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Alternative Water Transfers in Colorado

A Review of Alternative Transfer Mechanisms for Front Range Municipalities

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The report is available online at edf.org/ATMreport
The appendices are available online at http://bit.ly/ATMx45

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Executive summary

Background and purpose

Alternative water transfers (ATMs) refer to various methods, activities, and frameworks that have been established to transfer water on a temporary or intermittent basis, primarily from agriculture to other uses. They are labeled as "alternative" because they represent a type of water transfer that does not result in the permanent dry-up of agricultural land, which has been the primary form of water transfers in much of Colorado for decades. ATMs are a body of activities that represent general frameworks or concepts to be molded to the specific conditions of a place and need.

The Environmental Defense Fund (EDF) obtained a grant opportunity to fund research, analysis, and outreach toward the development of ATMs with the potential to improve the financial returns and long-term viability of farming, maintain or improve streamflows which support environmental and recreational activities, and provide a cost-effective means for municipalities to maintain water supply reliability into the future. The purpose of this project is to develop a comprehensive financial comparison of the water supply development options currently pursued by municipalities to applicable ATMs and to develop recommendations that can increase the application of specific ATM structures with the potential joint benefits to municipal and agricultural water users.

ATMs in Colorado

Flexible and temporary water transfers, inherent in ATMs, are often viewed as difficult to accomplish within the confines of Colorado's water rights system. A variety of recent laws have been aimed at making temporary and flexible water transfers more attainable, with less oversight in water court. These laws have allowed for water transfers to take place under a Substitute Water Supply Plan (SWSP), an Interruptible Water Supply Agreement (IWSA), pilot rotational fallowing programs, multiple use decrees, water banks, and other methods. Collectively, these recent laws have made it potentially easier and less-costly to transfer an agricultural water right to new uses, at least on a temporary and intermittent basis. These laws are largely the legal foundation on which ATMs are intended to be built in Colorado, providing flexibility for water transfers in an otherwise rigid water rights system. Such policy and legal changes have opened the door for water users to utilize ATM frameworks for water transfers.

A handful of ATM examples in Colorado were inventoried as part of this project, which represent a relatively small number of successful ATM transactions compared with the level of policy and research efforts by the Colorado Water Conservation Board and others since 2007. This project looks to bring a novel addition to these past efforts, by evaluating the financial perspective of municipalities toward ATM water supplies.

Municipal interest in ATMs is largely a function of cost and risk tolerance. Both in Colorado and other Western states, municipalities have been more interested in discussing ATM water supplies when more traditional water development project supplies are not available, and the municipality is forced to pursue leased water supplies. Therefore, a municipality's level of interest in ATMs is directly related to the cost and reliability of other water supply options available to it.

Municipal selection process

A screening analysis was undertaken to evaluate the conditions that influence municipal interest in an ATM, and to evaluate a list of municipalities based on those conditions. The goal was to identify potential case studies for a more detailed analysis of ATMs, but in the process a broad analysis of potential municipal participation in ATMs emerged. A total of 66 municipal water providers were initially identified on the Colorado Front Range. This total was reduced to 35 municipal water providers based on water source and demand size criteria. This prioritized listing of 35 municipalities indicates that there are a limited number of municipal demand entities on the Front Range who represent candidates to help meet state policy goals of expanded use of ATMs. Two case study participants were identified: City of Fountain and Town of Windsor. Both participants provide good representation of municipalities along the Front Range, based on the following characteristics: fairly rapid population growth and development, located in close proximity to several irrigation ditches, and historical reliance upon large-scale regional water projects for much of their water supply.

Case study results

The two case studies represented independent evaluations of future water shortages and the potential water supplies (both traditional and ATM types) that could be acquired to address such shortages. A financial analysis of water supply alternatives was completed based on a 30-year model of all major costs associated with each water source; including costs for acquisition, transfer, annual ownership and operations, leasing, and infrastructure tied to reliability and flexibility in use. A terminal cost value was incorporated to account for indefinite annual costs, in order to make leased water supplies comparable to permanent acquisitions beyond the 30-year model period.

