaffirmed the importance of stakeholder collaboration before an event. People in a watershed must know the individuals and entities who will respond to an event, who will be impacted by an event, who can help educate others about an event, and who can help restore the watershed to mitigate the risk of future events.

The Coalition for the Upper South Platte (CUSP) was cited by multiple speakers as an example of an organization that leads these types of efforts and serves as a nexus of planning and response efforts. A representative from CUSP offered her organization's assistance to others who might want to establish similar groups in their own watershed.[7] The Working Group also learned that several memoranda of understanding have been developed between federal agencies like the US Bureau of Reclamation and the US Forest Service and local entities such as water providers and nonprofit organizations to reduce the risk of fire through fuels mitigation, to plan more coordinated responses to future events, and to establish a mechanism for collaborative repair of damaged infrastructure. Whatever the format, the Working Group has heard loud and clear that collaboration is the name of the game in watershed health. For this reason, as was mentioned above, early action items identified by the Working Group focus on establishing one or more collaborative stakeholder groups in the Arkansas Basin. The Working Group strongly recommends that similar groups be established in other watershed where they may currently be lacking.

4.2.5. Deliverables as of July 31, 2014

Watershed Health Working Group deliverables as of July 31, 2014, can be found in Appendix 4.2 and include the following:

Appendix 4.2.A: Watershed Health Working Group In-Person Meeting Summaries

Appendix 4.2.B: Watershed Health Working Group Webinar Summary

Appendix 4.2.C: Watershed Health Working Group Participating Agencies and Entities

Appendix 4.2.D: Watershed Health Values and Threats Identified at the Statewide Basin Roundtable Summit

Appendix 4.2.E: Watershed Health Value and Threat Mapping Methodology

Appendix 4.2.F: Watershed Health Mapping Points of Interest

Appendix 4.2.G: Watershed Health Value and Threat Maps

Appendix 4.2.H: Draft Watershed Health Action Plan for Arkansas Basin Roundtable

Appendix 4.2.I: Draft Watershed Health Action Plan Template

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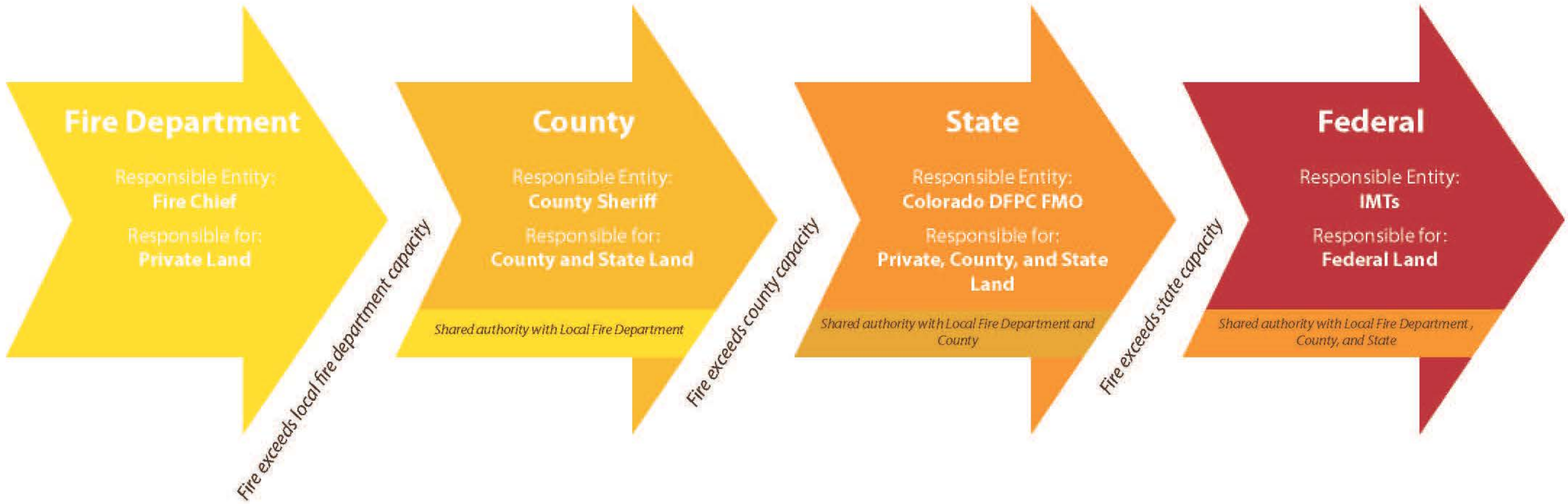
[7] Appendix 4.2.L includes CUSP resources as examples to assist in creating a collaborative stakeholder group.

Appendix 4.2.J: Draft Watershed Health Life Cycle Tools and Processes

Appendix 4.2.K: The Progression of Authority for Wildfire Response

Appendix 4.2.L: CUSP Resources for Creating a Collaborative Stakeholder Group

Figure 4.2.4-2. Progression of Authority for Wildfire Suppression Response on Private Land*



* For wildfires that begin on county, state, or federal land, the process will begin at the county, state, or federal level, respectively.

4.2.6. Summary and Challenges

The Watershed Health Basin Plan Working Group set out to bring agencies and entities together to explore watershed health issues, develop value maps, create an action plan for the Arkansas Basin, and outline what they learned so other roundtables or community groups could start farther ahead in the process. Based on its experience, the Working Group can identify several key conclusions and associated next steps; these are listed below. Other next steps are outlined in the action plan in Appendix 2.4.2-D.

1. Collaboration
   - **a.** Conclusion: Every watershed or sub-watershed should have a collaborative stakeholder group in place to build relationships among entities and individuals in the watershed, to plan for events, respond to events, and to facilitate restoration and recovery after an event.
   - **b.** Next Step: One or more collaborative stakeholder groups will be established in the Arkansas Basin in 2014 and 2015. To maintain the momentum in this direction, the Working Group will initiate the planning process to create a watershed coalition in the Upper Arkansas Basin in August 2014.
2. Planning
   - **a.** Conclusion: Planning before an event occurs is critical. Many tools exist at the state and federal levels to assist communities in planning and preparing for an event.
   - **b.** Next Step: One or more collaborative groups will continue wildfire mitigation and response planning for the Arkansas Basin in 2014 and 2015, building on the efforts of the Working Group.
3. Data
   - **a.** Conclusion: Having recent and accurate data at the right scale in the right format and all in the same place is the bedrock of watershed health planning.
   - **b.** Next Step: One or more collaborative groups will continue outreach to water providers, ditch companies, watershed groups, state and federal agencies, and other groups and entities as needed to continue to gather and integrate data to develop the most complete data set possible for the Arkansas Basin.

Working Group members have expressed an interest in remaining involved over time, as new collaborative groups form and begin to address the data and planning challenges that exist in the Arkansas Basin. The individuals who have been engaged in the Working Group process for the past six months have become acutely aware that watershed health is an expansive issue that is much larger than wildfire and fire-related flooding. Additional issues like wildlife habitat, wetland health, water quality, erosion, flooding, mine reclamation, and ecosystem services remain critical components of the watershed-level dialogue that is needed in the Arkansas Basin and elsewhere throughout Colorado. Although these issues were outside the purview and timeframe of their work together, Working Group members are steadfast in their commitment to seeing these and other important watershed issues elevated to the attention of Basin leaders and reflected in resource management and response plans throughout the Basin. Additionally, the Working Group believes that ongoing education and outreach about the importance of watershed health is a critical task that should be part of the work of any new collaborative. Education and outreach should also be integrated into the work of multiple entities throughout the Arkansas Basin, because ensuring that everyone understands that watershed health is the foundation of the health, safety, and vitality of our human and natural communities is a responsibility we all share.

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4.3 Conservation Projects and Methods

4.3.1 Introduction

When the pioneers came to Colorado, they staked claim to water, Colorado's most precious natural resource. By the 1880s, virtually all the water in the Arkansas Basin that flows from the mountains into the rivers had been claimed. That was 130 years ago! To stretch water supplies, large lake-size reservoirs were built so water could be captured in times of plenty in the spring to be used in time of scarcity and drought in the summer. Reservoirs were used to address disastrous flooding. After reservoirs were in place, pipes and tunnels were built to bring water from the Western Slope of Colorado because most of the water in Colorado is on the Western Slope, while most of the people in Colorado live on the Front Range. Water wells were drilled to make use of groundwater. Rainfall recharged the water being pumped from the ground, except during times of drought, when there was not enough rainfall to recharge the groundwater. Given the amount of rainfall needed to recharge the wells, as many wells have now been drilled as most experts find practical. Coloradoans are now living in the era of "efficiency improvements". It makes sense for every water user to pursue increased efficiency in every way they use water. Water is precious. However it's used, use it thoughtfully. Everyone must support solutions for the future. If Coloradoans can do this, Colorado will have water for generations to come.

4.3.2 Recent History of Urban Water Efficiency Planning

In 2006 the state legislature took a leadership role by encouraging municipal water users to update their water efficiency plans. Large water users were required to update their efficiency plans, while smaller water users were encouraged to create an efficiency plan. The state provided grants to defer costs of writing the plans. The planning process requires each water entity to consider certain factors, and decide if those factors are a fit for each individual community. Each plan identifies opportunities to use water more efficiently, if the plan is implemented. Concerns of "one size does not fit all" are one of the first comments raised with efficiency planning. That's why each water entity creates its own efficiency plan. Those water entities that write a plan, submit it to the state for approval, and gain the State's approval, are eligible to apply for state grants to help with the cost of implementing water efficiency plans. Efficiency plans have been approved for most of the larger water users in the Arkansas Basin, and many smaller water users have created water efficiency plans.

In 2010, a comprehensive examination of water supply was undertaken by the State of Colorado. This examination included a look at water efficiency efforts. That report spelled out that some efficiency happens to us, and sometimes we can take action to do something about efficiency. If, for example, a clothes washing machine breaks down, the owner will go to the store to buy a new machine, bring it home, and install it. New machines are much more efficient that old machines, using less water to wash the same amount of clothes.

Table 4.3.1 - Arkansas Basin Water State Approved Efficiency Plans, Source: Mark Shively

Water Entity	Population	Average AF	Revision Due
Cherokee	18,000	3,500	6/29/2014
Colorado Springs	369,815	93,587	1/28/2015
Fountain	21,000	2,762	4/4/2016
Salida	5,476	1,987	5/26/2016
Widefield	16,605	2,136	12/1/2016
Lamar	7,850	2,142	10/26/2017
St. Charles Mesa	4,100	2,300	11/29/2017
Security	18,000	3,351	4/23/2018
Trinidad	15,000	2,654	Conditional
Pueblo West	28,174	5,492	8/1/2019
Donala	5,500	1,208	8/23/2019
SECWCD Regional Plan	-	-	4/28/2020
Monument	2,508	280	3/2/2021
Palmer Lake	2,271	270	3/2/2021
Triview	1,986	500	3/2/2021
Average GPCD - 211	516,285	122,169	

It is no longer possible to buy an old inefficient washing machine because those designs are not made any longer. In this way, when a customer buys a new clothes washing machine, efficiency has just happened to the customer. On the other hand, a water user may devote time on a regular basis to look for water leaks in their irrigation system. The user may go out in the middle of the night when things are quiet, and listen for leaks. If a leak is found, it's fixed. In this way, water users are taking proactive actions to do something about water efficiency. Water efficiency plans are aimed at accelerating these more proactive efforts.[1]

The State of Colorado has continued its leading role in encouraging the efficient use of water, pulling together information that can be used by communities who have the willingness and ability to use their water supplies more efficiently. Many communities in Colorado have written plans describing specific steps they will take to use water more efficiently. It is not necessary to reinvent this wheel. It is easy to look through these prior efforts to find good ideas that match a community's needs. These efforts used to be called "conservation plans". Now they are called "efficiency plans". Every community gets to write its own plan, implement that plan, and educate and outreach to citizens about engaging the plan.

[1] Find more information from the 2010 report here: http://cwcb.state.co.us/water-management/water-supply-planning/Pages/SWSI2010.aspx

Table 4.3.2 – County Population Change and Water Use (Gallons/Capita/Day) within Arkansas Basin 2000-2010, Source[2]

County	Population 2000	2012	% Change	Water Use 2000	2010	% Change
Baca	4,517	3,788	-19	255	329	29
Bent	5,998	6,499	8	181	113	-38
Crowley	5,518	5,823	5	142	141	-0.7
Kiowa	1,622	1,398	-16	327	325	-0.6
Otero	20,311	18,831	-8	243	185	-24
Prowers	14,486	12,551	-15	287	232	-19
Chaffee	16,242	17,809	9	310	297	-4
Custer	3,503	4,255	18	226	226	0
Fremont	46,145	46,824	1	232	219	-6
Lake	7,812	7,310	-7	212	183	-14
Las Animas	15,207	15,507	2	222	221	-0.5
Pueblo	141,475	159,063	11	254	206	-19
El Paso	516,929	644,117	25	195	172	-12

4.3.3 State of Colorado Grants

State efforts with efficiency plans focus on three main themes. What are good ideas that can be taken from prior plans and applied more widely? Is a community moving along from simple ideas with water efficiency to more robust efforts? How are communities measuring success of efforts to use water more efficiently? It costs about $35,000 for a community of 10,000 persons to write a water efficiency plan to address these questions. Larger communities spend more than $35,000 on their plans. Smaller communities may spend a bit less. Writing a plan is not a technical process. The process does call for communities to come together to

House Bill 10-1051: House Bill 1051, enacted by the Colorado General Assembly in 2010, will usher in more robust efficiency reporting data. First results are due June 30, 2014. Comparative data will be available a year later. Incremental data will help entities better compare their own efforts year over year, but SHOULD NOT be used to compare one entity against another. For example, Douglas County's water use was 215 GPCD in 2000, but only 146 GPCD in 2010. While the 32% increase in efficiency achieved over ten years is certainly commendable, individual entity results will vary by community. The 2050 goal established by the Metro Roundtable for its urban water user members is 128 GPCD. The 1051 data will help each water entity create and measure specific numeric water savings goals. It's important to note that while per capita rates of consumption are declining, populations are growing at a faster pace. Water efficiency is part of an overall plan, but no panacea.

[2] Sources include the Colorado State Demographer and the Statewide Water Supply Initiative 2010

determine how they plan to use Colorado's most precious natural resource more efficiently. All communities are encouraged to write and implement an efficiency plan. Grants are available from the State to pay for up to 75% of the cost of writing the plan. Communities pay 25% of the cost of writing a plan. In the case of a $35,000 plan, the cost to local water entities is about $8,750. That $8,750 can be cash or it can be the value of staff time spent working on the plan, or related efforts. In this example, it would cost about 88 cents per person to write a water efficiency plan.

Once a water efficiency plan has been written by the water entity, and approved by the State, grant funding is also available for implementation of the water efficiency plan. That is, "putting the plan to work". The State offers grants for up to 75% of the cost of implementing the plan.

How to apply for a grant to draft a water efficiency plan:

1) Read about how planning and implementation grants work. There is a good "frequently asked questions" section, plus additional information at: http://cwcb.state.co.us/water-management/waterEfficiency/Pages/main.aspx

2) The phone number for the part of the state government that works with water efficiency is found at: http://cwcb.state.co.us/water-management/waterEfficiency/Pages/main.aspx. A telephone conversation can determine if it makes sense to schedule a time to sit down and talk about what a water entity would like to do. The office is located in downtown Denver. As part of the conversation, an applicant will need to create a budget for how the State funds will be used in the grant. When staff is OK with the idea, requests for up to $50,000 can be considered and approved at the staff level.

3) Once a grant request is approved by State staff, the contract for the grant goes through a procurement process. Allow six weeks for the process.

A good place for water entities to begin efficiency efforts is with leak detection in their collection, treatment, and distribution systems. Is all water use metered to show how much water is produced and how much water customers pay for? If these numbers do not balance, there is probably a leak. Looking for these system leaks and fixing them is a good place to start with implementation of a water efficiency plan. Is a system paying to produce water, but not charging for some water uses? If so, revenue that could be used to address aging infrastructure is simply going down the drain.

A link to a list of steps communities with approved plans have already taken to implement their plans and use water more efficiently is: http://cwcb.state.co.us/technical-resources/best-management-practices/Pages/main.aspx. If an entity has an approved efficiency plan in place, it looks through the list for ideas that sound like a fit for the community's needs. If some action appears to make sense for the community's efficiency goals, the entity is encouraged to apply to the State for a grant to implement the measure.

Once permission to proceed is received, it takes two to six months on average to write or update the efficiency plan. The State would like to see a fifty percent completion report and a seventy-five percent completion report. It is also advisable to send a final draft to the State for their comment. It is possible for the State to issue a "conditional" approval. Conditional approval will give the applicant confidence that pursuits are in fact heading in a reasonable direction for success.

Plans must include a public comment period, which usually lasts sixty days. A healthy sequence might feature submission of a draft to the applicant's Board or Council, and then the public comment period would follow. After the comment period ends, any items from the public might be included, the draft finalized, and the applicant's Board or Council may consider approval of the final draft. The final draft is then sent to the State for final approval. Communication with State staff is advised. 10% of grant funds are held back until the process is completed and the State gives final approval of efforts under the grant.

Once the plan receives final approval from the State, an applicant may then apply for a grant to help with implementation of the efficiency plan. Implementation is a repeat of the process detailed above. Typically, two years are allowed for completion of tasks under the implementation grant. The link to the grant application is: http://cwcb.state.co.us/LoansGrants/water-efficiency-grants/Pages/main.aspx.

4.3.4 Regional Conservation Planning

An element of the permitting for the Arkansas Valley Conduit, one of the Arkansas Basin's primary Identified Plans and Process ("IPP") since the inception of the Roundtable, was development of a Regional Water Conservation Plan. The Southeastern Colorado Water Conservancy District presented the Regional Plan to the Arkansas Basin Roundtable in 2014. The entire plan and related tool box of efficiency resources is available on the District's website at: www.secwcd.org/content/conservation-education.

SECWCD Regional Water Conservation Plan

Southeastern Colorado Water Conservancy District (District) is proud of its ongoing water conservation program. As a regional water provider, it is the District's responsibility to show stewardship in water conservation and promote efficient use of this valuable resource. The District has continually expanded these efforts by adding both programs and staff to carry-out the programs.

Southeast Colorado Water Conservancy District's "tool box" of water efficiency planning resources:

www.secwcd.org/BMPToolbox

The District's regional plan seeks to develop programs for efficient and sustainable water use. Of 38 plan participants, 6 new state-approved water efficiency plans will be put in place in 2014, part of efforts with The Arkansas Valley Conduit, the last piece in the Frying Pan/Arkansas Project of 1962! All entities are now collecting data that will be used to measure the effectiveness of efficiency efforts.

4.3.5 Land Use and Water Efficiency Planning

Most projects and procedures outlined above focus on taking an existing situation and making it more water efficient. That's good, but what about new communities that will be built in Colorado? It's expensive to build something, tear it down, and build it better. It's smarter and cheaper to build it right the first time. How can new houses be built more water efficient?

Decisions about how many houses can be built on a piece of land are determined by the Board of County Commissioners in the unincorporated portions of a county, or by the councils in cities and towns. These boards and councils appoint planning commissions to offer opinions on these decisions. Professional staff is hired to work with developers to develop good plans. Good plans are forwarded to the commissions for review and comment. After the commissions share their thoughts, the boards and councils take up the request for consideration of approval. The work of the planning staff and planning commissions is advisory. The actual decision about how the land can be used lies with the elected officials who serve on the boards and councils. Bad plans can be rejected, and good plans can be approved and built.

Most of the boards of water entities, as well as their management and staff, are not familiar with this process of consideration and approval, including the piece of the decision that involves water supply or water efficiency. This is especially true in the unincorporated areas. Similarly, the councils and boards and planning staff and planning commissioners may not be familiar with water supply realities and water efficiency opportunities. In this way, there is a "disconnect" in communications between the people who decide how the land will be used, and the people who provide the water to serve new projects.

Just as there is no "one size fits all" in water efficiency planning, there is no "one size fits all" in the dialogue between land use decisions and water supply planning. As water supplies become more stretched, it is important that this dialogue take place, and become more regular, more detailed, and more robust. Each community gets to decide how it wants to have this conversation, but in this era of water efficiency improvements, it's time for each community to have that conversation. Here is but one example of how that dialogue might progress initially.

1) A regional water entity (such as the Roundtable or a conservancy district) invites all land use authorities (cities, towns, County governments) in the areas it serves to participate in a series of lunches, every other month.
2) At the first meeting, everyone talks about this "gap" in knowledge of what one another does. Attendees share if they have experienced this gap themselves. Stories are told to illustrate the point.
3) Attendees seek common ground by asking, "What can everyone agree on?"

In July 2013, a summit was held for the roundtables located along the Front Range. Various measures in water efficiency for future home construction were discussed. One thing attendees agreed on that day was that there needs to be a standard for the construction of water efficient new housing. Fortunately, such a standard already exists.

The standard is called the EPA WaterSense New Home Specification. The link to the WaterSense New Home Specification is: http://www.epa.gov/watersense/pubs/ws_homes.html. WaterSense labeled plumbing fixtures, efficient hot water delivery systems, water-smart landscape design, and other features are independently certified to use 20% less water than typical new homes. Colorado Springs Utilities was recently named an EPA WaterSense Partner of the Year, and homes meeting the WaterSense New Home Specification have been built in Colorado Springs. Whether every community adopts this particular specification for water efficiency or some equivalent, this is a good topic for connection between water entities and land use authorities.

Water-smart landscape designs need smart operators, designers, and installers. The Conservation Committee of the Rocky Mountain Section of the American Water Works Association, the Green Legacies Water Returns work with trade groups like The Irrigation Association, and similar efforts are exploring paths to provide the educational content needed to elevate the skillsets of landscape practitioners, as well as utility and municipal employees who will evaluate and inspect plans, installation, and maintenance practices. Some entities are now certifying practitioners, but as water resources become even more precious, this trend may move towards licensure of these practitioners. This concern for efficient irrigation practices extends beyond homes to streetscapes, parks, and open spaces.

4.3.6 Good, Better, Best

How can every community, every water user, tell if it's doing a "good" job with water efficiency, or if it should try to do a "better" job, or if it's doing the "best" job with water efficiency it possibly can? There really isn't any magic number to measure how one community does as compared with another. But, there are ways to measure how a community performed in the most recent year against how it performed in past years. Colorado's House Bill 1051 reporting will help. Progress can be measured, considered, and adjusted as appropriate for each community to meet its goals. Using GIS data available at the County level, a water budget can, and should, be created for every water user so that efficiency gains can be measured.

What are realistic goals? This is one area where "one size doesn't fit all" rings particularly true.

a) Is a goal of 25% increased efficiency realistic? For some users that goal is economic and achievable. For others, it's simply not possible.
b) Is a goal of every person in Colorado using 128 gallons per day meaningful? In some instances that may be generous use, while in others it's never going to be achieved.
c) Is saving 1% per year too easy at first, but then too tough a few years later? Saving 1% the first year is achievable. Eventually, the point of diminishing marginal return is met.

<u>CWCB Recognized Guidelines for Good, Better, and Best Efficiency Practices</u>

(1 is considered "Good", while 14 is "Best". "Better" is in the middle.)

1. Metering, conservation-oriented rates & fees, customer categories
2. Integrated resource planning, goal setting, demand monitoring
3. System water loss control
4. Conservation coordinator
5. Water waste ordinance
6. Public information and education
7. Landscape water budgets
8. Rules and regulations for landscape design and installation
9. Water efficient practices for new and existing landscapes
10. Irrigation efficiency evaluations
11. Rules for new construction
12. High-efficiency fixture and appliance replacement
13. Surveys and evaluations of high demand customers
14. Non-residential surveys, audits, and equipment efficiency improvements

One size does not fit all. Each community should create their own plan that makes sense for each community!

In the Arkansas Basin, Colorado Springs Utilities (CSU) has had good success with water efficiency efforts. Smaller water providers may not be able to emulate all efforts, but could consider emulating some of these successful efforts. For example, CSU offers rebates of $750 to builders who construct and certify a WaterSense new home that is 20% more efficient than standard code-compliant house. The 2014 Parade of Homes features three WaterSense models.

CSU is partnering with local low- and no-income housing providers to retrofit housing inventory with WaterSense fixtures, as well as with students at the University of Colorado at Colorado Springs who replaced 287 showerheads and 233 toilets with WaterSense models. In 2013, CSU exchanged 2,815 inefficient showerheads for WaterSense labeled models saving each homeowner about $130 per year in water, energy and wastewater costs.

CSU's water education efforts have reached approximately 12,700 elementary, middle school, and high school students. The 2013 annual budget for the program was approximately $140,000, or $11.02 per student. Efforts focus on classroom presentations, and include a instruction for students to identify and fix leaky toilets. Outreach efforts focus on utility rebate and retrofit opportunities for apartments, offices, hotels, the Home Builders Association, property managers, homeowner associations, facility managers, restaurateurs, chefs, and schools. The public relations programs highlight social media, free media spots, and radio and TV ads featuring "Dewey the Water Drop". 10,000 porcelain toilets have been recycled from residential and business customers and reused in road projects in the community.

Irrigation upgrades are taking place in the City of Colorado Springs Parks Department to improve irrigation components, practices, plans and water use.

The Southeastern Colorado Water Conservancy District's regional conservation plan included good, better and best goals with best featuring the most robust efficiency efforts. The best goals for the 38 participants in the regional plan are included in the Environmental Impact Statement process for the Arkansas Valley Conduit. The "best" goal calls for a reduction of 164 ac-ft in consumption between now and 2070. This goal reflects a reduction of 11% from current water consumption levels during a time when population is forecast to grow by 40%. This reduction represents a little over 1% of the "Gap" in the Arkansas River Basin between identified water supplies, and water supplies that will be needed by 2050. Current trends among water providers in the Arkansas Basin with state approved efficiency plans are not as robust as this "best" goal, and about 80% of the potential water efficiency opportunities lie in the urban counties area stretching from Pueblo to northern El Paso County.

Current average water use in the Arkansas Basin, among water providers with state approved efficiency plans is 211 gallons per person per day. If trends of the past decade were to continue in the Arkansas Basin, in 2050 average per capita demand would fall by 28%. If all current factors remain in place for the next thirty-five years, which is highly unlikely, this trend predicts to 152 GPCD at 2050. Over the same period of time, population would grow by three times that rate. Overall demand would go up, not down, even with efficiency gains.

Complicating factors and constraints in any such long-term demand forecasts include reliance of some water users on Denver Basin Groundwater, some counties losing population, and constraints associated with the agricultural community's reliance upon wet year water purchases from the cities. Improved reporting from data collected from the House Bill 1051 process will provide for improved estimates about future trends. And of course, past performance is no assurance of future results.

Rebates and retrofits on outdoor efficiency efforts (such as rotary sprinkler nozzles - after water budgets are in place and E-mail lists are obtained) can accelerate movement towards these lower per capita water use levels. However inaccurate predictions of future trends in water use may prove to be, the current trend line is best altered through educating the public about community water ethics, dialogue between water providers and land use authorities, and outreach to landscape practitioners.

The goal for every water user, for every community, is to create its own water ethic. None of these measures apply well to all water users. What might be a good way for communities to act as a "sounding board" for one another to receive a reality check when creating a community water ethic? One benefit of the 1,000 meetings held by the Roundtable process these past years is that participants have gotten to know one another, and better understand how water is used in their respective basins. If someone from the Gunnison presents its water efficiency ideas to the Metro Roundtable, people may not understand the workings of water in the respective areas. There will be a disconnect in understanding. People within the same basin do understand how water works in their own communities. These participants can say yes, this notion of a prudent water ethic is real world, or no, there's really not much effort at water efficiency going on. The roundtable is the place to have informed dialogue about the need to create a locally appropriate water efficiency ethic, providing a "sounding board" for feedback on efforts. While most of the water efficiency opportunities lie in the urban counties area from Pueblo to northern El Paso County, the Southeastern Colorado Water Conservancy District's "Tool Box" of water efficiency planning resources is a treasure trove of information for these urban areas to draw from.

4.3.7 Looking Beyond Urban Water Efficiency

Water efficiency goes beyond the metric of daily usage in cities and towns. Following are areas where the efficiency ethic is beneficial:

- Around 85% of the water used in the State is used in agriculture. The first thing casual observers of Colorado water issues ask is if we need to save water, why not increase agricultural efficiency? That sounds simple, but the notion becomes very complicated very quickly. There is no doubt that converting from flood irrigation to center pivot sprinkler irrigation or to drip irrigation is more efficient. However, these measures change how water flows from the farm adopting these efficiency measures to the next farm downstream, or out of the state of Colorado into Kansas. Unless additional water supplies can be made available to address these changes, it may not be possible to adopt these more efficient practices on a widespread basis. In the short-term, additional water supplies are available from cities in wet years, but disappear in times of drought. As populations increase and the impacts of drought worsen, additional water supplies will not be available for purchase. New water supplies and new water projects are going to be needed. Urban efficiency does not meet this need, but efficiency can stretch existing water supplies and buy time until these projects and supplies can be built, paid for, and brought on line.
- Energy efficiency is water efficiency. Generation of electricity is Colorado's second largest industrial user of water. Every time a light is turned on, water is used to make that electricity. Every time water is pumped from one place to another, electricity is used. There are some opportunities to link power generation plants with water treatment plants, but every citizen can adopt behavioral changes so that electricity is used more efficiently (turn off the lights when leaving a room/replace incandescent bulbs with LEDs, etc.). When water is used more efficiently, less electricity is used moving that water around.
- Water quality and reuse are important considerations. Efficiency can concentrate the treatment process at treatment plants, while reuse water can create the need for more robust treatment processes. Ultimately, reuse water must be blended with fresh water supplies to meet health standards. In some cases, advanced treatment processes create a brine stream that creates its own environmental challenges. The Arkansas Roundtable has contributed funding for a pilot project at La Junta for zero liquid discharge solutions.
- Environmental goals vary from avoiding incremental impacts to redressing impacts already in evidence. Every time water is taken out of a stream, less water is left in the stream for the benefit of species that live in riparian areas at some point in their life cycles. Timing the release of water held in storage can contribute to the needs of these species. Efficiency can slow the

rate at which water is taken from streams. Environmental interests should be front and center in the dialogue concerning how to best create these projects.

- Recreational interests advocate for seasonal river conditions that support their respective activities, be they skiing or fishing, rafting or kayaking. If storage facilities had not been built, all the water in the rivers would come gushing down the mountains all at once, destroying communities, and providing very little opportunity for rafting or fishing. The timing of releases from these storage facilities is what makes the recreational opportunities possible. All parties should have a seat at the table to discuss how to make the best use of the water supply and storage projects that need to be built. Efficiency must be part of the dialogue concerning how to size these projects. Communities should be thoughtful about creating obstacles to meeting the needs of the future. Every community in Colorado needs an adequate water supply used efficiently.

4.3.8 Education and Outreach

Education and outreach take the message of water to the public. A recent statewide survey indicates 95% of Coloradoans would like more educational information on the history of water in Colorado, as well as current events in water. Education and outreach can begin with water efficiency because every individual citizen can take action to use water more efficiently in their home, at work, in their daily life. The State of Colorado offers grants to help with education and outreach needs. It is incumbent upon water entities to go to where the public lives, and bring them to the message of water. Water entities can work together on efficiency messaging because they ultimately have the same message.

An effective outreach effort begins by surveying water users to identify the target market segments most likely to take action to use water more efficiently. Users can be asked what they care about when they think of water, and how they would like to be communicated with about water. Do users prefer face to face meetings in the evening, post cards, newspaper articles, radio programs, or E-mails and websites? Farmers may prefer face to face evening meetings. People living in cul-de-sacs may prefer E-mail and websites. Don't guess, ask them! Surveys are useful in determining these preferences. While outreach may eventually include all water users, identifying and prioritizing specific target market segments of the population will help to wring out value from limited communications budgets. Consistent themes should be used across all targeted outreach.

Research to identify target markets has been conducted nationally, statewide, and at the river basin level. While some larger utilities have conducted their own research, efforts have not yet been performed on a widespread basis within each basin. Still, certain themes emerge, and those themes are a place to get started. Response to outreach associated with electronic media is more easily measured than traditional print media. For example, it is possible to measure how many people open and read an E-mail, or then click to view content on a website. By comparison, it's not as easy or as cheap to determine how many people actually read the material that's inserted with the monthly water bill that's mailed out. One large municipal water provider in the Arkansas reports the percentage of customers who read their billing inserts to be no higher than mid-teens. By comparison, a pre-roll advertising public service announcement saw 72% of the intended audience view the message to completion. http://www.youtube.com/watch?v=QJYYiP33jLA received 160,000 views in one month.

The fastest growing segment for outreach, and advertising, is centered on video content. Most viewers prefer brief, simple messages, perhaps two minutes in length. The messages should come from what the target market sees as a trusted source, such as a regional water entity, as opposed to a local water utility. Third party verification is important. The biggest theme is maintaining household potable water supplies. The segment most likely to take action on water efficiency is households in their late 20's to early 30's with household incomes above $75k. Many parents and grandparents take action to save water because they want to leave something for their kids and grandkids.

Link to series of "how to" water efficiency video series on YouTube.com:

http://www.youtube.com/channel/UCZ6EkqqSXp9Cfj4Ue2MtMzA

An effective path is to educate the children and grandchildren with a water message, then send the students home from school to share this information with Mom and Dad, Grandpa and Grandma. Most K-12 water education in Colorado is aimed at 4th or 5th grade students. In addition to the educational content provided by the schools to students on topics such as the water cycle, water utilities provide supplemental education about water and efficiency topics. Tests can be administered before and after the supplemental training to measure student learning. "Toilet test kits" (blue dye pills) can be sent home with each student to work with their parents to identify leaky toilets. Families can report how many toilets were fixed. This data can be extrapolated to gauge the amount of water saved by repairing leaky toilets. Send the parents and the grandparents the same messages to reinforce what they hear from the children. Surveys can be used to gauge changes in attitude by the parents and grandparents.

Most of our water use is outdoors, so it makes sense to focus efficiency efforts on outdoor use. If you create water budgets for each customer, you can identify who has the greatest opportunity to use water more efficiently, and monitor the results of your outreach program (education and outreach efforts, rebates, etc.) on outdoor water efficiency. Absent a water budgets, you may be targeting people who already use water efficiently, so it's more difficult to measure how much water people actually save by taking advantage of your outreach.

Many utilities find E-billing far cheaper than printing paper bills, mailing them, receiving checks, and depositing checks at the bank. In order to send E-bills, the customer's E-mail address must be known. Gathering E-mail lists is helpful to get your message out, but the lists are also helpful in reinforcing your message. It is helpful to remind people why they want to save water (water is precious), and to instruct or remind them exactly "how to" save water (use water thoughtfully). Never let the water run while brushing teeth or shaving is a good place to start. Properly adjusting the irrigation controller for use with high efficiency rotary sprinkler nozzle is more involved. Videos help, as do regular E-mail reminders. And once E-mail lists are created, it costs next to nothing to distribute regular messages to targeted customers. Frequency of consistent messaging over a protracted period of time is vital in persuading targeted audiences to change their attitudes and behaviors surrounding the efficient use of water.

4.3.9 Recommendations

Many communities are implementing water efficiency measure effectively. Here are some suggestions taken from those active in the field:

- Match fixed expenses to fixed revenues; avoid a revenue squeeze associated with reduced demand achieved through efficiency.
- Capture every E-mail address in the basin. It's cheap to communicate electronically. It's expensive to print and mail. The trend towards smart phones and videos is going to intensify. E-mail is the key to success.
- Create water budgets for every user. Budgets are easy to put in place, and provide a good way to measure success, or identify opportunities to use water more efficiently.
- Once water budgets are in place and E-mail lists created, retrofit existing lawn sprinklers with rotary sprinkler nozzles. These nozzles are up to 30% more efficient than traditional designs, and economic at current water prices. Teach landscape practitioners how to design, install, and maintain water efficient landscapes and irrigation systems.
- Deliver an easily understood consensus message in every school in the Basin. The "Water Ambassadors" model features high school students teaching 4th graders about water. It is the low cost leader in K-12 water education efforts in Colorado, and has won state and national awards the past two years. This program is a path for taking water messages into every house in the Basin.
- Create a high level regional outreach message, drill down locally, stay on consistent message, and repeat, repeat, repeat from multiple trusteed sources.
  - Water is precious
  - Use it thoughtfully
  - Support solutions for the future
  - If these things are done, there will be water for generations to come
- Use words every person can understand, words that resonate.
- Talk to ever widening circles of citizens, not just to one another in the water industry, until every citizen is engaged in water issues and solutions.
- Avoid sending mixed messages. Offer incentives, and keep restriction in place every year, not just in the midst of drought. Avoid telling people to use water wisely at the same time messaging tells them to use as much water as possible.

4.3.10 Summary and Challenges

Efficiency is important because it can reduce costs, stretch supplies, and buy time to address water issues. Efficiency is the best path to introducing the public to water issues. While Colorado cannot conserve its way out of its water issues, efficiency buys time to get going on new storage and water supply projects! Create an efficiency plan, implement it, and move from simple to rigorous measures. Become a sounding board for one another on what are good, better, and best efficiency practices. Dialogue with land use authorities on water efficiency for new housing, and outreach to landscape practitioners. The task of water efficiency represents generational change in ethics, behaviors and attitudes about water. As such, expectation levels should be that these tasks may take 15 years to accomplish, or longer. Reinforce the message of water throughout the community, increasingly using new media to distribute simple messaging. Take the message of water to every person in the Arkansas Basin, every person in Colorado.

Water is precious. However water is used, use it thoughtfully. Everyone needs to support water solutions for the future. If Coloradoans can do this, Colorado will have water for generations to come.

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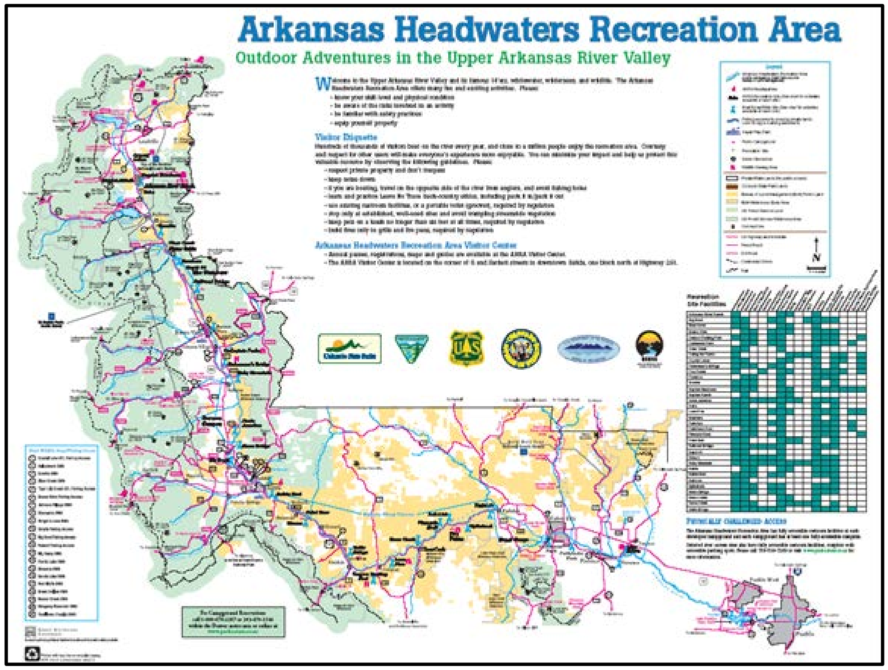
Figures

4.4 New Multipurpose, Cooperative, and Regional Projects and Methods

Figure 4.4.1 - Arkansas Headwaters Recreation Areas



Collaborative water resource initiatives in the Arkansas River Basin pre-date the *Water for the 21st Century Act* and the creation of the roundtables. The Frying Pan-Arkansas Project, signed into law by President John F. Kennedy in Pueblo in 1962, was conceived and constructed as a multipurpose project, serving agriculture, municipalities and recreation. Commonly referred to as "Fry Ark," the project provides storage for western Colorado at Ruedi Reservoir, consumptive use water for cities and farms, and provides for recreation at Turquoise Reservoir and Lake Pueblo. Through an innovative, regional effort to understand the environmental benefits of imported water to the fishery of the Upper Arkansas River, a *Voluntary Flow Agreement* was negotiated in the late 1990's to manage water storage in support of adequate river flow for fish spawning each Spring and Fall. This model of interagency[1] coordination meets multiple habitat needs while sustaining flows for rafting into late summer. The Arkansas Headwaters Recreation Area is now an economic engine for the region, supported in large measure by this model collaboration and cooperation in the management of water resources.