For Windsor, one ATM approach in which water rights are both purchased and leased to address projected shortages was found to provide small cost savings relative to more traditional water right acquisition approaches. Other ATM approaches such as rotational fallowing and buy and supply approaches were found to have greater long-term (indefinite) costs compared with permanent acquisitions and traditional sources of supply. For Fountain, many of the ATM water supply alternatives had similar estimated costs when compared with permanent water right acquisitions. Rotational fallowing was found to have higher equivalent costs, due to the long-term (indefinite) cost of continuous leasing of water supplies. In both case studies, groundwater development was found to have the highest cost, due mostly to the costs associated with augmentation and advanced treatment.

Results of the financial analysis for the two case studies are summarized in the graphs below. The assumed rates of appreciation and discounting utilized in this analysis influence the comparisons between water supply alternatives, and the results were found to be quite sensitive to assumed economic inputs. A sensitivity analysis adjusting input costs and rate assumptions was included in the analysis to illustrate this variability.

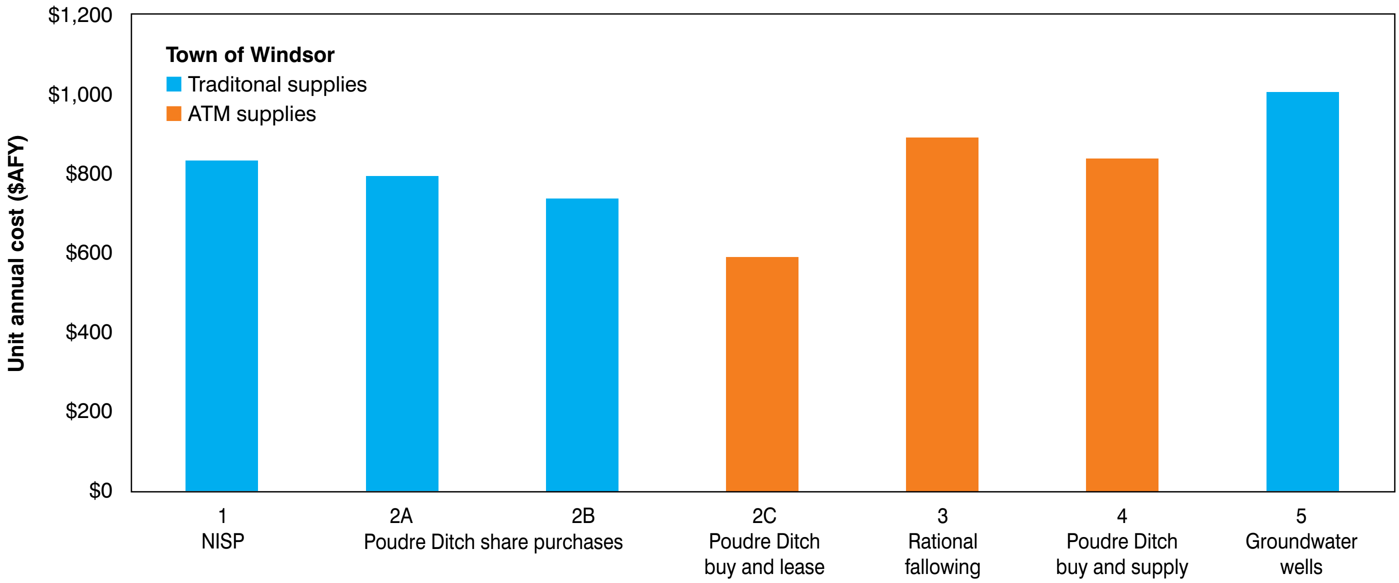
Recommendations

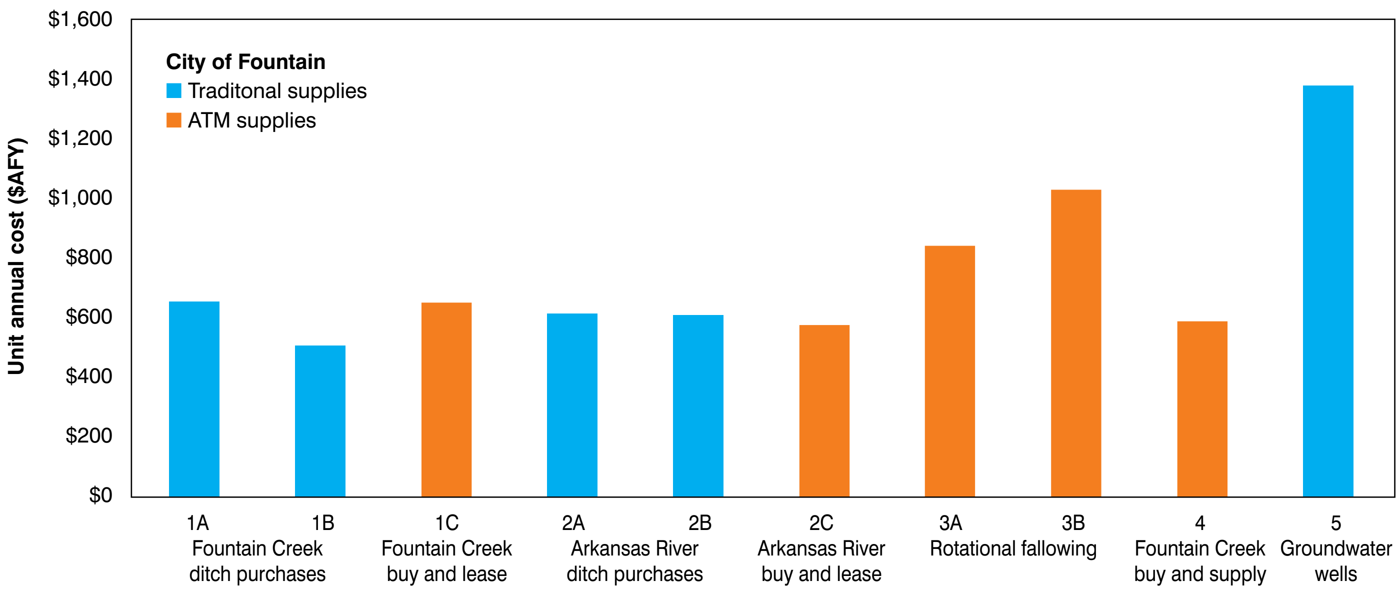
The State of Colorado has made significant investments in both understanding and promoting the use of ATMs, and has set a policy goal of 50,000 acre-feet of ATM projects in place by 2030. Based on the information compiled and developed through this project, the following recommendations are made toward expanding the use of ATMs in Colorado:

- There have been a series of laws passed in recent years that make it possible to structure an ATM type of water agreement within the bounds of Colorado water law. In many cases, an

FIGURE E1

Cost comparison of water acquisition options for two case-studies





ATM agreement can legally be implemented, and the higher hurdle to overcome is identifying parties to voluntarily agree to enter into an ATM agreement. Efforts should be focused on motivating parties through the creation of incentives and programs that reduce the costs associated with ATMs.

- Most ATMs inventoried in Colorado and the other Western states were initiated from the demand side, with an entity seeking temporary and/or intermittent water sources that could be provided through an ATM type of water transaction or agreement. This should encourage and focus efforts to implement ATMs toward the demand side as a starting point, with outreach to municipalities, industrial water users, and environmental organizations.
- The pool of potential ATM participants on the Front Range is somewhat limited. This study identified 35 municipal water providers across the Front Range who would be potential

candidates for participating in an ATM agreement. This number is small enough that each one of these municipalities could be analyzed for ATM opportunities and contacted to become informed about such opportunities. Past examples of ATMs being implemented also indicate that outreach efforts should be focused on those municipalities that have limited options for new water sources.

- The financial analysis results show that ATM water supplies can represent similar costs when compared against more traditional permanent water acquisition supplies. However, ATMs which are structured entirely as lease agreements, such as under a rotational fallowing program, were found to have significantly higher costs over the long-term. Financial incentives may be required for municipalities to see the long-term financial benefit of ATM water supplies compared with permanent water acquisition options.
- The higher long-term (or indefinite) costs associated with leased ATM water supplies might be one area for water leaders in Colorado to address in order to incentivize participation by municipalities in ATM projects. Reducing the cost of leased water supplies might be explored through a number of ideas including: direct subsidies, creation of an institution (such as a water bank) to both reduce transaction costs and motivate participation by agricultural users by reducing lease terms, and/or development of shared infrastructure projects that could benefit water supply options or water exchanges.
- Water supply risk is believed to be a significant roadblock to municipal acceptance of ATM supply sources. Potential cost savings, particularly in the short term, could encourage municipalities to explore the limited use of ATMs to fill some portion of their water supply portfolios, which over time may lead to a greater level of comfort with leased water supplies in the municipal sector. To the extent possible, water leaders should educate the municipal water community about water leasing opportunities and support pilot projects where needed to begin to build a greater level of comfort and an informed perspective on future water supply options.

Introduction

Background and purpose

Water markets have provided an important water supply for growing urban communities in Colorado for many decades. Historically, municipal water providers along Colorado's Front Range have expanded water supplies through permanent acquisition of irrigation water rights and change to municipal use ("buy and dry"). This approach has come under increasing scrutiny by Colorado water policy leaders and rural communities because it permanently reduces the irrigated land base and negatively impacts the more rural communities that rely upon agriculture for income, employment and cultural identity. In recent years, Colorado has funded multiple studies and pilot projects to promote the use of Alternative Transfer Methods (ATMs) as an alternative to traditional buy and dry practices to balance the health of rural communities and the environment with the water supply needs of expanding urban areas. However, past ATM study conclusions and the limited set of implemented examples both indicate that, absent the necessary market incentives, ATMs are likely to remain a small component of municipal water supply portfolios.

Buy and dry water right acquisitions provide key advantages to buyers but result in third-party impacts in the water source region. Buy and dry acquisitions are cost-effective, scalable to growing demand, and provide the future water supply certainty that municipal water providers prefer. Municipalities commonly lease acquired water rights back to an agricultural producer until such time as the water is needed for municipal purposes. This type of arrangement is viewed as undesirable to agricultural producers and communities because it only delays a permanent shift of the water away from agriculture. Further, there is risk that the water rights may be recalled for municipal purposes at any time resulting in water supply uncertainty for agricultural producers. Permanent water transfers through buy and dry acquisitions are also considered undesirable within the rural communities where agriculture is an important economic sector and is valued for the open space and aesthetics it provides.

ATMs can encompass a wide variety of water sharing approaches including rotational fallowing agreements, deficit irrigation, dry year options (interruptible water supply agreements), payments for conservation, and shared infrastructure development. Rotational fallowing agreements in various forms have been established in other states for a number of years and a pilot rotational fallowing agreement was recently implemented in Colorado. However, other forms of ATMs capable of generating a reliable water supply for municipal consumptive uses have proven more difficult to implement due in part to the challenges and costs associated with successfully modifying a water right to provide for flexible water uses under an ATM agreement. In addition, the difficulties in quantifying the water savings and providing an acceptable land management and monitoring plan complicate some of the more innovative ATMs.

The establishment and management of ATMs is generally more complicated than buy and dry transactions. Successful ATM implementation often involves agreements and coordination with multiple parties which can result in increased transaction costs and risks for buyers and sellers. Due to the structure of ATM agreements, there is limited opportunity for a single agricultural operator to supply enough water to be cost-effective for a municipal buyer. Therefore, most ATM agreements must be negotiated with a ditch company or an irrigation district to provide sufficient supplies for municipal needs. One solution to this issue of scale isto utilize a water banking program as an ATM framework. In addition, ATMs are more likely to be implemented if the water supplied by the agreement can utilize existing water storage and conveyance infrastructure. Limited excess storage and conveyance capacity will affect the types of ATMs that can be feasibly implemented, at least without the construction of additional infrastructure.