Many of the architects of the Voluntary Flow Agreement and the participating agencies are active members of the Arkansas Basin Roundtable. The Roundtable has embraced the multipurpose approach to supporting projects and methods to meet the needs of the basin. This section provides summaries of the initiatives approved by the Arkansas Roundtable for Water Supply Reserve Account[2] grant funding or support subsequent to SWSI 2010. In addition to the projects provided within the body of this report, new projects and methods are being identified through the public outreach and education initiative. Information for outreach and education identified projects is provided in the appendix.

[1] Southeastern Colorado Water Conservancy District, U.S. Bureau of Reclamation, Colorado Parks and Wildlife, U.S. Bureau of Land Management, Pueblo Board of Water Works, Colorado Springs Utilities and Aurora Water.
[2] Colorado Revised Statutes 39-29-109 *et seq.* The Water Supply Reserve Account (WSRA) grants are approved by the basin roundtable, approved by the Colorado Water Conservation Board and administered by the CWCB staff.

4.4.1 Definitions

New, Regional and Multipurpose: New projects are those projects commenced or completed subsequent to the SWSI 2010 process. Regional projects are intended to serve multiple end-user of water or include cooperation with other basin roundtables. Multipurpose projects address more than one of the following water supply gap areas:

- Agricultural;
- Municipal;
- Environmental;
- Recreational;
- Storage.

Colorado River Storage Project: The 1956 act authorized construction of the Colorado River Storage Project (CRSP) which allowed for comprehensive development of the water resources of the Upper Basin states (Colorado, New Mexico, Utah, and Wyoming) by providing for long-term regulatory storage of water to meet the entitlements of the Lower Basin states (Arizona, California, and Nevada). There are four initial storage units built as part of the CRSP: The Wayne N. Aspinall Unit in Colorado (Blue Mesa, Crystal, and Morrow Point Dams), Flaming Gorge Unit in Utah, Navajo Unit in New Mexico, and Glen Canyon Unit in Arizona.

4.4.2 Inter-Basin Projects

The 2009 Meeting the Needs report articulated the continuing interest that the Arkansas Basin has in the future of the Colorado River. To investigate increased reliability of stored water in the Colorado River basin, particularly within the Aspinall Unit of the Colorado River Storage Project, the Arkansas Roundtable teamed up with the Gunnison Roundtable for a study of Blue Mesa Reservoir. In an effort to stay ahead of developments by private parties to import water from Flaming Gorge Reservoir, the Arkansas Roundtable initiated a facilitated dialogue between all nine (9) basin roundtables in 2011. Summaries of those efforts include:

Blue Mesa Storage Capacity

Applicant: **Southeastern Colorado Water Conservancy District**
Approved: **April, 2012**
Status: **Complete**
WSRA Funds: **$122,500**

The objectives of this project were to assess the effectiveness of using excess capacity storage in Blue Mesa Reservoir to avoid, forestall, and mitigate the magnitude and duration of potential Colorado River Compact curtailment. A principle objective was to evaluate the use of Blue Mesa Reservoir as a potential storage location for a Colorado water bank. The analysis also considered and used the output of the Water Banking Study (partially funded by the CWCB through the ATM grant program) conducted by the Water Bank Group as input reflecting the available supplies (e.g., pre 1922 consumptive use credits) which might be deposited in a water bank. The project contributed to a better understanding of circumstances surrounding a potential curtailment of Colorado River diversions in Colorado and the effectiveness of utilizing excess storage capacity in Blue Mesa Reservoir as a water bank. The project provided a draft report that included conclusions and recommendations based upon the findings (Appendix 4.4-A). The draft report also included potential water banking operations and guidelines in Blue Mesa Reservoir. The intent of this study was to create a feasible operational framework for a water bank that could be the basis for an excess storage capacity contract at Blue Mesa Reservoir.

Basin Roundtable Project Exploration Committee: Flaming Gorge

APPLICANT: **Pikes Peak Regional Water Authority**
APPROVED: **December 2011**
STATUS: **Completed**
WSRA FUNDS: **$12,443**
MATCHING FUNDS: $10,000 per each of nine other basin roundtables

This grant established the Basin Roundtable Project Exploration Committee to serve as a venue for roundtable to roundtable discussions of potential water supply projects, with the Flaming Gorge Pipeline project serving as a test case or starting point. The Basin Roundtable discussions did not seek consensus on whether or not to build a Flaming Gorge project, but rather they will examine the issues involved in the project, the challenges or barriers to such a project, and potential benefits of such a project. This grant builds on the Flaming Gorge Task Force Situation Assessment WSRA grant approved by the Board in May 2010. The Assessment grant asked independent facilitators to assess the timeliness and merits of a discussion on the topic of a Flaming Gorge project. The Assessment concluded that a discussion would have value to the majority of the individuals interviewed, that the discussion should be roundtable to roundtable, and that the Basin Roundtables should focus on the benefits and challenges with a potential Flaming Gorge project not whether or not to build it. The Committee Report is included as Appendix 4.4-B.

4.4.3 Multi-Purpose Projects

Helena Diversion Structure and BV Boat Chute Improvement

Applicant: **Colorado State Parks**
Approved: **November, 2012**
Status: **In Progress**
WSRA Funds: **$325,000**

The Helena Diversion Structure at Buena Vista is owned and operated by the Colorado Department of Corrections, Mr. and Mrs. Cogan, Moltz, and Diamond. The structure is navigated by both private and commercial boaters. It was extremely dangerous because portions of the structure had shifted over time, creating an unpredictable spillway and leading to a boating fatality in the summer of 2007. The structure also prohibited the safe passage of aquatic species both up and down the river during the spawning season. The Arkansas Headwaters Recreation Area engineered and constructed a new structure that will allow for safe recreational boat passage and improved fish migration. Additionally, new structure improved water delivery efficiency at all water levels. Specific objectives of the project included:

- Improved public safety by replacing a failing diversion structure and dangerous boat chute;
- Improved water delivery by replacing a failing diversion structure;
- Improved fishery by constructing a fish ladder; and,
- Reduced trespassing by constructing a beginner level boat chute.

The project is expected to be substantially complete for the 2014 rafting season. The applicant has requested a time to present the project to the roundtable in the late summer of 2014.

Hale Reservoir Renovation

Applicant: **Cross Creek Metropolitan District**
Approved: **December, 2012**
Status: **In Progress**
WSRA Funds: **$120,000**

Cross Creek Metropolitan District sought to renovate the reservoir in a way that met multiple needs, including storm water management, and also served nonconsumptive aesthetic and recreational opportunities. These opportunities included environmental restoration of surrounding wetlands and provided wildlife habitat and birding opportunities. The Hale Reservoir renovation was designed to be considered a non-potable well, to serve as a supply for irrigation in the Cross Creek Regional Park, and to serve surrounding landscape irrigation needs as well.

4.4.4 Projects to Address Regional Gaps

Projects which meet regionally identified gaps are of particular importance the Roundtable. In the first example, the SWSI 2010 recommendation to address the loss of nonrenewable groundwater has led to a collaborative effort between El Paso County water purveyors and the partners of the Southern Delivery System. In the second example, a regional project in Huerfano County will meet multiple needs for the basin and provide a foundation for future economic growth.

Pikes Peak Regional Water Supply Infrastructure Study

Applicant: **Pikes Peak Regional Water Authority**
Approved: **November, 2013**
Status: **In progress**
WSRA Funds: **$75,000**

The intent of this cooperative effort was to identify the critical water supply objectives of each participant, to identify and analyze possible joint water projects to meet those objectives, and to plan for the necessary actions to develop feasible projects. The study identifies and analyzed six (6) infrastructure projects within the Pikes Peak region. The project was approved by the Colorado Water Conservation Board at its January, 2014 meeting. Details on the project participants, scope of work, and schedule are contained in Appendix 4.4-C.

Red Wing Augmentation Facility

Location: Huerfano County
Applicant: Huerfano County Water Conservancy District
Date: May, 2014
Contact: Sandy White, sandyw@white-jankowski.com
Funding: $50,000 Basin Fund and $200,000 Statewide Fund

The Red Wing Augmentation Facility is part of a permanent regional augmentation plan covering the Huerfano River Basin within Huerfano County. In addition to the Basin Fund grant, the regional plan was provided a $2.22 million initial loan from the Colorado Water Conservation Board's Water Project Loan Fund in addition to tax revenue support. The plan's goals are to:

- Provide augmentation water to entities illegally using water due to the absence of a functional augmentation plan; and,
- Support future uses of water from an over-appropriated stream.

Both of these objectives will support and develop the tax base within Huerfano County.

The Red Wing Augmentation Facility will enable upstream storage and release of historic consumptively used water. Over the past five years the Huerfano County Water Conservancy District has provided augmentation water, using temporarily leased water rights, to an increasing number of water users. The water was provided through individual annual leases. The regional augmentation plan will provide consumptive water to the District's customers, including over 300 homes, the County Road Department, and new water users in the basin. Water users will purchase permanent augmentation certificates covering their consumptive depletions, in addition to paying annual administrative fees.

4.4.5 Anticipated Future Projects

In developing this Basin Implementation Plan, the Arkansas Basin Roundtable engaged in the solicitation of input by citizens throughout the basin. This outreach effort is described in detail in Section 4.1, Education, Participation and Outreach. The input provided from the outreach effort will be incorporated into a later draft of the Plan (using the definitions of Identified Projects and Processes ("IPP's") and Methods contained in the Glossary).

4.4.6 Summary and Challenges

The Arkansas Basin Roundtable has taken the lead on many Inter-Basin and Regional projects to address common needs that cross jurisdictional boundaries. Early in the roundtable process, there was the recognition that the Arkansas basin is both an importing and exporting water resource system. Imports from the Colorado River basin mean that the Arkansas Roundtable is a stakeholder in the dialogue about future uses of Colorado's Compact Entitlement. Water export from the Arkansas basin means that there is even greater pressure on sources of supply that are generated by growth within the basin's boundaries. A level of cooperation and willingness to extend a friendly hand across historic barriers has been the hallmark of the Arkansas Basin's effort in the past and going forward.

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4.5. Municipal and Industrial Projects and Methods

The earliest projects to meet the municipal and industrial gaps in the Arkansas Basin focused primarily on infrastructure solutions: New raw water conveyance systems like the Southern Delivery System, serving urban El Paso County, and the Arkansas Valley Conduit serving the Lower Valley, or; Development of additional storage capacity, like the Preferred Storage Option Plan (PSOP). Methods, on the other hand, have explored the frontier of water resource allocation in Colorado, focusing on concepts like rotating fallowing of farm land to serve municipal needs, or alluvial aquifer storage and recovery and other non-evaporative, underground storage approaches. Over the decade since the SWSI process began, many of these earliest projects and methods have advanced significantly.

To fully understand the potential for municipal project and methods throughout the basin, the Roundtable has initiated a public outreach program. As that information is collected and reviewed by the Roundtable, the concept of localized needs and local and/or regional solutions to those needs is gaining greater validity. A shift in viewpoint from the aggregate needs of the basin to increased understanding of local needs builds on the experience gained in SWSI 2010.

This section will update the status of Identified Projects and Process (IPP's) from SWSI 2010, discuss projects and methods supported by the Roundtable since SWSI 2010, and chronicle efforts that are currently underway.

4.5.1. Definitions and Glossary

These definitions and a glossary are provided for edification of the section contents and to provide clarity to the reader.

- **Alluvial Water:** Ground water that is hydrologically part of a natural surface stream system.
- **Aquifer:** An underground layer of sand, gravel or rock through which water can pass and is stored. Aquifers supply the water for wells and springs. They may be alluvial or nontributary in nature.
- **Conjunctive Use:** Coordinated use of surface and ground water supplies to meet demand so that both sources are used more efficiently.
- **Designated Basin:** An area in which the use of ground water is assumed not to impact the major surface river basin to which the designated basin would otherwise be tributary. Much of eastern Colorado is in designated basins.
- **Environmental Impact Statement (EIS):** Detailed analysis of the impacts of a project on all aspects of the natural environment required by federal National Environmental Policy Act for federal permitting or use of federal funds.
- **National Environmental Policy Act (NEPA):** The federal law enacted to ensure the integration of natural and social sciences and environmental design in planning and in decision making that may impact the quality of the human environment.
- **Nontributary Ground Water:** Underground water in an aquifer that neither draws from nor contributes to a natural surface stream in any measurable degree.

- **Record of Decision:** The final approval of an Environmental Impact Statement which will be issued by Federal Agency review in the EIS. It is a public document that explains the reasons for a project decision and summarizes any mitigation measures that will be incorporated in the project.

4.5.2. Projects to Meet the Municipal Gap

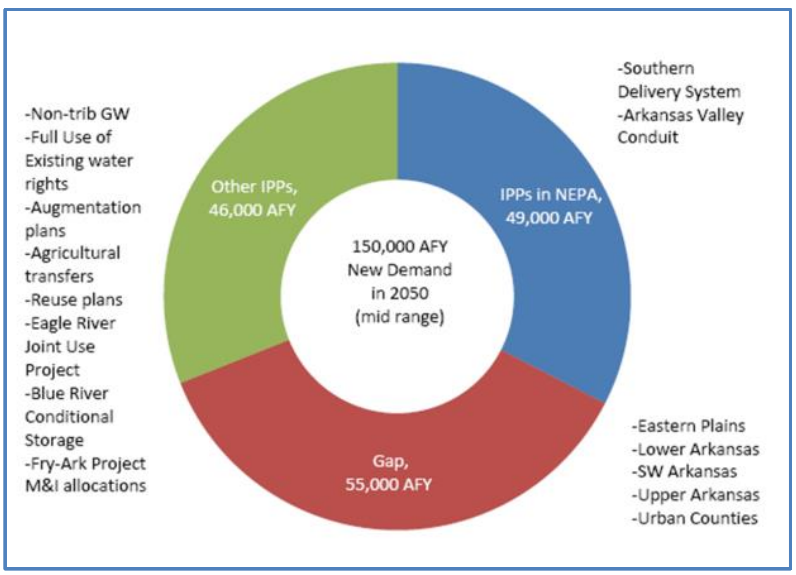
The Statewide Water Supply Initiative (SWSI) 2010 Executive Summary provided three primary recommendations to address the Municipal and Industrial (M&I) supply gap in the Arkansas Basin:

- The Arkansas Basin Roundtable acknowledges a limited number of Identified Projects and Process (IPP's) were able to meet the majority of the gap – the Southern Delivery System, the Arkansas Valley Conduit, and the Preferred Storage Option Plan;
- Storage is essential to meeting all of the basin's consumptive and nonconsumptive needs. In addition to traditional storage, aquifer storage and recovery must be considered and investigated as a future storage option;
- The Roundtable identified a critical gap as the need to replace nonrenewable groundwater and augment the sustainability of designated basins.

4.5.2.1. SWSI 2010 Identified Projects and Processes

A graphic from SWSI 2010 illustrates the role of the earliest identified projects to address the gap. Since SWSI 2010, the Arkansas Basin Roundtable has made progress on its recommendations. The three projects have all completed National Environmental Policy Act compliance and are in the implementation phase,:

Figure 1 - 2050 New Demand



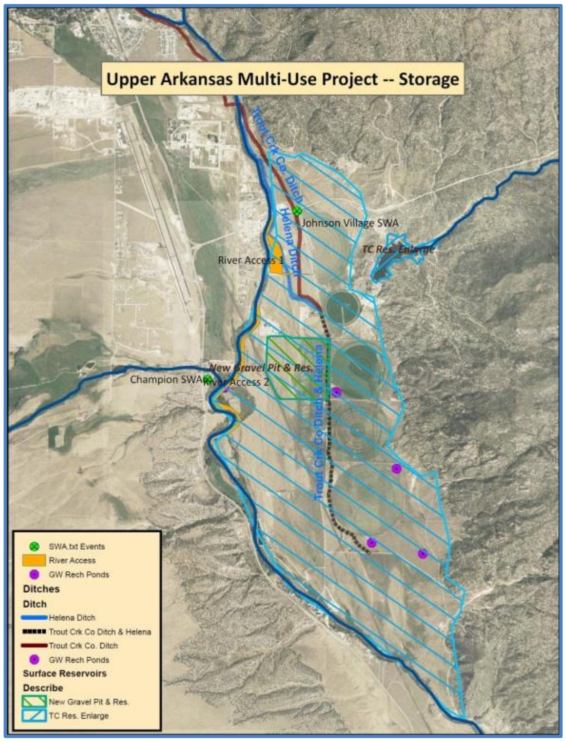
1. The Southern Delivery System is currently under construction, with anticipated deliveries commencing in 2016.
2. The Arkansas Valley Conduit has a Record of Decision approving the final Environmental Impact Statement. The Bureau of Reclamation Record of Decision for the Arkansas Valley Conduit selected the Comanche North Alternative.[1]
3. The Preferred Storage Option Plan was modified to become SWCWCD Long-Term Storage Contracts (40 years), which now has a Record of Decision for its Environmental Assessment.

[1] Bureau of Reclamation – February 27, 2014: http://www.usbr.gov/newsroom/newsrelease/detail.cfm?RecordID=46104

4.5.2.2. Storage Projects and Processes

The concept of underground water storage, particularly Alluvial Aquifer and Storage and Recovery (ASR), is employed in many Western states as a means to retain water for future needs. The Colorado General Assembly promulgated Senate Bill 06-193, which funded a study of underground storage in the Arkansas and South Platte basins. Some of the earliest Arkansas Basin Roundtable initiatives continued to build on the potential of this form of storage within the Arkansas basin.

Figure 2 - Multi-Use Storage Project Map



In 2007, the Roundtable supported both an investigation of the alluvial aquifer storage potential of the Upper Black Squirrel Designated Basin and a two-day ASR conference in collaboration with the American Ground Water Trust on the subject (See appendix xxx and xxx). Since SWSI 2010, the Roundtable has supported investigations in the Upper Arkansas and continued investigations into the viability of alluvial aquifer storage.

Upper Arkansas Basin Multi-Use Project builds on earlier work with the United State Geological Survey concluded in 2005.[2] The following is a brief summary provided by the Upper Arkansas Water Conservancy District:

Upper Arkansas Water Conservancy District Multi-Use Project

The Upper Arkansas Water Conservancy District (UAWCD) Multi-Use Project is a collaborative approach to address multiple needs and issues, while providing a high level of benefit throughout the basin. This

[2] U.S. Geologic Survey, Scientific Investigative Report 2005-5179, Kenneth Watts

project will have a multi-purpose focus that will strive to address needs associated with municipal, industrial, agricultural, recreational and environmental demands. The Multi-Use project has the ability to integrate all of these demands and create win- win situations for all parties. The focus of this project will be presented through 5 key topics:

1. **Storage**: address future water supply demands through the effective use of existing storage, creation of new storage, and integration of surface and groundwater for storage.
2. **ATM and IPP**: produce a reliable water source through interruptible water supply and rotational lease fallowing and implement planned projects by using the Lease Fallowing Tool.
3. **Recreation & Environment**: effectively enhance and provide recreational opportunities and environmental benefits.
4. **Hydro-Power**: promote cost effectiveness through the development of a low-impact hydropower system to generate revenue.
5. **Storage Authority and Cooperation between Water Users**: promote collaboration and cooperation between private, government and public entities and create a basin wide Water Storage Authority.