In order for ATMs to supplant traditional buy and dry practices, it will be necessary for agricultural and municipal entities to enter into sufficiently long-term agreements that guarantee municipal water providers a firm water supply. Agricultural water right holders are often reluctant to consider long-term agreements due to concerns that they will be required to forego water use and associated crop production during periods of high crop prices and that they will limit the ability to renegotiate water prices higher should market conditions change. Agricultural water users might also be concerned about the risks of forfeiting their water rights when such rights are tied to long-term lease agreements. At the same time, municipal water providers are unenthusiastic about short-term agreements that can be challenging to negotiate and implement during dry years when they are needed most and that create financial planning challenges due to future water price and supply uncertainty.

The Environmental Defense Fund (EDF) has obtained a grant opportunity to fund research, analysis, and outreach toward the development of ATMs with the potential to improve the financial returns and long-term viability of farming, maintain or improve streamflows which support environmental and recreational activities, and provide a cost-effective means for municipalities to maintain water supply reliability into the future. The purpose of this project is to develop a comprehensive financial comparison of the water supply development options currently pursued by municipalities to applicable ATMs and to develop recommendations that may help to increase the application of specific ATM structures with the potential joint benefits to municipal and agricultural water users.

Report organization

This report is organized according to the following sections:

- **Overview of alternative water transfers:** Provides important background on common types of ATMs and examples of different ATMs both in Colorado and other Western states, as well as a summary of past research on ATMs in Colorado.
- **Municipal selection process:** A summary of the data compilation and analysis undertaken to identify municipal water providers who may be good candidates for an ATM project.
- **Analytical framework:** Provides the basic framework for both the quantification of water acquisition needs for each case study, and the financial analysis of water supply alternatives over a 30-year timeframe.
- **Case studies:** A summary of each case study, including data on projected water supply shortages and costs of water supply acquisition alternatives.
- **Summary of findings:** A brief summary of major findings from the study.

Overview of alternative water transfers

Types of alternative water transfers

Alternative water transfers refer to various methods, activities, and frameworks that have been established to transfer water on a temporary or intermittent basis, primarily from agriculture to other uses. They are labeled as "alternative" because they represent a type of water transfer that does not result in the permanent dry-up of agricultural land, which has been the primary form of water transfers in much of Colorado for decades. This section provides a broad overview of alternative water transfer methods that are either found in practice in the Western U.S. or have been the subject of significant research and consideration.

Alternative water transfer methods (or ATMs as they are referred to in Colorado) can be defined by two categories: (1) agricultural water supply methods and (2) transfer methods. Agricultural water supply methods refer to activities or approaches of generating water from agricultural operations that can be transferred to a different use. Agricultural methods therefore refer to the supply method, or activities the individual farm or collective group of farms can apply to produce a water supply for transfer. Transfer methods refer to the contract structure or regulatory framework in which the water transfer takes place. Once water is generated from an agricultural water supply method, the transfer method defines how it finds its way to a buyer or lessee. The body of water law that defines water administration and management in Colorado also defines which transfer methods are possible or probable. Appendix A provides an expanded description of ATMs along with illustrations and examples.

Water transfer laws

Understanding ATMs in Colorado should begin with a description of the body of water law that defines how water can be transferred from one use to another, because it determines how legal methods of agricultural water supply and transfer can be shaped. Much like other Western states, Colorado water law is rooted in the following principles related to the establishment and transfer of water rights:[1]

- A water right is a usufructuary right, meaning that the holder of the water right has been granted legal permission to use the state's public water resources in a specific manner defined by the water right, but in no other manner.
- Water rights have been established in a variety of ways over the course of state history, but typically a water right is first claimed or applied for, second approved by state administration and/or water court, and then third perfected (or made absolute) through the activity of putting the water to beneficial use.
- A water right must be continually put to beneficial use, as specifically defined on the water right, or else it is subject to forfeiture and abandonment.
- In many cases, more water has been appropriated from water systems (or granted under water rights) than is available for use. When all valid water rights cannot be exercised, the

prior-appropriation doctrine of "first in time, first in right" is utilized which allows the earliest water rights to be fully met before later water rights are fulfilled. Thus, water rights may list a quantity of allowable (decreed) use that is larger than the actual quantity available to the water right.

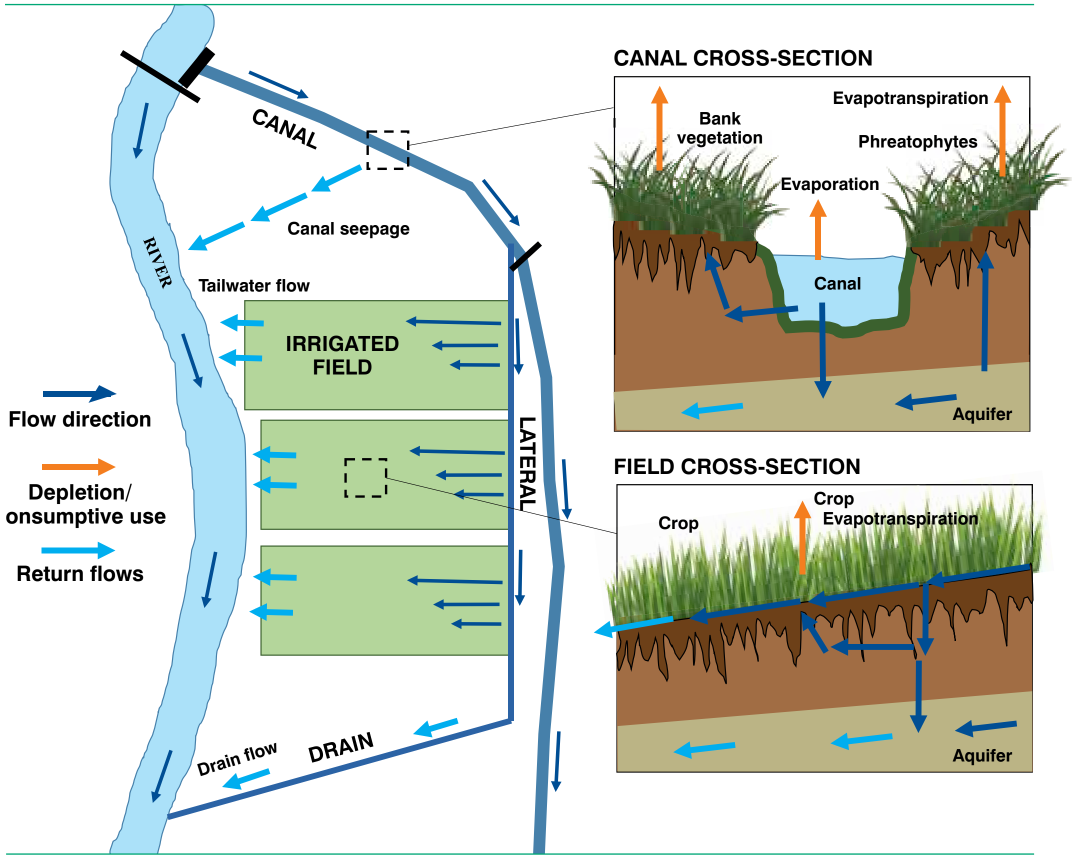
- When establishing or claiming a water right, or when transferring a water right to a new use, the claimant must be able to show a specific and well-defined use of the water. Water rights and transfers cannot be made for speculative reasons.
- An agricultural water right is defined by an ability to divert a certain quantity of water from a natural water source during the irrigation season and to use that water for agricultural purposes. Administration and/or enforcement of such agricultural water rights is often practiced by measuring the amount of water diverted and verifying that the water is being used for irrigation, which often excludes a detailed understanding of how water is consumptively used by crops and how much returns to the hydrologic system.[2] There are often significant uncertainties about, and a lack of regulation over, how agricultural water rights are used and consumed downstream of the diversion point.
- When an agricultural water right is proposed to be changed to a new use, a much greater level of investigation and scrutiny is placed on understanding how water has been historically used under the water right. The transfer of a water right allows only the transfer of the Historic Consumptive Use (HCU), which is the water that was consumptively used or depleted (in crop irrigation) and not any of the water which was diverted but then returned to the hydrologic system.[3]
- A water right transfer or change in use must be completed in a manner that does not impair the water rights and uses of other entities, which often includes the preservation of water flows present under the original use of the water right. The water right holder is responsible to maintain historic return flow patterns and complete any other activities to ensure that all other (surrounding) water right holders are not impacted by the transfer or change.