Pikes Peak Regional Water Authority Black Squirrel Water Quality Monitoring Study

Applicant: El Paso County Board of County Commissioners
Completion: December 26, 2013
Status: Complete
Funds: Basin: $35,000; State: $0

The Pikes Peak Regional Water Authority (PPRWA) Black Squirrel Water Quality Monitoring Study is currently in a data collection phase. The project is to monitor water quality for potential aquifer recharge uses. The project is on-going with periodic meetings of the Groundwater Quality Study Committee, with technical advice provided by the United States Geological Survey.

4.5.3. Projects in support of Municipal Operations

This section provides information for projects in progress subsequent to SWSI 2010 which were supported by the Roundtable for ongoing municipal operations.

North Lake Dam Rehabilitation Project

Applicant: City of Trinidad
Completion: June 30, 2014
Status: In Progress
Funds: Basin: $36,962; State: $702,273

The City of Trinidad is rehabilitating North Lake Dam. North Lake Reservoir is located approximately 40 miles west of Trinidad and is the primary source of municipal water for the City. Due to safety concerns, the Office of the State Engineer imposed a restriction on the dam. To avoid further restrictions, the City is addressing the dam safety concerns by constructing a new stability berm and replacing the spillway.

Hale Reservoir Renovation

Applicant: Cross Creek Metropolitan District
Completion: June 30, 2014
Status: In Progress
Funds: Basin: $20,000; State: $100,000

Cross Creek Metropolitan District is renovating the reservoir in order to meet multiple needs, including stormwater management and nonconsumptive aesthetic and recreational demands. The nonconsumptive renovations include environmental restoration of surrounding wetlands and development of wildlife habitat and birding opportunities. In addition, the reservoir will be considered a non-potable well and will provide irrigation water to Cross Creek Regional Park and surrounding landscapes.

Water Tank Replacement

Applicant: McClave Water Association Inc.
Completion: December 31, 2014
Status: In Progress
Funds: Basin: $64,300; State: $0

The tank is one of two 50,000 gallon water tanks constructed in 1974 that has undergone regular maintenance and cleaning during their service life, and remains in good condition, if not for the failure of the cement retainer ring. The cement retainer ring around the base of the tank failed, allowing the soil under the west portion of the tank to compact and settle, causing the drain line to snap in June, 2013 and resulting in the draining of the tank. Together, the two tanks provide water to approximately 25 homes, and the fill/supply for a 150,000 gallon tank that supplies water to the system's remaining customers. Without the storage tank the supply wells and pumps are being stressed, creating an untenable and unsustainable situation. The request was by a small Water Association with few cash reserves to fund this emergency project. In addition, the urgent nature of the project precludes funding sources that would take additional time to secure and obtain a notice to proceed.

Lamar Raw Water Transmission Line Replacement Project

Applicant: City of Lamar Wastewater Department
Completion: June 30, 2015
Status: In Progress, Contracting
Funds: Basin: $50,000; State: $150,000

4.5.4. Anticipated Future Projects

Current and future water supply gaps in the Arkansas Basin demand adaptability to develop and implement new projects going forward. There are two primary drivers behind anticipating future projects and needs:

- The Public Education and Outreach efforts will generate new projects in the short to medium term. The Arkansas Basin Roundtable will need to address these potential projects through its existing processes and determine those with sufficient and appropriate cost-benefits. The outreach effort is critical in understanding stakeholder concerns and generating future projects; and,
- Data used in the Applegate 2008 report and SWSI 2010 were aggregated to the basin level, leaving the potential for significant regional or local gaps. Future projects need to address localized supply gaps at the county level. To do this, data need to be disaggregated to the county level and analyses need to provide local insights into future supply and demand.[3]

Additionally, House Bill 1284 allows pilot projects to examine new and viable ways to providing water to users. These include Super Ditch[4] and technology projects. New IPP's are anticipated in the future in order to make further use of the pilot project concept.

Finally, SWSI 2010 assumed that water supplies which were available in 2008 would remain available in 2050. This assumption needs to be revisited in future projects to account for changing watershed health, nonrenewable groundwater yields, and localized supply and demand information. New projects need to address these concerns.[5]

4.5.5. Summary and Challenges

SWSI 2010 clearly articulated that the Arkansas Basin faces a substantial municipal supply gap 40 years hence in 2050, between 36,000 and 110,000 AF depending on the success rate for IPP's,. Through regular dialogue since SWSI 2010, and particularly in the Portfolio Tool process conducted by all basin roundtables in 2012, the Arkansas Basin Roundtable has come to the realization that the timing for a municipal gap is right now.

Municipal dependence on nonrenewable hard-rock aquifers and designated groundwater sources become significant liabilities as these aquifers reach the end of their useful life. That terminal date, when the economics of continued pumping increase exponentially, is here. Alternatively, the storage potential and non-evaporative nature of these same groundwater sources indicates these liabilities can become assets in addressing the gap. Municipal projects and methods which attempt to address the immediacy of the civic supply gap will continue to be supported by the Arkansas Basin Roundtable.

[3] For more information see Sections 2.2 and 3.0
[4] A pilot program to release water to Fowler by the Arkansas Valley Super Ditch was terminated in early March when irrigators/farmers who were providing the water removed their support.
[5] See Section 2.2

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4.6. Agricultural Projects and Methods

Agriculture plays a critical role in the economy and culture of the Arkansas Basin. The transfer of agricultural water resources to the growing municipalities is a historic fact of the post-World War II era. Maintaining reliable water supplies within the basin has been a priority of the Arkansas Basin Roundtable since its inception. The 2004 Statewide Water Supply Initiative (SWSI 2004) stated:

> *"Colorado will see a significantly greater reduction in agricultural lands as municipal and industrial water providers seek additional permanent transfers of agricultural water to provide for increased urban demand." – SWSI 2004.*

The Governor's Executive Order echo's this concern about the future of irrigated agriculture when it states: *Coloradans find that the current rate of purchase and transfer of water rights from irrigated agriculture (also known as "buy-and-dry") is unacceptable."*[1] This section will describe the Arkansas Basin Roundtable's funding of projects and methods to address the needs of agriculture. The earliest efforts focused on methods. Since SWSI 2010, projects and methods have centered on three focus areas: Alternative Transfer Methods (ATM), projects which improve agricultural operations, and most recently, the need for augmentation water to support increased efficiency on the farm.

Considerations for Agriculture to Urban Water Transfers

Some of the Roundtable's earliest funded work resulted in the 2008 report *Considerations for Agriculture to Urban Water Transfers*. Arkansas Basin water stakeholders made significant efforts to answer the question: "If water is going to be transferred from agriculture, how can it be done right – with full awareness of the issues to be resolved?" The 2008 report was specifically referenced in SWSI 2010's executive summary recommendations, which reaffirmed the Basin Roundtable's support for the framework and its application to future agricultural to urban transfers. The Basin's 2009 *Meeting the Needs* Report was included in SWSI 2010 as an appendix. The 2009 Report proposed rotating fallowing of agriculture as the primary method to reduce permanent dry-up of farm land.

Considerations for Agricultural to Urban Water Transfers, 2008

FRAMEWORK CRITERIA

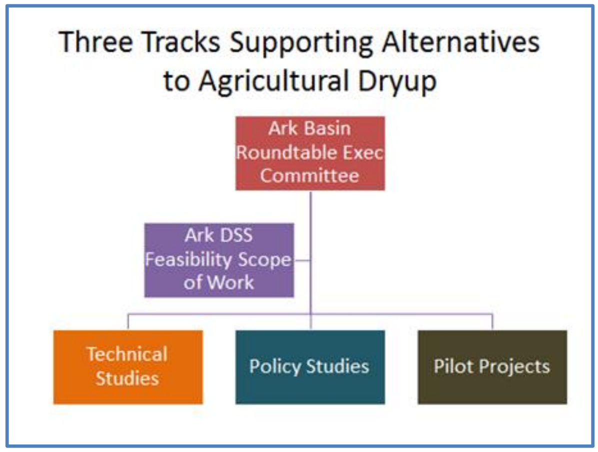
- Size of the transfer relative to the affected areas;
- Location of the transfer relative to the affected areas;
- Period of time to implement the transfer;
- Point of diversion;
- Time of diversion;
- Means of conveyance;
- Storage issues;
- Water quality impacts;
- Impact on environment;
- Impact on recreation;
- Economic impact to affected communities;
- Non-economic social impacts (psychological, health, cultural, historical, aesthetic, etc…); and,
- Local government interests.

[1] Executive Order 2013-005, Section II Purpose and Need, para. C.

Three Tracks for Rotating Fallowing

Subsequent to SWSI 2010, the Basin Roundtable has approved funding to establish rotating fallowing as an "alternative agricultural transfer method." The roundtable continues to build on the three-track program[2] developed in 2009, now conducted in conjunction with the CWCB's Alternative Agricultural Transfer Grant program. The three tracks, Technical Studies, Policy Studies and Pilot Projects, are pursued with oversight by the Roundtable's Executive Committee, and in support of a future Arkansas Decision Support System.

Figure 1 - Three tracks supporting ATM



As these three tracts developed, one of the unique constraints of the Arkansas Compact emerged. Increased farm efficiency, for example a change from flood irrigation to center-pivot sprinklers, requires increased supplemental volumes of water (augmentation)[3]. There is now a recognition that the development of alternatives to permanent dry-up will also support agriculture as it becomes more efficient in the future.

4.6.1. Definitions and Glossary

Agricultural definitions and a glossary are provided for edification of the section contents and to provide clarity to the reader.

- **Agricultural Gap**: the difference between what the basin indicates it wants to achieve with regard to agriculture, as defined in its goals and measurable outcomes, and what projects and methods it has determined could be implemented to meet those needs (from SWSI 2016 Glossary, Colorado Water Conservation Board). This definition is significantly different than that provided by SWSI 2010, which defined the gap as the difference between full irrigation water requirement consumptive use and water-supply-limited consumptive use.
- **Alternative Agricultural Transfer Methods**: methods to prevent the permanent transfer of water away from agriculture (typically to meet urban demands). They include rotational fallowing, water banks, purchase and leasebacks, deficit irrigation, and alternative crops.
- **Augmentation Water**: Augmentation water provides replacement of out-of-priority depletions to prevent injury to other water rights, and is required under Rule 10 and Rule 14 Plans, approved by Colorado Division of Water Resources Division 2 Engineer. Augmentation water

[2] See Section 2.2.4.1

[3] The Arkansas River Compact of 1948 apportions the waters of the Arkansas River between Colorado and Kansas, while providing for the operation of John Martin Reservoir. The Compact is "not intended to impede or prevent future beneficial development… as well as the improved or prolonged functioning of existing works: Provided, that the waters of the Arkansas River… shall not be materially depleted in usable quantity or availability…" (Article IV, para. D.).

sources include fully consumable irrigation water that has been through a water court change case, municipal effluent from transbasin sources and effluent from non-tributary groundwater.

- **Decision Support System**: water management system developed by the Colorado Water Conservation Board and the Colorado Division of Water Resources for each of the State's major water basins. It provides water resource data, modeling, geographic information systems, and documentation to support basin and statewide water decision making. At this time, there is not a fully articulated Decision Support System in place, however, funding continues on elements identified in a Feasibility Scope of Work.
- **Rule 10 plans**: The Colorado State Engineer, in order to comply with the Compact, developed "Compact Rules Governing Improvements to Surface Water irrigation System in the Arkansas River Basin in Colorado." Rule 10 allows ditch systems to collaborate on a Compact Compliance Plan to cover multiple irrigators. Plans must be filed by irrigators within the relevant regions (above and below John Martin Reservoir) detailing their acquisition of augmentation water to preclude depletion of flows within the Arkansas River.
- **Rule 14 plans**: Developed in accordance with Rule 14: Applications for Approval of Plans to Divert Tributary Ground Water. These rules were promulgated in response to the Kansas v. Colorado U.S. Supreme Court decision in 1996 requiring augmentation of groundwater wells constructed after 1948.

4.6.2. Projects to Support Alternatives to Permanent Dry-up

Studies to develop projects and method supported by the Arkansas Roundtable came from both the Water Supply Reserve Account program and a separate ATM grant program. Both grant programs are approved by the Colorado Water Conservation Board and administered by the CWCB staff, however, only WSRA grants are subject to approval by the Roundtable. Following are summaries derived from various CWCB memoranda describing the individual programs, organized in time periods since SWSI 2010. Studies conducted under the separate ATM program are included in Appendix XXX.

4.6.2.1. SWSI 2010 through July, 2012

The following are the WSRA grant summaries maintained by the Colorado Water Conservation Board for the programs and studies initiated:

Accounting and Administrative Tool for Lease Fallow

Applicant: Upper Arkansas Water Conservancy District
Approved: March 2013
Status: In Progress
WSRA Funds: $59,215

The Accounting and Administrative Tool project will build, assess, and document accounting and administration tools for lease fallowing as part of a "Super Ditch" style plan, in which several ditches come together, among seven Arkansas River ditches located between Pueblo Reservoir and John Martin Reservoir. The objectives of the tool are to:

1. Quantify the transferrable consumptive use derived from fallowed land parcels;

2. Quantify the associated changes in the amount, timing, and location of:
    a. Surface runoff to drains and to the Arkansas River;
    b. Recharge to the alluvial aquifer; and
    c. Groundwater return flows to the Arkansas River.
3. Support the development of plans to maintain return flows at or above historical levels and to quantify transferrable consumptive use at or below historical levels in a manner that complies with Colorado water law and the Arkansas River Compact; and,
4. Develop data interfaces that will complement the Arkansas River Decision Support System (ArkDSS) and build a common technical platform for the transfer of data to and from Hydrobase.

The Accounting and Administrative Tool is scheduled to be completed by January, 2015. For further information regarding the Accounting and Administrative Tool contact Terry Scanga, Upper Arkansas Conservancy District, at manager@uawcd.com.

Super Ditch Delivery Engineering

Applicant: Lower Arkansas Valley Water Conservancy District
Approved: November, 2011
Status: In Progress
WSRA Funds: $225,837

The Super Ditch Delivery Engineering project is an extension of the previous work performed by and for the Lower Arkansas Valley Water Conservancy District (LACWCD) to advance the Super Ditch fallowing project. The LAVWCD and the Super Ditch Company seek to preserve irrigated agriculture in the Lower Arkansas Basin with temporary water transfers and other methods than can benefit both the municipal interests and those of the local agricultural based economy. This additional engineering analysis is intended to enhance the understanding of the water resources in the Lower Arkansas Basin and improve the modeling of the operations. The key objectives of the project include:

- Analysis of reservoir operations in the lower Arkansas basin;
- Analysis of Pueblo Reservoir operations;
- Analysis of the Winter Water Storage Program;
- Recovery of non-exchangeable supplies;
- System calibration and optimization; and,
- Engineering and economic integration.

For further information on the Super Ditch Delivery Engineering project, contact Jay Winner, General Manager, Lower Arkansas Valley Water Conservancy District, at jwinner@centurytel.net; or Carla Quezada, Office Manager, LAVWCD, at cquezada@centurytel.net, (719) 254-5115.

4.6.2.2. 2012 to the Present

The dialogue between Arkansas Roundtable members revealed additional areas appropriate for investigation. The economic contribution of agricultural water supplies to the environment (species habitat and open space) and recreation (rafting, fishing, etc.) was examined[4]. Senior agricultural water rights in the Lower Arkansas Valley call water downstream, providing sustainable river flows in the Upper Arkansas. An understanding of the economic benefits of the current condition was deemed useful to better evaluate the economic impact of potential permanent dry-up. Legislative initiatives taken in good faith to support agriculture during this period, also prompted the Roundtable to convene a conference for water policy makers, to better understand the economics of agricultural water usage.

Legal challenges were raised to the first pilot project efforts. In the 2013 session of the Colorado General Assembly, legislation was passed known as House Bill 13 1248, *CONCERNING THE AUTHORIZATION OF PILOT PROJECTS FOR THE LEASING OF WATER FOR MUNIPAL US*E (Appendix XXX). This legislative solution was preceded by a public policy working group to coordinate with other basin roundtables on state law that might impact other basins. Following are summaries of the programs:

Study of Economic Contribution of Agriculture to Arkansas Basin

Applicant: Colorado State University
Approved: 2013
Status: Completed

A study was conducted in 2013 by Prof. James Pritchett and M.S. Candidate Jake Salcone (Dept. of Agricultural and Resource Economics, Colorado State University) to better understand the implications of water transfers out of agricultural uses. Methods were summarized for calculating a comprehensive value of the water used in agriculture by considering irrigated crop sales, economic spillovers from direct agriculture sales and additional non-consumptive water use benefits accrued to recreational activity through agricultural water deliveries. In a specific application, the direct, indirect and induced economic activity from the Arkansas River basin's irrigated agriculture is estimated using a generalized input-output model (IMPLAN) and recreation values are estimated using benefit transfer methods. Limitations of this study include a reliance on secondary data rather than primary data collection, and the accounting stance does not include all potential water values such as the provision of non-market ecosystem services and dynamic effects found in multiple years of impact adaptation. Results estimate a collective economic activity totaling more than $1.5 billion, employing over 12,000 people from industries intertwined with Arkansas Basin agricultural water use.

[4] At the request of the Arkansas Roundtable, this study was funded by a Task Order directly from CWCB to the Colorado State University Water Institute. A "Value of Agriculture" committee was formed within the Roundtable, which provided oversight and regular updates on the progress of the study.

***Pilot Project**: Agricultural Municipal Conservation Easement Demonstration*

Applicant: Lower Arkansas Valley Water Conservancy District
Approved: December, 2012
Status: Completed
WSRA Funds: $270,000

The purpose of the Agricultural Municipal Conservation Easement Demonstration is to demonstrate the use of conservation easements on irrigated agricultural land to both preserve long-term agricultural irrigation and provide secure long-term water supplies to a municipality. The concept would create an additional new alternative to the historical "buy- and-dry" of irrigation water rights for Municipal and Industrial uses. An Agricultural Municipal Conservation Easement would perpetually preserve the irrigated land and give the municipality a secure, legally enforceable permanent source of additional water supplies.

Subsequent to the demonstration project, three additional projects have been completed, with one in progress along the High Line Canal. The project area includes 400 acres with the option for municipalities to lease the water during three out of ten years. Additionally, the project ties the water to the land permanently and facilitates intergenerational transfer. Finally, the Lower Arkansas Valley Water Conservancy District is operating or commencing similar (although not intergenerational) projects on both the Holbrook and Catlin Canals. Funding for several projects is coming from the Gates Family Foundation (Colorado) and the Palmer Foundation.

Public Policy: Rotating Agricultural Fallowing Public Policy Work Group

Applicant: Pikes Peak Regional Water Authority
Approved: July, 2011
Status: Completed
WSRA Funds: $20,000

This grant helped fund a facilitated dialogue with interested stakeholders regarding the need for legislation to facilitate alternative agricultural water transfers (e.g. agricultural fallowing) based on research into existing statutes. The Work Group was a response to the proposed yet unsuccessful legislation (HB11 1068) of the 2011 legislative session. The goals of the working group are listed below:

- Review existing statutory law concerning agricultural transfers;
- Identify pertinent citations that might be modified for expediting agricultural transfers;
- Conduct a facilitated dialogue with the stakeholders; and
- Produce a summary report of the process.

Public Policy: *Agricultural Economics and Water Resources: Methods, Metrics and Models A Speciality Workshop*

Applicant: Colorado State University
Approved: June 2013
Status: Completed
WSRA Funds: $9,746
Other Funds: Provided by a working partnership with the Colorado Ag Water Alliance (CAWA).

The project convened workshop in Colorado Springs, CO that included experts in the field of agricultural and water resource economics. The objective of the workshop was to examine current methods and modeling techniques to estimate the value of water for various uses including agriculture and other nonconsumptive uses. The Draft Report, dated February 18, 2014, is still under review, and is included here as Appendix XXX.

4.6.3. Agricultural Projects Directly in Support of Agriculture

The Arkansas Roundtable approved grants that were directly in support of current agricultural operations, including:

Ordway Cattle Feeders Water Line Extension, Phase II

Applicant: Crowley County Board of Commissioners
Approved: April, 2013
Status: Completed
WSRA Funds: $72,500

The purpose of the Line Extension Project was to complete a raw water system to provide a consistent, viable water supply, enabling Ordway Cattle Feeders to sustain its operations and improve economic stability within Crowley County. The total cost of the Project was estimated to be $3.38 million. Crowley County was approved for a $275,000 WSRA grant by the Arkansas Basin Roundtable. The Company also obtained a loan from the CWCB to cover the remaining 90 percent of Project Costs.

Project: A Multi-Media Program for Reporting Crop and Turf Water Use Estimates from the Colorado Agricultural Meteorological Network (CoAgMet).

Applicant: Sangre de Cristo RC&D Council Inc.
Approved: September, 2011
Status: Completed
WSRA Funds: $9,000

This project employs a multi-media approach to communicate crop and turf water use reports to irrigators in the Arkansas Basin, particularly the areas served by the Colorado Agricultural Meteorological Network (CoAgMet). It consists of a multi-media approach over a three year period to expand the CoAgMet with improvements to allow other types of devices (such as cellular phones) to be used in place of computers. An additional project component developed a telemetric system for daily or weekly distribution of evapotranspiration reports through cellular telephone text messaging.

4.6.4. Anticipated Future Projects

The Basin Implementation Plan Outreach[5] program is currently seeking input from regional and local stakeholders. This process will reveal or generate additional projects potentially eligible for WSRA funding through the Arkansas Basin Roundtable. In addition, expanding the pilot programs into fully operational, basin-wide projects and methods is critical to future success in meeting the needs of agriculture in the Arkansas Basin. The pilot projects, many of which are in-progress, demonstrate successes and opportunities for improvement before full expansion or investment.

4.6.5. Summary and Challenges

The Arkansas Basin Roundtable fully recognizes the challenges facing irrigated agriculture within the Basin; the primary concern of agricultural stakeholders is the permanent drying of irrigated land. The Roundtable has sought to develop projects and methods to promote rotating fallowing using projects such as conservation easements, accounting and administrative tools, along with supportive changes in public policy. In addition, the Roundtable has focused on specific economic needs, such as the Ordway Cattle Feeders project and modern delivery of CoAgMet data. These projects underpin the ability of local producers to maximize their resources and encourage economic development.

To further understanding of agriculture's contribution to the Arkansas Basin economy, the Roundtable commissioned an economic study by the Water Institute and convened a conference for policy makers in partnership with the Colorado Agricultural Water Alliance. While rotating fallowing projects are being undertaken, as of this date, their outcomes are uncertain. The Roundtable is using pilot projects to study the efficacy of fallowing projects. However, the group acknowledges that the strong economic forces driving water toward municipal users from agriculture will continue.

The Arkansas Basin Roundtable has identified a primary goal of "sustaining an annual $1.5 billion agricultural economy within the basin." By selecting an economic goal, as opposed to a gross acreage goal, the Roundtable's projects and methods may allow water to be removed from the most marginally productive lands, while encouraging projects and methods that move the basin toward high-value crops and production. At the same time, support for collaborative solutions between and municipal and agricultural will continue. This approach addresses the need for additional augmentation water for agriculture, while acknowledging the important role agricultural water plays in the entire economy of the Arkansas River Basin.

[5] See Section 4.1 Outreach, Participation and Education

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4.7 Nonconsumptive Projects and Methods

Opportunities for environmental and recreational activities and enjoyment are boundless in the Arkansas Basin, and nonconsumptive water use is a major component of the basin's planning and distribution of water resources. Environmental and recreational uses of water are expected to increase with population growth. Managing Colorado's water supply is essential to meeting the state's and the Arkansas Basin's nonconsumptive needs.

4.7.1 Background and Definitions

A key component of SWSI and the Colorado Water Plan is to identify ways to close the existing consumptive and nonconsumptive water supply gaps. For the BIPs, BRTs will identify both short- and long-term projects and methods that will be critical to understanding how Colorado can meet its future water challenges. The projects and methods will be categorized, the degree to which nonconsumptive needs are met will be assessed, and strategies will be devised for implementing identified projects and processes (IPPs). For these efforts, the following terms are defined in accordance with the SWSI 2016 glossary:

- **Nonconsumptive IPP –** Nonconsumptive Identified Plans and Processes must have the following criteria:
  - The project or method has a project or method proponent.
  - The project proponent plans to utilize the project to meet nonconsumptive needs by 2050.
  - The project or method must have at least one of the following: preliminary planning, design, conditional or absolute water rights, rights-of-way (ROWs), and/or negotiations captured in writing with local governments or consumptive water users that the project could affect.
  - The nonconsumptive needs must be identified and included in the BIPs and/or SWSI documents.
- **Nonconsumptive New Proposed Project or Method** – Additional projects and methods identified by the BRTs that could meet future water needs, but do not meet the criteria of IPPs.
- **Nonconsumptive Gap –** The difference between what the BRT indicates it wants to achieve with regard to meeting its nonconsumptive needs, as defined in its goals and measurable outcomes, and what projects and methods it has determined could be implemented to meet those needs.

4.7.2 Arkansas Basin Nonconsumptive Goals

Based on the basin's unique nonconsumptive needs, the Arkansas BRT Nonconsumptive Needs Subcommittee has defined a set of goals that will be used to evaluate proposed projects and methods to help determine which IPPs should be implemented. The Arkansas Basin's current nonconsumptive goals are as follows:

- Maintain or improve native fish populations;
- Maintain, improve, or restore habitat for fish species;
- Maintain or improve recreational fishing opportunities;

- Maintain or improve boating opportunities including rafting, kayaking, and other non-motorized and motorized boating;
- Maintain or improve areas of avian (including waterfowl) breeding, migration, and wintering;
- Maintain or improve riparian habitat, and restore riparian habitat that would support environmental features and recreational opportunities;
- Maintain or improve wetlands, and restore wetlands that would support environmental features and recreational opportunities; and
- Improve water quality as it relates to the environment and/ or recreation.

4.7.3 Focus Areas and Areas of Concern

Past mapping efforts of nonconsumptive features by 12-digit HUC have highlighted areas with high concentrations of environmental and recreational attributes, primarily in three locations: 1) the mainstem Arkansas River upstream of Pueblo; 2) Fountain Creek watershed; and 3) areas around major reservoirs on the Lower Arkansas River between Las Animas and Eads (**Section 2.1.4.3**).

To appropriately prioritize projects and methods to be implemented, these focus areas and other areas throughout the basin will be further analyzed to determine problem areas and areas of concern. Projects and methods may be more critical in identified areas of concern for providing protections to environmental and recreational attributes. Not all attributes require protection, and projects and methods may not be necessary at this time for select areas where environmental and recreational attributes are at a desirable and sustainable level. This analysis will be supported by input from stakeholders, subject matter experts, and BRT members.

At present, the Nonconsumptive Needs Subcommittee has identified the following priority objectives:

- Lake San Isabel is an important fishing lake with multiple associated recreational activities that has insufficient water resources to cover evaporative loss. Due to limited water rights, the lake level has been lowered, thereby diminishing fishing and other recreational opportunities, and risking deleterious impacts associated with this reduced water level. It is a priority to obtain additional water rights to allow the lake to be raised to its full, functioning level.
- Grape Creek is an important fishery that runs through the Grape Creek Wilderness Study Area, which adds to its importance as a nonconsumptive resource that has suffered from inadequate flow. Efforts are ongoing with Deweese-Dye Ditch & Reservoir Company to re-operate the ditch to provide additional water flow through the stream during crucial periods.
- Important wetland resource evaluation needs to be accomplished. Although some information exists on the wetlands in this basin, it is not available basin-wide.
- Chilili Ditch, a canal that runs through the center of Trinidad in Las Animas County, is extremely outdated and in serious need of renovation to improve nonconsumptive resources. This priority would involve a project that addresses both consumptive and nonconsumptive needs, including an update to the ditch diversion to make it fish friendly through the use of fish ladders or other methods, which allow fish to move up and down this stream more easily.

The Nonconsumptive Needs Subcommittee will continue to identify priority areas as additional data and information are obtained from current projects and studies, stakeholder input, and from the public outreach campaign conducted for the BIP.

4.7.4 Gap Analysis Framework

The Gap Analysis Framework (Framework) (Appendix 4.7-A) is a method created by CWCB (April 2014) to aid BRTs in the process of project and method identification, and implementation of IPPs. Combined with the focus mapping and nonconsumptive toolbox, the Framework serves as a third resource for continued analysis of nonconsumptive needs and determining how to meet the goals of the basin. It is designed as a tool to help BRTs evaluate existing projects and methods, and identify where there may be opportunities to implement additional IPPs to address gaps in nonconsumptive needs. Specifically, this Framework is intended to help BRTs quantify current levels of protections for attributes that will serve as a baseline for establishing measurable outcomes. The Framework also serves as a tool for assessing existing projects and methods in each basin.

The Framework is designed as a series of questions to which the answers will guide the BRT in assessing and categorizing existing projects and methods. Four categories have been defined for projects and methods:

1. INFORMATION/KNOWLEDGE
Information and knowledge project types are those that emphasize knowledge generation or data gathering. These project types can include plans, studies, task forces, etc. The assumption is that these projects identify needs but do not necessarily directly protect an attribute. BRTs can then specify if any future project and methods are being planned or implemented because of these studies.

2. ISFs/RICDs
Projects in this category are included in CWCB's ISF program. These water rights are nonconsumptive, in-channel or in-lake uses of water made exclusively by CWCB for minimum flows between specific points on a stream or levels in natural lakes. These rights are administered within the state's water right priority system to preserve or improve the natural environment to a reasonable degree. Recreational in-channel diversion structures (RICDs) limit water rights to the minimum stream flow necessary for a reasonable recreational experience in and on the water.

To further assess ISFs and RICDs, BRTs can allocate "rules" *(e.g., ISFs/RICDs being met 75% or more of the time = low P&M Gap; 25 – 75% of the time = medium P&M Gap; < 25%= high P&M Gap; Never met = no known protection)* and use their local knowledge and expertise to further categorize the gaps in nonconsumptive needs.

3. IMPLEMENTATION
Projects and methods in this category emphasize more applied types of work, including flow agreements, structural improvements, habitat restoration, recreational improvements, and water quality projects.

4. STEWARDSHIP

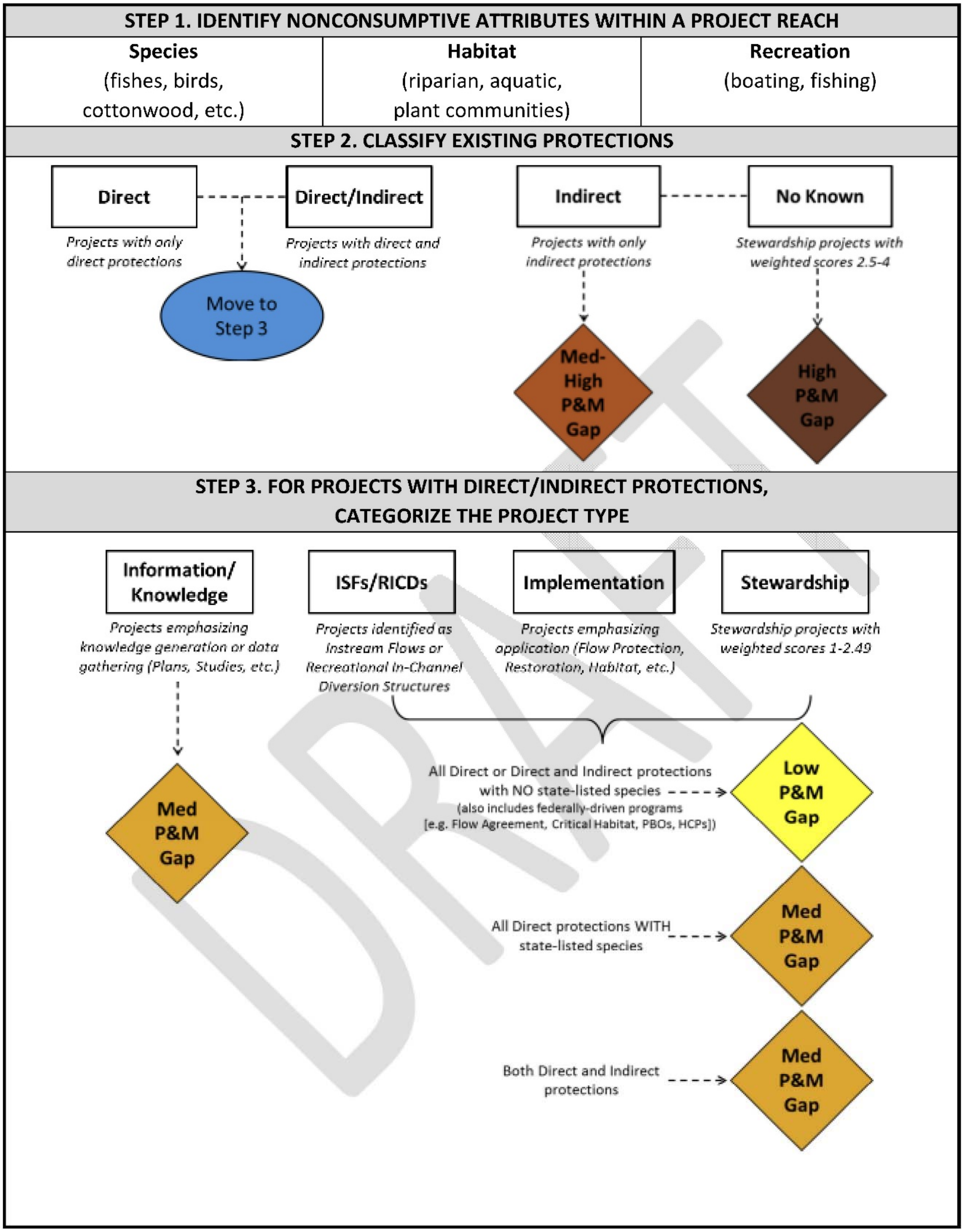
During the SWSI 2010 process, CWCB incorporated USGS SRGAP data into the projects and methods database. The SRGAP created detailed, seamless GIS data layers of land cover, all native terrestrial vertebrate species, land stewardship, and management status values. The management status values quantify the relationship between land management and biodiversity throughout the State of Colorado. Four SRGAP management status values are as described below (USGS 2010):

- Status 4 lands are where there are no known public or private institutional mandates, legally recognized easements, or deed restrictions held by the managing entity to prevent conversion of natural habitat types to anthropogenic habitat types. The area generally allows conversion to unnatural land cover throughout.
- Status 3 lands comprise areas having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area
- Status 2 lands are areas having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.
- Status 1 lands include areas having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management.

After projects have been categorized, BRTs can also use the Framework to assign a status to each project and method based on its capacity to protect identified nonconsumptive attributes within a given area. A status score of “4” means the project and method highly protect the nonconsumptive attribute and there is a low need (gap) for additional projects and methods. A status score of “3” means the project and method offer some level of protection for nonconsumptive attributes and there is a medium need (gap) for additional projects and methods. A status score of “2” means the project and method offer very little protection for nonconsumptive attributes and there is a high need (gap) for additional projects and methods. Status scores of “1” and “0” means the project and method offer no known protection for nonconsumptive attributes and there is a very high need (gap) for additional projects and methods

The step-by-step process of the Framework is illustrated in Figure 4.7.1. For the assessment to be successful, input from stakeholders and local experts is crucial to appropriately classify projects and assign levels of protection to individual attributes.

Figure 4.7.1 - Rubric for Gap Assessment and Evaluating Nonconsumptive Needs, Source: CWCB, 2014



STEP 4. VERIFY PROTECTION CLASSIFICATIONS AND IDENTIFY LOCATIONS FOR ADDITIONAL PROJECTS AND METHODS

High P&M Gap	A stream reach or waterbody that does not have a Project or Method that directly addresses nonconsumptive needs. ** Tends to be Stewardship (land management) with a SRGAP status score of 2.5-4.*
Med-High P&M Gap	A stream reach or waterbody that is highly in need of additional Projects and Methods to meet nonconsumptive needs due to significant gaps in existing or planned Projects and Methods.
Med P&M Gap	A stream reach or waterbody that is moderately in need of additional Projects and Methods to meet nonconsumptive needs due to the presence of Projects and Methods that may not be fully addressing nonconsumptive attributes.
Low P&M Gap	A stream reach or waterbody whose nonconsumptive needs are met with existing or planned Projects and Methods and is therefore a low priority for additional Projects and Methods. **These projects should consider the Monitoring Program.*

** The following step can be taken by the BRTs to further assess Projects and Methods in their Basins and create strategies for IPPs.*

STEP 5. IF THERE IS A GAP IN PROTECTION, DETERMINE TYPES OF PROJECTS AND METHODS NEEDED.

Existing programs to address nonconsumptive gaps and develop Projects and Methods can be found in Appendix G: Existing Program in the Nonconsumptive Toolbox. The categories listed below can be thought of as a way for BRTs to organize their nonconsumptive Projects and Methods. The table includes a list of programs and policies that can serve as resources for stakeholders:

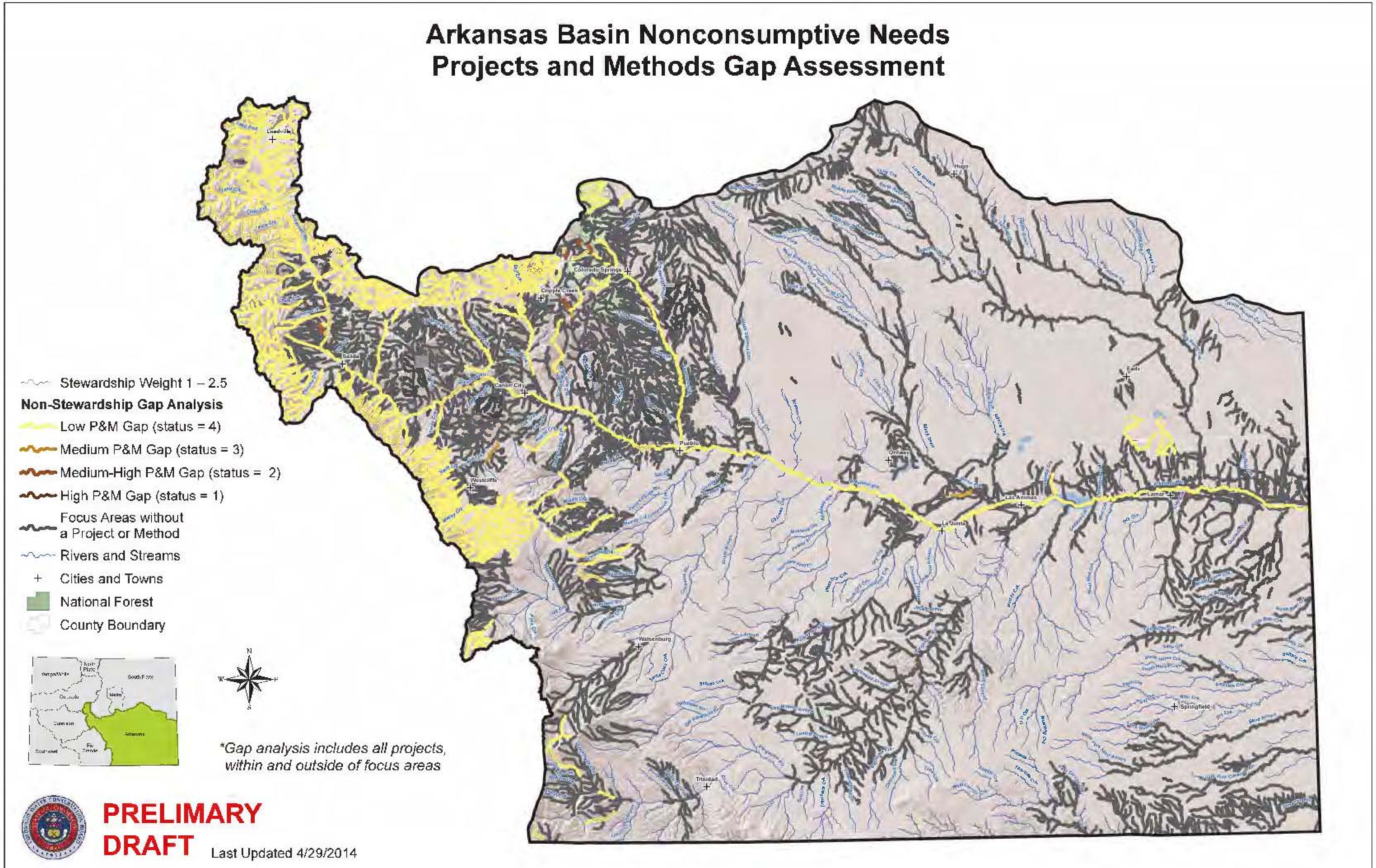
- Instream flows for environmental and recreational purposes
- Habitat protection, restoration, and enhancement
- Planning, administrative, and regulatory program

CWCB processed data from SWSI 2010 through the Framework and created an initial draft Gap Assessment for each basin. The results are intended as a starting point to illustrate the capabilities of the Framework for evaluating gaps in nonconsumptive needs and existing projects and methods, knowing that the process will need to be refined to address each basin's goals and to incorporate new information gathered during the BIP effort. The gap analysis and associated GIS maps were not completed for the BIP. However, concepts from the Framework were utilized to evaluate IPPs, as described in the sections below. Nonconsumptive attributes CWCB used for the initial Arkansas Basin Gap Assessment are presented in Table 4.7.1. Results of the assessment are illustrated in Figure 4.7.2.