Important distinctions about types of water use are made in the above principles that arefundamental to understanding water rights and transfers. A water right provides the ability to divert water from a source (stream, river, aquifer, etc.) or maintain water in a source as instream flow. For diversions, the water right provides for the consumptive use of some fraction of the total amount diverted, and a corresponding obligation to return the non-consumptive fraction back to the water system either directly or indirectly. These flow paths are illustrated for an irrigation water right in Figure 1 (page 12), and they apply to other purposes of water use as well.

In a water transfer, there are typically two types of water that can be generated from an irrigation water right: (1) consumptive use and (2) instream flows.[4] In Colorado, the consumptive uses that occur along the canal or other conveyance are usually considered to be relatively minor, and are not transferrable under a water right change in use. A transfer of consumptive use is based on the crop consumptive use resulting from evapotranspiration (ET). A transfer of crop consumptive use allows the transferred water to be used for municipal and industrial purposes, and therefore has been the most common type of water transferred in change of use cases. A water transfer can also generate new instream flows in the natural water source. If irrigation diversions are reduced or ceased altogether, then the previously diverted water is maintained in the water source as instream flows downstream of the canal diversion point. The instream flow benefits from diversion reductions are two-fold: (1) an increase in streamflow equal to the full diversion reduction between the canal point of diversion and the location of the return flows, and (2) an increase in streamflow equal to the consumptive use

FIGURE 1

Example consumptive use and return flows for irrigation



fraction between the location of return flows and all downstream reaches. Table 1 (page 13) summarizes the common types of water generated from different water transfer methods.

These principles have been established and defined by both the legislative and judicial branches of government in Colorado. The State Legislature enacts laws related to the administration of water rights and uses, and these laws are fairly adaptive to changing public values and desires related to water use. Colorado has a unique system of water courts which have been established to interpret and judge decisions on water rights matters under State law. Beyond the principles stated above, water right transfers in Colorado are affected by a variety of recent laws which have been aimed at making temporary water transfers more flexible, with less oversight in water court. A brief summary of these laws is provided below, with an expanded summary of each law provided in Appendix B.

- A **Substitute Water Supply Plan (SWSP)** can be proposed to and approved by the State Engineer to allow out-of-priority water diversions to take place, as long as the plan specifies how depletions related to the water use will be replaced in the water system to prevent injury to other water rights. A SWSP is approved for a 1-year term and can be renewed annually for up to 5 years.
- An **Interruptible Water Supply Agreement (IWSA)** can be approved by the State Engineer, outside of water court, as an option agreement where water is loaned between two or more water right holders. The option under an IWSA can be exercised for up to 3 out of 10 years, and the IWSA can be renewed, subject to State Engineer approval, for up to three total 10-year periods.