Table 4.7.1 - Arkansas Basin Environmental and Recreational Attributes Used in Gap Assessment, Source: CWCB, 2014

Arkansas Basin Environmental and Recreational Attribute Dataset	
Additional Wilderness Areas and Wilderness Study Areas	Gold Medal Trout Lakes
Arkansas Darter	Gold Medal Trout Streams
Arkansas Headwaters Recreation Areas	Greenback Cutthroat Trout
Arkansas State Wildlife Areas and State Fishing Units	Least Tern
Arkansas Wilderness Areas	Lesser Prairie Chicken
Audubon Important Bird and Biodiversity Areas (IBAs)	National Wetlands Inventory (NWI)
Bald Eagle Sites	Piping Plover
Birding Trails	Pueblo Fishing
Boreal Toad	Recreational In-Channel Diversion Structures
Colorado Outstanding Waters	Significant Riparian/Wetland Communities
CWCB Instream Flow (ISF) Water Rights	Waterfowl Hunting / Viewing
CWCB Natural Lake Level Water Rights	Whitewater Boating
Flatwater Boating	Wilderness Area Waters

Figure 4.7.2 - CWCB Arkansas Basin Nonconsumptive Needs Projects and Methods Gap Assessment



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4.7.5 GIS Mapping

To support BIP efforts, additional GIS mapping will occur. Complimentary maps will be created from datasets to illustrate current attributes and protections (similar to those produced for SWSI 2010), and maps showing areas of concern with problems and potential solutions by way of IPP implementation. The list of environmental and recreational attributes in Table 4.7.1 will be reviewed by the BRT and updated if necessary for use in nonconsumptive mapping for the BIP. Appendix 4.7-B contains draft maps of the individual attributes listed in the table.

To aid in identification of areas of concern, additional GIS layers will be mapped including watershed health attributes (Table 4.7.2), conflict areas for consumptive and nonconsumptive uses, and multi-benefit project locations. By combining the various GIS layers, areas with multiple features or concerns will be highlighted and may help prioritize which projects and methods or IPPs are implemented. Information gathered from stakeholders, subject matter experts, and BRT members will be used for these maps (see Section 4.7.3). Nonconsumptive mapping efforts for the BIP will be determined and approved by the Arkansas BRT.

Table 4.7.2 - Watershed Health GIS Layers Available for use in the Arkansas Basin Implementation Plan, Source: Colorado Springs Utilities, 2014

Watershed Health GIS Layers			
Recreational Points of Interest	**Environmental Points of Interest**	**Municipal and Industrial Points of Interest**	**Agriculture Points of Interest**
Whitewater Boating	Tributary Sedimentation	Otero Pump Station	Sedimentation and Erosion
Gold Medal Water	Bear Creek	Transmountain Transfers	Salinity in Lower Arkansas Basin
Pueblo Reservoir	Arkansas Mainstem	Transmountain Ditches	Pueblo Reservoir
Arkansas Headwaters Recreation Area	Lower Arkansas Wetland / Habitat	Homestake Reservoir	Irrigation Diversion Structures
John Martin Reservoir	Agriculture Lands as Habitat	Homestake II Memorandum of Understanding (MOU)	Beetle kill - Fire and Upstream Reservoirs
Birding Areas at Reservoirs	Arkansas River	Rampart Reservoir	Waterlogging / Agriculture
RICD Canyon City	Water Quality - Arkansas	Pueblo Reservoir	
RICD Salida	Riparian/Wetlands	North Slope Reservoirs	
RICD Buena Vista	Boreal Toad Habitat	Colorado Canal	
Twin Lake, Clear Creek Recreation	Arkansas Darter	Kansas Compact	
U&CQ		Upper Black Squirrel DWB	

4.7.6 Identifying Projects and Methods

A combination of available tools and information will be used to identify the general projects and methods needed to address nonconsumptive needs in focus areas and areas of concern. GIS maps will help to illustrate the location of attributes, the location of current projects and methods, and areas where additional projects are needed to provide protections to environmental and recreational attributes. Once these areas are identified, the Nonconsumptive Toolbox (Section 2.1.4.6) will be used to identify general projects and methods that are needed in the Arkansas Basin. Thereafter, specific IPPs can be identified for implementation.

4.7.7 Identified Plans and Processes

An updated list of IPPs was generated through stakeholder input for the BIP. Several lists were received from various agencies and can be found in Appendix 4.7-C. As a next step for the BIP, the lists will be consolidated into one master list by verifying project information, removing duplicates, and incorporating data received from the public outreach effort. During the outreach, stakeholders were contacted and given opportunities to provide input during development of the BIP through public meetings, e-mails, and online input forms. More information on public outreach and education can be found in Section 4.1. A list of Arkansas Basin nonconsumptive stakeholders can be found in Appendix 4.7-D.

The IPPs will be assessed using the Nonconsumptive Toolbox to help identify and prioritize which IPPs should be implemented to help meet the Arkansas Basin's nonconsumptive needs. Input from stakeholders and the Arkansas BRT will be fundamental for this step. Methods presented in the Gap Analysis Framework may also be utilized to evaluate IPPs. The BRT will review the IPP list CWCB used for the Gap Assessment, and will incorporate and update information into the BIP IPP list where applicable. Items that will be considered when ranking IPPs include, but are not limited to, correlation to goals and measureable outcomes, cost, funding, timing, location, attributes that will be affected, potential for multi-benefit impacts, conflicts with consumptive and other nonconsumptive needs, and severity of nonconsumptive need being addressed.

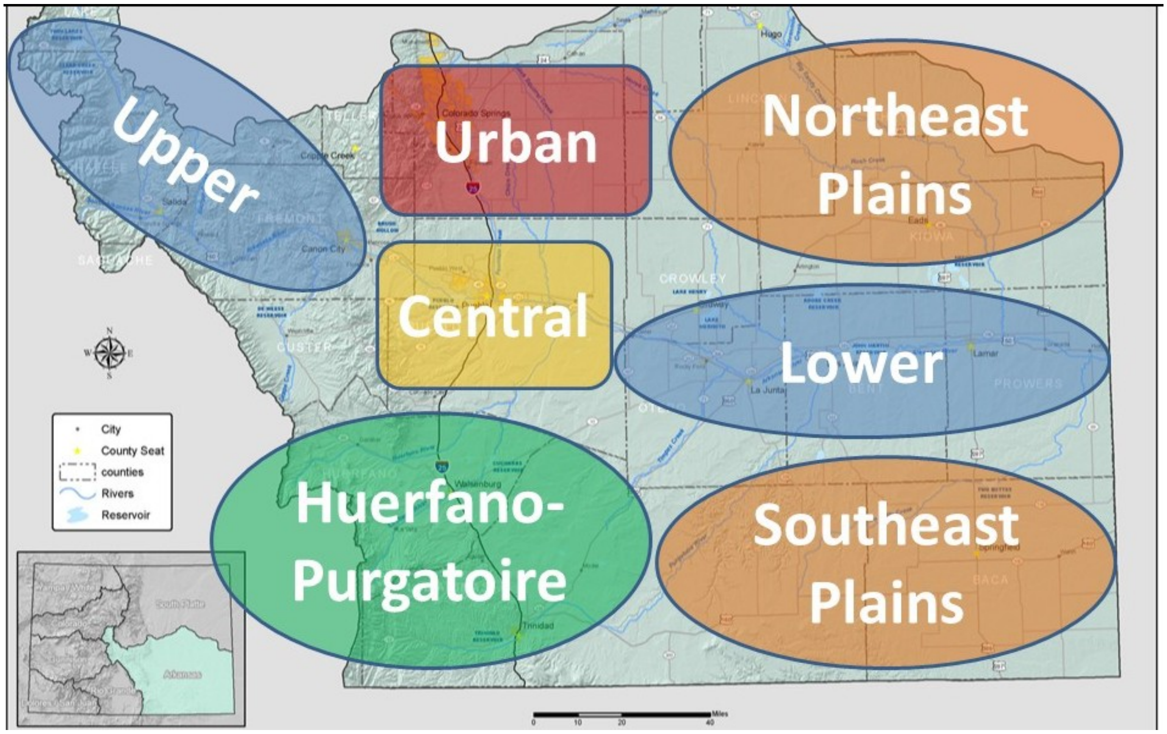
4.7.8 Anticipated Future Projects

The Gap Analysis Framework is the most comprehensive tool developed to date for assessing nonconsumptive needs. With further refinement to specialize the Framework for the Arkansas Basin, it may prove to be a tool that can be used continuously while maintaining an updated database of nonconsumptive attributes and IPPs.

Outreach to stakeholders will also be an ongoing effort to maintain an updated list of IPPs. It is likely the outreach process will be refined and streamlined so that assessment of received IPPs can be performed efficiently using the Gap Analysis Framework or other tools for assessment and implementation.

The Arkansas Basin is being further divided into subregions. Given the size of the Arkansas Basin and the diverse needs across the region, subregions are anticipated to assist in stakeholder outreach and advocacy, and improved identification of nonconsumptive needs in rural areas.

Figure 4.7.3 – Approximate Arkansas Basin Subregions, Source: Arkansas BRT, 2014



4.7.9 Summary and Challenges

The Arkansas BRT is continuing the effort to identify, prioritize, and implement projects and methods to meet nonconsumptive needs in the basin. It is understood that this process will be ongoing in order to adapt to the nonconsumptive needs and available water supplies over time. To increase our understanding of environmental and recreational attributes and their nonconsumptive needs, we must broaden our outlook to include related areas such as watershed health. A comprehensive understanding of Colorado's water components can result in more efficient and valuable water resource planning and management.

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4.8. Interbasin Projects and Methods

Interbasin projects and methods focus on those projects where multiple basin roundtables may have a common interest. The Arkansas Basin is an importing and exporting basin, receiving water transfers from several watersheds in the Colorado basin, and delivering native water to the South Platte basin. Imported water can be used to extinction within the Arkansas Basin, which, when combined with storage in the Upper and Lower Arkansas Valley, becomes the corner stone for all types of uses, recreation, environmental, agricultural and municipal.

Section 4.8 was deemed optional by the Colorado Water Conservation Board; however, the Arkansas Basin Roundtable included it for three reasons:

1. As an importing and exporting basin, the future of the State's Colorado River Compact Entitlement directly affects all water uses in the Arkansas Basin; in particular, a future without New Supply, as that term is understood in the lexicon of SWSI 2010, is detrimental to the future of agriculture in the Arkansas Basin;
2. There are opportunities for collaboration across the Continental Divide in both directions. Collaboration at that scale might only be possible through vigorous dialogue between basin roundtables with support from the Interbasin Compact Committee, and;
3. Storage in all forms— both restoration of existing structures and construction of new storage vessels— is impacted by the regulatory regime that governs dam design. Practical and realistic design of dam structure using the latest in technological advances will benefit every basin in Colorado.

Previous reports and documents have described agricultural dry-up as a medium to long-term issue; however, the Arkansas Basin Roundtable sees the issue as critical in the near-term. Discussions concerning new supplies need to include all potential alternatives. New, interbasin supplies are a potential alternative to long-term permanent agricultural dry-up, as identified in the Governor's Executive Order D 2013-005.

Cooperation in the storage and release of water in the Upper basin creates the recreation that underpins the economy of several counties. Because the bedrock of the Voluntary Flow Agreement is appropriate hydrology for fish species in the Spring and Fall, the management of storage releases is fundamental to a robust environment. New storage vessels are needed to meet all demands, yet the high cost of construction for new storage is exacerbated by current design requirements. Improved analysis, for example, the Extreme Precipitation Assessment Tool ("EPAT"), could potentially reduce those future costs, but needs support from water users in all basins.

4.8.1. Definitions and Glossary

<u>Interbasin Compact Committee</u> (CRS 37-75-101 et seq.)**:** The Interbasin Compact Committee (IBCC) was established by the Colorado Water for the 21st Century Act to facilitate conversations among Colorado's river basins and to address statewide water issues. A 27-member committee, the IBCC encourages dialogue on water, broadens the range of stakeholders actively participating in the state's water

decisions, and creates a locally driven process where the decision-making power rests with those living in the state's river basins.[1]

Interbasin Compact Charter: Foundational legal principles for the Interbasin Compact Committee.[2]

4.8.2. Background on New Supply Initiatives

The 2009 Needs Report acknowledged the Arkansas Basin's dependence on the Colorado River. At that time, two efforts—a private effort known as the Million Resource Group and a public effort by the Colorado-Wyoming Coalition—were exploring construction of a pipeline from Flaming Gorge Reservoir. What impact might development of new supplies from Flaming Gorge mean to the Arkansas Basin; and, given the scale of the municipal supply gap identified by the Metro and South Platte Roundtables, would any new supply from the Flaming Gorge ever reach the Arkansas Basin?

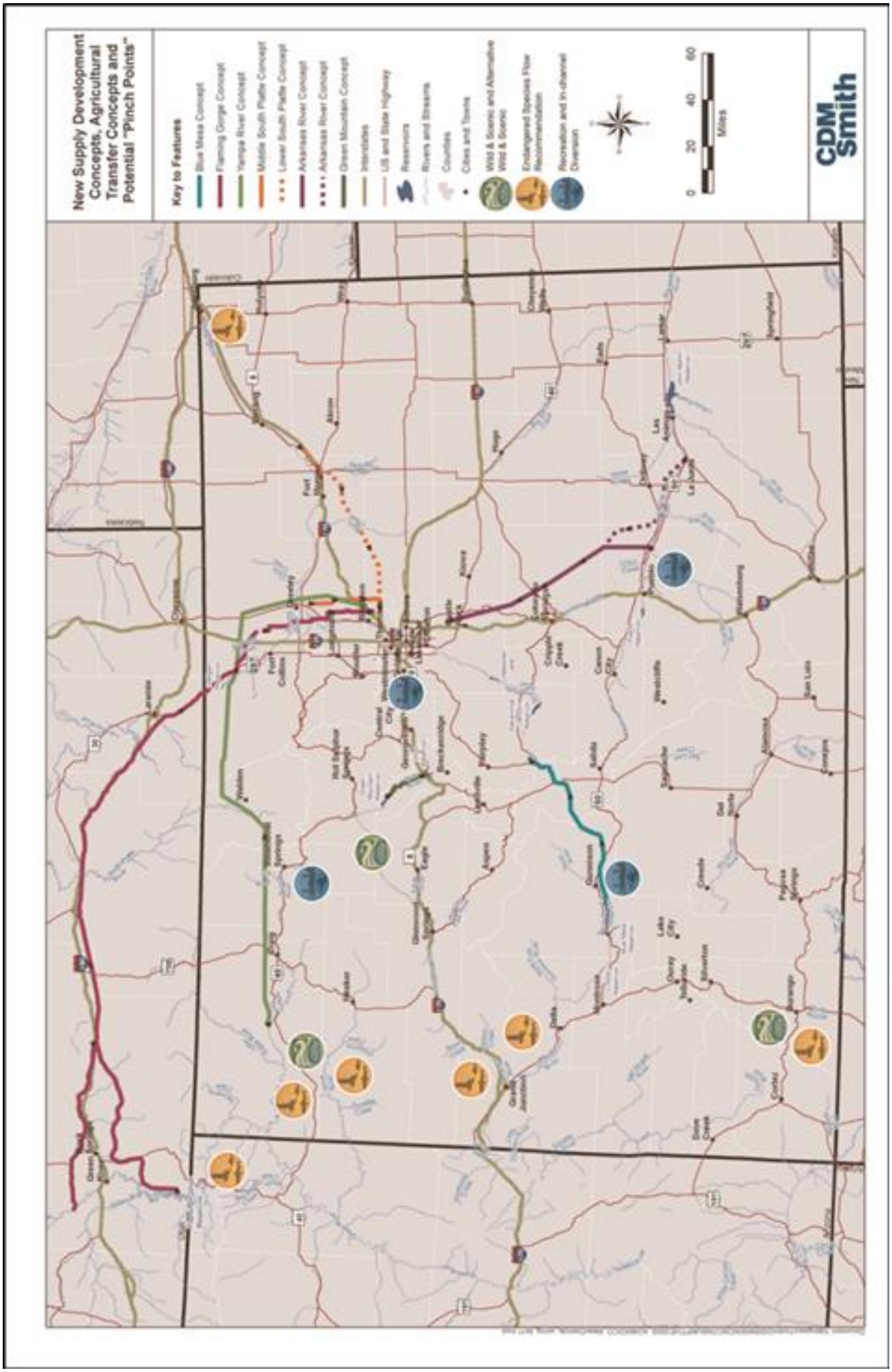
The Arkansas Basin Roundtable, in collaboration with the South Platte Roundtable, commenced work in 2010 on an evaluation of the merits of a basin-to-basin working group. The Assessment was conceived in order to determine the viability of dialogue on new water supplies from the Colorado River Basin. The Flaming Gorge Project Task Force Assessment is detailed below.

Flaming Gorge Project Task Force Assessment

Applicant: El Paso County Water Authority
Approved: May, 2010
Status: Completed
Funds: Basin: $20,000 each, total Arkansas and South Platte Roundtables, total $40,000

The Flaming Gorge Project Task Force Assessment determined the viability of forming a task force, similar to the Fountain Creek Vision Task Force, to inform a Flaming Gorge Project. The Assessment reviewed constituent agendas, supply alternatives, demand management, environmental impacts, and project development strategies to determine if a collaborative task force model is viable. Keystone Center prepared a written Assessment Summary, including a recommendation on whether to proceed to the convening of a task force or not. The Assessment recommended proceeding with a full task force with an invitation for all nine basin roundtables to participate. Concurrently, the Colorado Water Conservation Board, in drafting SWSI 2010, produced a Pinch Points map. The Assessment Summary is included as Appendix XXX.

[1]For further information: http://cwcb.state.co.us/about-us/about-the-ibcc-brts/Pages/main.aspx
[2] For further information: http://cwcbweblink.state.co.us/weblink/0/doc/114181/Page1.aspx?searchid=c38d2e6b-e19e-4b70-9c88-89fd819136e6


New Supply Development Concepts, Agricultural Transfer Concepts and Potential "Pinch Points"
Key to Features
Blue Mesa Concept
Flaming Gorge Concept
Yampa River Concept
Middle South Platte Concept
Lower South Platte Concept
Arkansas River Concept
Arkansas River Concept
Green Mountain Concept
Interstates
US and State Highway
Reservoirs
Rivers and Streams
Counties
Cities and Towns
Wild & Scenic and Alternative Wild & Scenic
Endangered Species Flow Recommendation
Recreation and In-channel Diversion
0
20
40
60
Miles
CDM Smith

4.8.3. Background: Statewide Water Supply Initiative 2010

The Arkansas Basin's edition of the Statewide Water Supply Initiative of 2010 included the recommendation that all 4 legs of the stool, including New Supply, were critical to the future, and included a discussion of the Flaming Gorge Task Force Assessment.

4.8.4. Post SWSI 2010: Projects In-Progress

The Flaming Task Force convened as recommended in the Assessment. In approving the program, the CWCB divided the effort into two phases. Phase One was completed in the Fall of 2012, a summary is included below:

Project Exploration Committee: Flaming Gorge

Applicant: Pikes Peak Regional Water Authority
Approved: December 2011
Status: Completed
Funds[3]: Statewide: $50,000, Arkansas WSRA Basin: $5,300, Metro: $8,700, South Platte, Gunnison & Colorado: $2,000 each, Rio Grande & Southwest: $1,000 each.

This grant established the Basin Roundtable Project Exploration Committee to serve as a venue for roundtable to roundtable discussions of potential water supply projects, with the Flaming Gorge Pipeline project serving as a test case or starting point. The Basin Roundtable discussions did not seek consensus on whether or not to build a Flaming Gorge project, but rather examined the issues involved in the project, the challenges or barriers to such a project, and potential benefits of such a project. This grant built on the Flaming Gorge Task Force Situation Assessment WSRA grant approved by the Board in May 2010. The Assessment grant asked independent facilitators to assess the timeliness and merits of a discussion on the topic of a Flaming Gorge project.

The Task Force Report is included in Appendix xxx, and includes a Process Flow Chart and a list of elements that would constitute a "Good" Project. In January, 2013, the CWCB board declined to proceed with Phase Two of the Task Force, perhaps in anticipation of the Colorado Water Plan.

Subsequently, the Roundtable has continued its interest in the New Supply dialogue, with discussion of a more environmentally-centered approach to a pipeline from the Green River as described below:

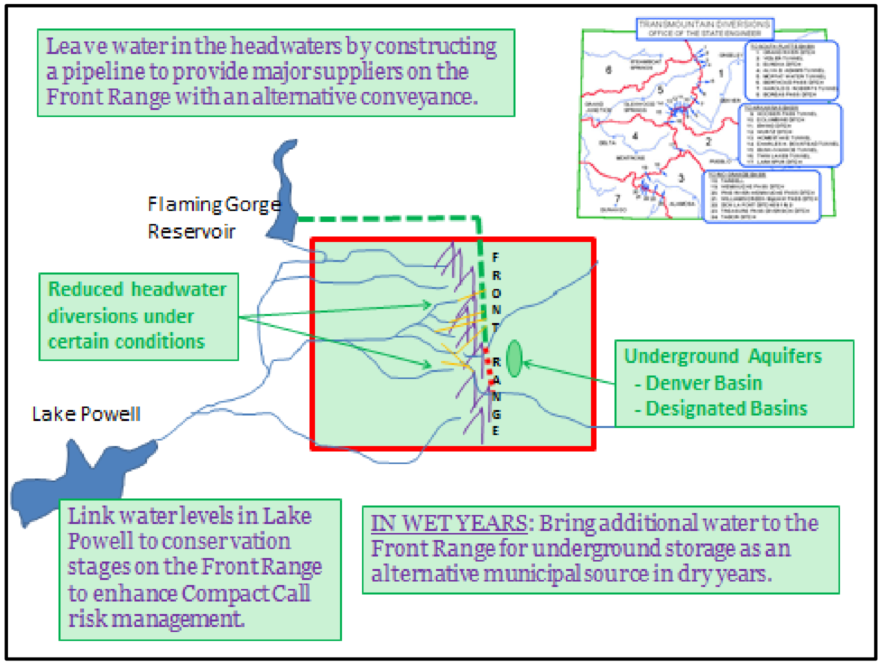
Green River Riparian Restoration Project

The New Supply conversation is proceeding at the IBCC under the heading "preserving options" or "conceptual agreement." On a parallel track, a discussion among roundtable chairs in early 2014 reviewed the following approach for further dialogue between roundtables.

[3] SUMMARY MINUTES AND RECORD OF DECISIONS, September 13-14, 2011,Final and Approved November 15, 2011

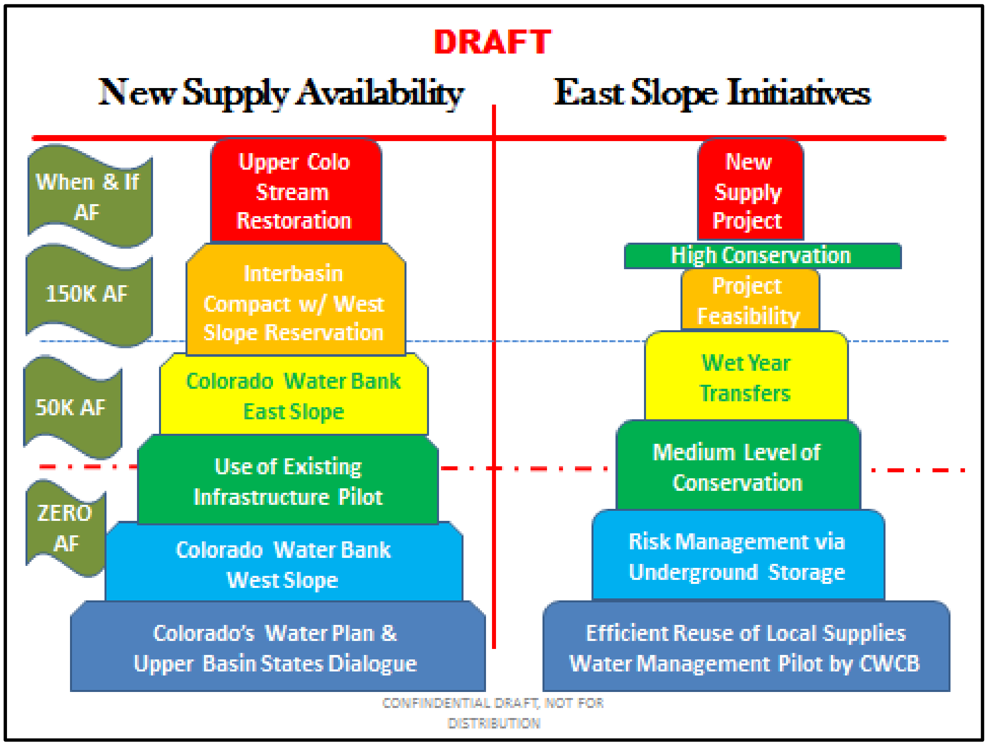
Objectives of a Project Proposal

The Project Exploration Committee asked its members to articulate perspectives on the advantages and disadvantages of a potential pipeline project. One of these, as shown in the graphic, was framed as an alternative conveyance for existing Colorado River Compact water rights, which would then allow reduced diversions in Colorado River headwater streams for restoration of the riparian habitat. With an alternative delivery mechanism, those entities with entitlements to divert at the headwaters would convey an equivalent amount of water through a new pipeline. The pipeline then becomes a tool for greater flexibility in management of Colorado's entitlement under the Colorado River Compact.



In the summer of 2013, in the wake of the Governor's Executive Order calling for a State Water Plan, the three East Slope roundtables began development of a White Paper as a means to align approaches to the various topics under discussion. The draft White Paper was specific as to New Supply, including the Pinch Points map from SWSI 2010 identifying potential pipeline configurations. Of the six (6) identified projects, only the one sourced in the Green River appeared as a viable alternative to move Colorado River water to the East Slope without excessive energy costs. When an alternative delivery mechanism is in place, headwaters restoration becomes possible.

The White Paper also agreed with many West Slope concepts for elements precedent to any project development, such as risk management. The proposed Section 4.8 draft would proffer specific actions establishing milestones along the path of project development—a "stack strategy." The graphic below is intended to describe the milestones, which are then linked to availability of new water supplies. The strategy takes on Risk Management, Conservation, and a reservation of water for future growth on the West Slope. Such an "intrabasin compact" is an integral component of the *Water for the 21st Century Act.*



Next Steps

In a conversation between roundtable chairs on March 8, 2014, there was a willingness to respond to this approach within basin implementation plans if proposed by the Arkansas roundtable, hence its inclusion here.

4.8.5. Continuing Interbasin Dialogue

The July 8, 2014 Arkansas Basin Roundtable included a brief discussion of the Draft Conceptual Agreement by the IBCC. A summary memorandum by Jacob Bornstein, IBCC, and Roundtable Program Manager of CWCB staff, is included as Appendix XXX.

4.8.6. Design and Construction of New Storage

The State of Colorado needs to support the continual improvement of the design criteria and parameters for new storage. This support is important for the all Basin Implementation Plans. As technology changes, the State should provide funding to support updating technical programs and activities which will help meet the gap. Better management tools will optimize projects to meet multiple needs, minimize cost, and protect public health and safety.

4.8.7. Summary and Challenges

Although an "optional" section, a discussion of Interbasin Projects and Methods is fundamental to an Arkansas Basin Implementation Plan. The Arkansas Roundtable has consistently taken the initiative to foster basin-to-basin initiatives. The motivation is derived from what the Basin stands to lose—not only continued and increasing transfers from agriculture to municipal uses—but also significant recreational and environmental benefits derived from Colorado River basin imports. Hundreds of thousands of tourists enjoy rafting the Arkansas River each year, with no awareness (nor is one needed) that they are rafting on imported Colorado River water. Water is stored in the headwaters, retimed to support native flows ,and recaptured in Pueblo Reservoir where it serves agriculture and municipal needs. When managed through the Voluntary Flow Agreement, the supplemental flow supports the Gold Medal fishery of the Upper Arkansas River and the economy thereof. All water interests present at the Arkansas Roundtable are therefore stakeholders in the future of the Colorado River. This subject is important to our collective future.

Section 5 Implementation Strategies for Projects and Methods

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5.1 Introduction

This section identifies water management challenges and opportunities within the basin and outlines a framework for addressing them. The Arkansas Basin Implementation Plan continually emphasizes the need to develop sustainable and reliable water supplies for the future. This implies focusing on quality and quantity through standardized decision making processes, stakeholder engagement, public outreach, and thorough research.

The Arkansas Basin Roundtable has focused on water as an economic asset while incorporating its cultural, social, and environmental aspects in decision making. The Roundtable intends to continue using this framework for grant decision making. In addition, the Basin Implementation Plan has provided the Roundtable the opportunity to deepen community and stakeholder engagement, outreach and education. Stakeholders and water constituents are critical to developing a well-rounded and complete needs assessment of the Basin going forward. While the Basin Implementation Plan provides significant needs assessments (see Section 2), it is critical that the Basin continue to develop needs assessments, as changing public attitudes, regional demographics and economics demand attention.

Fundamental to the outreach and education process are the Roundtable's goals of integrating water planning across the Arkansas Basin. Providing Water Supply Research Account (WSRA) grants to a broad variety of users and water uses is important to the future of the Basin in addressing all water needs and concerns, from developing sustainable municipal water supplies for at-risk regions to maintaining and growing water based tourism, the Arkansas Basin Roundtable seeks equal input from all stakeholders in order to create an integrated plan.

Finally, the Arkansas Basin Roundtable finds research to be critical to its understanding of the roles water plays in the Arkansas Basin. Recently, the Roundtable funded a Colorado Water Institute (Colorado State University) study of the economic role of water in the Basin, conducted an infrastructure study, and established exploratory committees to review opportunities. These projects demonstrate the ongoing commitment by the Roundtable to developing greater knowledge and understanding of the roles water plays in the lives of Arkansas Basin Residents.

5.2 Meeting the Challenges and Implementing the Identified Projects and Processes (IPP's)

The Arkansas Basin Roundtable has a strong history of stakeholder engagement and methodical planning. In developing the Basin Implementation Plan, the Roundtable used a two tiered approach:

1. Water planning is conducted through an economic perspective, an initiative supported directly through the Governor's Executive Order 2013-005. The Executive Order requests that the Statewide Water Plan, and by extension the Basin Implementation Plans, incorporate *"a productive economy that supports vibrant and sustainable cities, viable and productive agriculture, and a robust skiing, recreation, and tourism industry."*
2. Water planning incorporates public outreach and education in order to elicit stakeholder responses, generate broad coverage of water issues, and detail the totality of the Arkansas

Basin's needs. This process has revealed the sub-regional nature of the projects and processes identified by the Basin Implementation Plan, and the importance for those projects and processes to have local support in the future.

The Arkansas Basin Roundtable, through the previous reports, came to consensus through the SWSI 2010 process on the critical needs and paths forward for the Basin. A subset of the SWSI 2010 recommendations includes:

- Implementing all "four legs of the stool[1]";
    - Active and passive conservation;
    - Implementation of all identified projects and processes;
    - Alternatives to agricultural transfers;
    - Development of Colorado River supplies;
- Addressing the critical gap that exists in nonrenewable groundwater supplies and the sustainability of designated groundwater basins;
- Acknowledging that storage, including alluvial storage and recovery, is critical to meeting the Basin's consumptive and nonconsumptive needs, and is essential to all solutions;
- Generating greater stakeholder input and participation for environmental, recreational, and agricultural water users and advocates; and,
- Acknowledging the importance of agriculture as a key cultural and social component of the Basin, beyond its economic importance.

The Arkansas Basin Roundtable continues to view the SWSI 2010 recommendations as critical components of water strategy and planning going forward. The SWSI 2010 document and recommendations built on dialogue generated by the preceding reports produced by the Roundtable.

5.3 Finalizing the Basin Implementation Plan

In order to process the input received, bring clarity to identified projects and processes (IPP's) and understand potential projects and methods, the Arkansas Basin Roundtable will follow three steps:

1. Review and determine status of all input received, sorting into categories:
    A. Meets the IPP criteria, or;
    B. Qualifies as a Project or Method, or;
    C. Requires more information, or;
    D. No project identified—expression of sentiment or general commentary on the process
2. Convert the input into a project sheet format organized by sub-regions
3. Establish a protocol for setting priorities
    A. How the project meets the basin needs and goals

[1] This euphemism was articulate by the Interbasin Compact Committee in a Portfolio Tool Exercise (2012) that explored various combinations of these elements at the basin-wide level. The Arkansas Roundtable adopted recommendations that emphasized that all four elements were critical to meeting the Arkansas Basin's gaps. For a complete list of the recommendations see SWSI 2010 page ES-

B. Tier 1, 2 & 3 methodology

The historic approach by the Arkansas Basin Roundtable, as documented in SWSI 2010, took a basin-wide viewpoint. Seeking to address local and regional issues through collaboration is recommended as the guiding principal for the Arkansas Basin Roundtable and its constituents for future water planning.

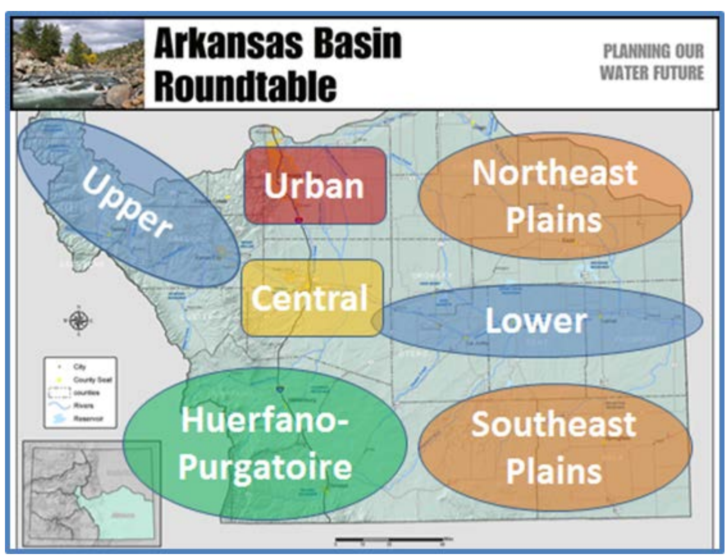
<u>*Decision Mechanisms*</u>

Prior to SWSI 2010, the Arkansas Basin Roundtable produced the document *Meeting the Needs of the Arkansas Basin 2009*, which used a sustainability model to rank and prioritize projects and methods. The sub-regional nature of water supply gaps in all topic areas, agriculture, environment, recreation and municipal, was identified as a critical issue during the planning process. Therefore, the information derived from the Roundtable's outreach effort should be organized along the same lines. Since the bulk of Roundtable members are identified in the *Water for the 21st Century Act* by County, the Input Forms included a similar designation. Grouping these County identifiers into sub-regions provides an organizing protocol for processing the suggestions garnered from Basin stakeholders.

Table 1 – Counties as Sub-Regions, Arkansas Basin.

Subregion	County					
Central	Pueblo					
Huerfano-Purgatoire	Huerfano	Las Animas				
Lower	Bent	Crowley	Otero	Prowers		
Northeast Plains	Cheyenne	Elbert	Lincoln			
Southeast Plains	Baca					
Upper	Chaffee	Custer	Fremont	Lake	Teller	Saguache
Urban	El Paso					

Processing the input received, and continuing to identify projects and methods that are underway in various sub-regions of the Basin, will be the primary task of the Arkansas Roundtable during the period of August 1, 2014 through the end of the year. In parallel with the sorting and processing, the Roundtable will develop a Project Summary Sheet and a protocol for establishing priorities among the suggestions received. Excellent examples of both a Project Summary Sheet and a set of Tiered Criteria were presented by other Basin Roundtables to the Colorado Water Conservation Board at its July, 2014 meeting. Modified versions of these tools will be adapted by the Arkansas Roundtable for its internal use and for input to Colorado's Water Plan and SWSI 2016.



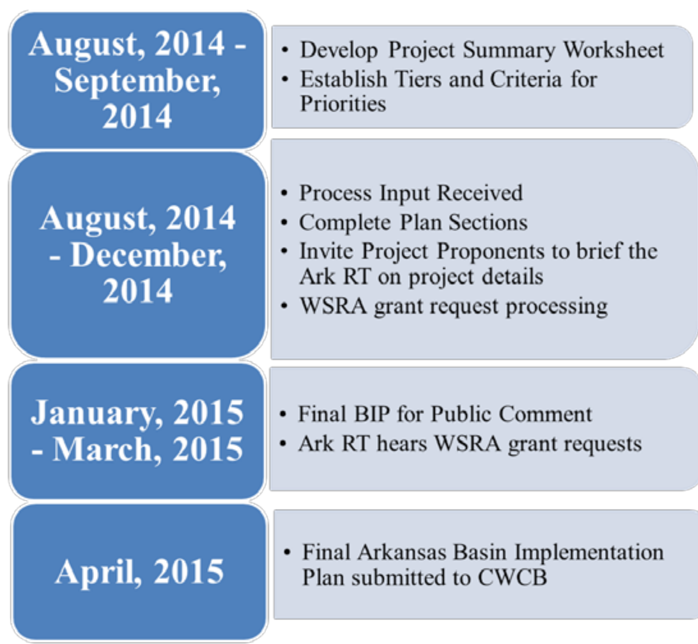
5.4 Timeline for Activities

The Arkansas Basin Roundtable will move forward over the next year to build a solid foundation of projects, processes, and methods for the SWSI 2016 initiative. The identified timeline involves spending the remainder of 2014 reviewing Basin Implementation Plan results, input forms, presentations, and project proposals. Beginning in January 2015, the Roundtable intends to invite public comment both at Basin Roundtable meetings and on the Roundtable's website (arkansasbasin.com). Comment and feedback on projects and processes going forward has always been welcomed.

5.5 Processing Input and Regional Initiatives

Beginning in August, through December 2014, the Roundtable will develop and complete its own Project Summary Sheets, organize these on a sub-regional basis, and establish internal criteria for setting priorities. Factors in the criteria might include whether the project is multi-purpose, brings partnerships together, provides creative and multi-source funding and the extent to which the project or method addresses specific Basin Goals.

Many sound concepts appear to have merit, as proposed, but will need to be understood in greater depth. Therefore, project proponents may be asked to present their project to the Roundtable at a regular, monthly meeting. This provides an opportunity for feedback and suggestions from Roundtable members to strengthen the project's potential for implementation.



Finally, the projects can be measured against the criteria developed, the standards for qualifying as an IPP and the Basin's Goals. The tables below present an example based on a recent request for WSRA funding approved by CWCB in May, 2014. The first table shows that the Red Wing Augmentation Facility meets the standards of an IPP[2], is a Tier 1 project (criteria to be developed, shown here for illustrative purposes) and addresses several of the Basin's categories of need. The second table highlights specific Basin Implementation Plan goals that are met by the project proposal.

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[2] See SWSI 2016 Glossary for details of standards for IPP classification.

Tables 2 – Example of How a Project Meets Basin Needs

Project SubRegion	Project or Method	IPP?	Proponent	Tier	Needs Meet				
	Name	Y/N	Name	1,2 or 3	Storage	M & I	Ag	Enviro	Rec
H-P	Red Wing Aug Facility	Y	HCWCD	1	X	X	X	X	

Project or Method	Basin Goals Met																			
Name	S1	S2	S3	S4	M1	M2	M3	M4	A1	A2	A3	A4	NC1	NC2	NC3	NC4	NC5	NC6	NC7	NC8
Red Wing Aug Facility	X		X					X		X							X		X	

5.6 Receiving Public Comment

The Arkansas Basin Implementation Plan process included a series of town meetings, allowing the Roundtable to directly hear the suggestions, concerns and questions of its constituents. The Arkansas Basin Roundtable will commence a final review of the Basin Implementation Plan documentation from October through December 2014 in anticipation of receiving public comment on the final draft document. This preparation includes finalizing or refining Sections 2.1 Nonconsumptive Needs, Section 4.2 Watershed Health, and Section 4.7, Nonconsumptive Projects and Methods. These sections were completed just in time for the July 31, 2014 deadline for submission of a Draft Plan, and will be reviewed by the Roundtable over the next few months.

Beginning in January, 2015, the Arkansas Basin Implementation Plan will be available in a final draft form for public comment. The Roundtable needs to determine the process for soliciting and reviewing public comment. Suggestions include formal presentations to the conservancy district and water utility boards of directors, public presentation to non-governmental organizations with specific areas of interest (conservation, stream flow restoration, boating, wildlife viewing, etc.), regional public meetings hosted by Roundtable members throughout the Basin, and perhaps a custom input form available on the website. Through this process, the Basin Roundtable will engage the public to elicit feedback which may refine the project selection process, and finalize the Basin Implementation Plan for inclusion in the State Water Plan. This process sets the Arkansas Basin on the path to compile all of its IPP's in support of the SWSI 2016 initiative.

5.7 Cross Basin Recommendations and Collaborations

The Arkansas Basin Roundtable has encouraged collaboration between basins within Colorado. The process used for Section 4.2 of the Basin Implementation Plan, Watershed Health, is one the Roundtable feels has application in other basins. During development of the Watershed Health section of the plan, the Arkansas Basin Roundtable invited other basins to participate. The Rio Grande and South

Platte/Metro Basins actively participated, while Gunnison River Basin observed the process. Going forward, the Arkansas Basin Roundtable seeks continued collaboration with all Colorado Basins.

Discussions with Basin Roundtable Chairs at the March, 2014 Roundtable Summit, led to the inclusion by the Arkansas Basin of the Green River Riparian Restoration Project (GRRRP) in Section 4.8 of the Basin Implementation Plan.[3] Between 2009 and 2012, the Arkansas Basin Roundtable organized and funded a project exploration committee that included all nine basin roundtables. The committee was funded in two phases: Phase One produced a report and process flowchart; Phase Two was not funded. During the process, the committee defined a "good" project that anticipated basin-to-basin dialogue, including creating roles for the Interbasin Compact Committee (IBCC), Colorado Water Conservation Board (CWCB), and the State of Colorado. This approach may be replicated in similar contexts and for future projects.

Section 4.8 stresses the need for continued interbasin dialogue. As interbasin water imports and exports are critical to meeting gaps across the state, basin roundtables and stakeholders are encouraged to find collaborative solutions within Colorado's Water Plan. The Arkansas Basin both imports and exports water. Therefore, the Roundtable places a high value on basin-to-basin collaboration in meeting its needs. Of particular note is the recently completed Interbasin Compact Committee (IBCC) Draft Conceptual Agreement.

The IBCC Draft Conceptual Agreement is the fruit of many years of Interbasin dialogue. At its June 24, 2014 meeting, the IBCC unanimously agreed that: "*the Draft Conceptual Agreement is ready to go the Board [CWCB] for consideration while we continue to get feedback from our roundtables, our constituencies, and the public.*[4]" The document embodies seven principles for a possible Trans-Mountain Diversion ("TMD"):

IBCC Summary Points

1) The East Slope is not looking for firm yield from a new TMD project and would accept hydrologic risk for that project.
2) A new TMD project would be used conjunctively with East Slope interruptible supply agreements, Denver Basin Aquifer resources, carry-over storage, terminal storage, drought restriction savings, and other non-West Slope water sources.
3) In order to manage when a new TMD will be able to divert, triggers are needed.
4) An insurance policy that protects against involuntary curtailment is needed for existing uses and some reasonable increment of future development in the Colorado River system, but it will not cover a new TMD.
5) Future West Slope needs should be accommodated as part of a new TMD project.
6) Colorado will continue its commitment to improve conservation and reuse.
7) Environmental resiliency and recreational needs must be addressed both before and

[3] See Section 4.8.
[4] Memorandum by Jacob Bornstein, IBCC and Basin Roundtable Program Manager to the Colorado Water Conservation Board Members dated July 16, 2014

conjunctively with a new TMD.

Discussion at the July 9, 2014 Arkansas Roundtable meeting on this topic was favorable.

Finally, the Arkansas Basin Roundtable has recognized the need for advanced techniques and technology to measure extreme rainfall for scaling safe spillways for dams in Colorado. As the Arkansas Basin Roundtable has identified storage as critical to all solutions within the Basin, reservoir renovation, design, and construction costs are critical to the Basin's future. Spillway construction or refurbishment adds significantly to the cost of reservoirs. By developing a modern, effective tool for assessing extreme rainfall events, the costs of spillway construction may be reduced and increased storage made more viable for all Colorado water basins. A viable extreme precipitation assessment tool, shaped by participation and collaboration across basins, could significantly improve development of storage across Colorado, aiding most basins in meeting their water supply gaps in the future.

Collaboration is seen as critical by the Arkansas Basin Roundtable, both within the Arkansas Basin and between basins. Through interbasin collaboration, the State of Colorado may address its needs, new tools tested and shared, and perhaps water resources better coordinated.

5.8 Funding Mechanisms

The Roundtable is presented with more opportunities than it is able to fund at current levels. The Water Supply Reserve Account funding has been the primary funding mechanism. However, the fund is not sufficient to satisfy all of the potential projects. This highlights the need for a decision model to be used by the Roundtable in allocating limited funds to address the needs of the Basin, fill current and future water supply gaps, and develop sustainable and renewable water supplies.

Exploration of new and existing funding mechanisms could improve the efficacy of the Arkansas Basin Implementation plan while also informing the Colorado Water Plan and its capacity to address all of the Arkansas Basin's needs. The Arkansas Basin has several examples that support this exploration. The potential use of conservation easements as a method to support rotational fallowing concepts is a demonstration project in the Lower Valley. Transition to an active program of coordinated land and water conservation through the State of Colorado's tax credit program could support both agriculture and the environment, the latter through protection of high biodiversity species habitat.

Similarly, the Great Outdoors Colorado website describes the types of projects it funds[5]. These include whitewater parks, fishing piers, non-game wildlife habitat preservation, land acquisition for future outdoor recreation facilities, land protection along river corridors and agricultural land. These categories align with many of the Arkansas Basin's goals. Finally, Water Supply Reserve Account grant recipients in the Arkansas Basin have leveraged the WSRA funds as a match for grants from state and federal agencies. Examples include the Colorado Division of Local Affairs ("DOLA") and the National Resource Conservation Service. Clearly, this form of collaboration in seeking funding partners not only

[5] http://www.goco.org/grants/about/what-we-fund

increases the efficiency of WSRA funds, it substantially strengthens the dialogue within the Arkansas Basin. Expanding the tools for Roundtable funding provides a fulcrum for implementation of solutions and an extension of the Roundtable's collaborative model.

5.9 Meeting the Gap

Previous documents and reports have identified the existing and anticipated supply gaps in the Arkansas Basin, as well as identifying various challenges, opportunities, and projects. Those reports include:

- *Meeting Colorado's Future Water Supply Needs, 2008*
- *Considerations for Agriculture to Urban Water Transfer, 2008*
- *Projects and Methods to Meet the Needs of the Arkansas Basin, 2009*
- *Statewide Water Supply Initiative 2010*
- *Projects and Methods to Meet the Needs of the Arkansas Basin Update, 2012*

For the past decade, the Arkansas Basin Roundtable has identified methods, projects and processes to meet the water supply gaps identified through research, education, outreach, and assessment. Many of the projects and processes have been successful, but much of that work was conducted with a larger, basin-wide view. In order to secure the Arkansas Basin's water future, identifying local and regional challenges that can be addressed through local and regional solutions becomes the new perspective, coupled with continued diligence to understand the multi-purpose importance of sustaining agriculture.

The interdependence of agriculture with environmental and recreational water uses needs greater definition and study. Through the Basin Implementation Plan, a better understanding of the knowledge gaps has been developed. Further review of environmental needs is necessary in order to identify projects and processes for implementation. Recreational water use plays a significant economic and cultural role within the Arkansas Basin. The Roundtable explicitly supports projects and processes to increase and all types of water-based recreation, and to improve fish and wildlife habitat. Critical to maintaining all of these is the Voluntary Flow Agreement[6].

Agricultural water security is a continuing objective for Colorado and the Arkansas Basin. The Governor's executive order specifically addresses the rate of agricultural dry-up, and implores water planners and responsible stakeholders to find alternatives to agricultural to urban transfers. Projects such as rotational fallowing have met with implementation challenges. The Roundtable is working to identify and implement more projects and processes focused on rotational fallowing, not only for agricultural to urban water transfers, but also for increased agricultural efficiency. The Roundtable explicitly acknowledges that agriculture is part of the social, historic, and cultural fabric of the Arkansas Basin, and is focused on maintaining and increasing the $1.5 billion agricultural economy within the Basin.

[6] See Section 4.4 for details. The Voluntary Flow Agreement stores in headwaters reservoirs, then releases flow from storage that supports species habitat and rafting, with recapture in Pueblo Reservoir.

Storage is a critical component of water management within the Arkansas Basin. The Roundtable, through various reports and studies, including SWSI 2010 and *Projects and Methods to Meet the Needs of the Arkansas Basin, 2009*, has identified storage as critical to all water solutions within the Arkansas Basin. At present, increasing storage options and improving storage requires further assistance from stakeholders and the State.

Municipal projects and processes have focused on providing secure and reliable water supplies for growing urban populations. While strides have been made, significant work remains in freeing some municipalities from reliance on nonrenewable groundwater sources. Several sub-regions within the Arkansas Basin face the need to replace existing public water supplies. The challenges inherent in acquiring and funding a replacement water supply for any community are daunting.

The Arkansas Basin faces many dynamic challenges as it grapples with growth in some regions and the decline of available water resources in others. Roundtable members are pursuing a number of initiatives to improve the understanding of localized needs and gaps. Perhaps it is too soon to tell whether all needs can be met to the satisfaction of stakeholders. However, through dialogue, collaboration, and transparency, the Arkansas Basin Roundtable will continue to provide leadership, engage stakeholders, identify opportunities, and encourage projects and processes to meet all future water needs.

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6. Introduction: Meeting the Goals and Outcomes

The objective of Section 6 is to identify how the projects and methods described in the Basin Implementation Plan will meet future water needs. The overarching objective by the Arkansas Basin Roundtable is to attempt to meet all demands within the basin. However, the available native and non-native water supplies may make it challenging to completely meet that objective. Frank Melinski, a long-time irrigator on the Catlin Canal and founding board member of the Southeastern Water Conservancy District, observed in his 1990 book Water: The Answer to a Desert's Prayer[1]:

> *"Competition for water has always been keen. The miners fought over it; then the farmers fought over it and soon the cities were fighting over it. In eastern Colorado, streams were already over-appropriated by 1890, so canal companies tried to develop water storage facilities. When water storage facilities failed to provide enough water, farmers turned to ground water pumping. Then they turned to transmountain water diversions. Cities acquired all the early water they could get; they began to develop storage facilities especially around Denver from 1900 to 1910; and they threw themselves into the fray of transporting water across the mountains. In less than a hundred years, man has developed about 8,000,000 acre-feet of storage in Colorado, but the search for water goes on."*

The Arkansas Basin Roundtable has been committed to exploring new projects and methods to meet the needs of the basin, and to engaging in public outreach in order to disaggregate the needs of the basin and identify potential opportunities. However, the path to success for the Arkansas Basin remains challenging.

Section 1.0 of the Arkansas Basin Implementation Plan identifies the existing and future water supply gaps within the basin. Subsequent to the SWSI 2010 process, the Arkansas Basin Roundtable has concluded that all water uses have valid gaps: agriculture, municipal and industrial, and environmental and recreation users are all facing shortages in supply.

Agriculture

Agriculture continues as the primary use of water as measured by volume diverted. As farm practices become more efficient, additional supplemental water will be needed to meet the requirements of the Arkansas River Compact with Kansas. Currently, most of this augmentation water is leased from municipal suppliers, who have either converted historic farm water to fully-consumable supplies, or water that is new to the basin, imported from the drainages of the Colorado River under the State of Colorado's entitlement under the Colorado River Compact. The availability of augmentation for agriculture is expected to diminish as this municipal return flow is reused to meet future urban demands. Therefore, the Arkansas Basin Roundtable approached a future gap in agriculture by defining an economic base line.

[1] Milenski, F. (1990). Water: The answer to a desert's prayer. Boone, CO: Trails Publishing Co

A study by Colorado State University's Water Institute found that agriculture contributed $1.5 billion to the economy of the Arkansas Basin. To maintain that level of economic productivity, projects and methods described in Section 4.6 focus on development of rotating fallowing, conservation easements and increased storage capacity to allow agricultural water to sustain agricultural productivity. In particular, a three-pronged approach to understanding rotational fallowing within the Prior Appropriation Doctrine is underway—an administrative and accounting tool, pilot projects and public policy dialogue— and will continue.

Municipal

Further examination of the municipal supply gap in the wake of SWSI 2010 revealed that the municipal gap falls into two categories:

- Continued dependence on nonrenewable groundwater:
  Water purveyors in the northern El Paso County and in the southeastern part of the Arkansas basin are highly dependent on non-renewable groundwater sources that are approaching the end of their useful economically available supplies. The lack of cost effective alternative renewable supplies have resulted in some purveyors pursuing the development of remote well fields.
- Alluvial groundwater:
  In a variety of localized settings, there is a need for either replacement or augmentation of alluvial wells in the near-term. In the Lower Arkansas Valley, water quality is the driver. While the Arkansas Valley Conduit could relieve the problem, federal funding may be challenging to secure. In the Upper Arkansas and the southwest portion of the basin, augmentation of existing uses and anticipation of growth are the focus.

Projects described in Section 4.5 are under development to address many of these needs. Many of the municipal water supply gap issues are highly localized. Therefore, the Roundtable is attempting to support efforts that disaggregate demand projections for the basin to identify localized needs. This will allow a more refined assessment of where needs are located within the basin and methods for addressing localized gaps. The Arkansas Roundtable should expect to continue its support for regional solutions to local supply problems.

Nonconsumptive

For environmental and recreational gaps, collectively nonconsumptive gaps, the Arkansas Basin Roundtable has relied significantly on public outreach during the Basin Implementation Plan, a continuing process. The public outreach process has allowed the Roundtable to disaggregate information and identify localized issues and needs. A primary objective of this process is to identify potential multi-purpose projects that meet both non-consumptive and consumptive need. The public outreach process continues, and the Arkansas Basin Roundtable is working to summarize the results and findings.

The detailed solutions, both project and methods, will be articulated in greater detail as Section 4.7 is completed.

6.1. Challenge, Solution, Plan of Action

Challenge	Solutions	Actions	Comments
Municipal Supply	Conservation		
	Better understanding of localized demands and timing of needs		
	Regional infrastructure projects		
	Development of new funding sources		
Agricultural Water Shortages	Rotating fallowing		Challenging implementation with limited results
	Dry-up of least productive land		
Environmental Water Demand	Watershed Health action plan		
Recreational Demands	Continued outreach, local solutions		

6.2. Storage: a Critical Element

The Arkansas Basin Roundtable has identified and reiterated throughout the Basin Implementation Plan storage as critical to all paths forward. Increased storage capacity will help all water users meet their needs. Two areas of investigation should be continued, the restoration of older storage vessels, particularly those with storage restrictions, and the viability of underground storage. The Roundtable pursued concepts of alluvial storage in concert with investigations by the Colorado Water Conservation Board. The non-evaporative nature of underground storage is attractive, however, public policy in Colorado does not currently favor its ready implementation.

6.3. Role of the Basin Roundtable

The Basin Roundtables were created by the General Assembly to, as described in Colorado Revised Statute (CRS) 37-75-104 (1) (a): *"facilitate ongoing discussions within and between basins on water management issues, and to encourage locally driven collaborative solutions to water supply challenges. Each roundtable was vested with the authorities and responsibilities necessary to develop a basin wide consumptive and nonconsumptive water supply needs assessment, conduct and analysis of available unappropriated waters within the basin, and to propose projects and methods, both structural and nonstructural, for meeting the identified needs."*

The Arkansas Basin Roundtable has been actively pursuing these goals and responsibilities since the 2009 report *Meeting the Needs of the Arkansas Basin*. The 2012 Update Memorandum emphasized the importance of understanding the native and imported water supplies in the basin under wet, dry and average conditions. The results of that research are contained in this basin plan in Section 3.

The Roundtable has developed its understanding of the Arkansas Basin in several prominent ways:

1. Extremes of hydrology have tested the Prior Appropriations Doctrine as an allocation model and the Prior Appropriations Doctrine has held up under the extreme conditions. However, the individual hardships generated have been a stimulus to seek viable, temporary reallocation models.
2. The cost and time required to reallocate water from a previous to new use is significant, and at times appears insurmountable. Community values have changed, as reflected in the Governor's Executive Order, although the capacity to respond to these changes with reallocations of water to new uses is limited.
3. Attempts to develop rotational fallowing as a solution to permanent agricultural land dry-up remains challenging.
4. Imports from the Colorado River Basin have been both a benefit and a constraint on the Arkansas Basin. The dynamics of seven basin states with demands on the Colorado River may directly impact the Arkansas Basin.

6.4. The Future

The Arkansas Basin Roundtable's focus on supporting research and communication between various stakeholders has improved not only multi-constituency working relationships, but has emphasized to the participants that the challenges and solutions are interdependent. Water in the Arkansas Basin is used multiple times for all purposes – all uses are fundamentally related and codependent, and changes to one use will have impacts on others.

The Roundtable continues to be part of the solution, with a strong record of stakeholder engagement, support, and funding for projects across all uses and needs. The goal of the Roundtable is to continue encouraging stakeholder involvement, focusing on local needs, and supporting solutions that maintain the economic vitality of the Arkansas Basin.

The Roundtable will continue to seek new projects and methods to continue moving the Arkansas Basin toward a sustainable water future. While many projects have already been identified and funded, the Roundtable is continually addressing new challenges and exploring new opportunities, including the continuation of public outreach programs in order to garner input from across the Basin and across user needs.

6.5. Conclusion

The Arkansas Basin Draft Implementation Plan is the first step in a process of continuing to identify and implement solutions to the Basin's water supply challenges. The Basin Implementation Plan articulates the supply needs, local knowledge, and regional, sub-regional, and basin-wide demands. It also makes a concerted call for further work in order to continue developing the Roundtable's understanding of water challenges and opportunities within the Basin.