- **Agricultural water transfers**, which include permanent and temporary water transfers from agricultural water rights are the most common type of transfer, and are the subject of several laws.[5] For agricultural water rights, the following conditions and opportunities apply:
  - Permanent transfers of agricultural water rights outside of the county of origin, and in a volume in excess of 1,000 AF of HCU, must meet specific regulatory requirements and mitigation payment obligations;
  - Agricultural water rights can be loaned to other agricultural water holders for up to 180 days per year if approved by the Division Engineer, and water right holders on the same ditch or stream system can exchange water with one another for a limited time if notice is provided to the Division Engineer;

TABLE 1

Summary of alternative water transfer methods

Category	Name	Description
Agricultural water supply methods	Full-season fallow	An agreement to temporarily idle irrigated land for a full growing season in exchange for payment for the water that can be transferred to a new use.
	Split-season fallow	A lease agreement based on splitting the water use in a single growing season between agriculture and other uses, typically with irrigation occurring in the first part of the season, and water leased in the latter part of the season used for other uses.
	Rotational fallow	A temporary fallow in which the idled land is rotated periodically for agronomic and regulatory reasons, and no one field is idled for multiple consecutive years.
	Regulated deficit irrigation	Application of less irrigation water than is needed to satisfy maximum crop ET and achieve maximum crop yields.
	Crop switching	Compensate agricultural producers for adopting a crop rotation with a lower diversion requirement and consumptive use than traditional practices.
	Infrastructure	Direct funding of water storage and/or conveyance infrastructure that benefits agricultural producers in exchange for a share of the generated water supply.
Water transfer methods	Regional water bank	An administrative structure that connects buyers and sellers, allowing interested parties to conduct temporary water trades with a reduced regulatory burden and transaction cost.
	Public water bank	An entity with taxing authority that can purchase agricultural properties and water rights and make a portion of that supply available for other uses.
	Buy and supply	Purchase irrigated land and lease it back for farming with a permanent IWSA in place.
	IWSA/option contract	A long-term lease agreement that maintains water in its original use in most years, but provides an intermittent water supply to other uses under preset conditions.
	Purchase/lease	A standard permanent purchase or temporary lease contract
	Lease to fix	Provide initial payments to agriculture in exchange for reduced water use. These payments are then applied toward water supply development or efficiency improvements with the intent of providing a long-term supply for other uses in partnership.

ATM = Agricultural water supply method + Water transfer method

- Under some water transfer proceedings, an agricultural water right that was enrolled in a water or land conservation program, fallowing program, or water banking program, or if it was leased for instream flows, shall not be negatively impacted in terms of abandonment analysis and calculation of HCU.[6] Also, HCU determinations cannot be re-quantified once decreed for an associated water right, and must be based on a representative study period and exclude un-decreed water uses.
- Pilot projects are allowed to explore fallowing-leasing water transfers. The pilot projects may last up to 10 years, and require both Colorado Water Conservation Board approval and a State Engineer factual determination regarding injury.
- Up to 50% of the HCU for decreed agricultural waters right may be changed under rules promulgated by the State Engineer, and then leased to other unspecified (non-agricultural) uses. The associated agricultural land base of the water right must be enrolled in an agricultural conservation program during the lease, and the water lease is limited to a 1-year term with up to two renewals.

- A **water bank** may be created within the State's water divisions, based on a request by a water conservancy or conservation district. Rules of the water bank are to be developed by the State Engineer, allowing for the lease of storage water to uses within the water division.
- Water rights may be temporarily leased to the Colorado Water Conservation Board to provide for instream flows. Such instream flow leases can occur for up to 120 days in a calendar year. The CWCB is required to adopt criteria and keep records of instream flow leases, and obtain a decree quantifying HCU for the water right.

Collectively, these recent laws have made it potentially easier and less-costly to transfer an agricultural water right to new uses, at least on a temporary and intermittent basis. These laws are largely the legal foundation on which ATMs are intended to be built in Colorado, providing flexibility for water transfers in an otherwise rigid water rights system. There have been additional bills proposed in the Colorado legislature in recent years that have sought even greater flexibility and ease in conducting water transfers, but such proposed measures do not represent the current state of Colorado water law.

Agricultural water supply methods

Agricultural water supply methods require that less water is used on the original land base associated with a water right. In its simplest form, an agricultural water supply method provides water for a new use by simply foregoing diversion of the water and not irrigating the land. This is referred to as fallowing or idling the land. A permanent fallow is another way to describe the permanent dry-up of agricultural lands, an activity which ATMs are intended to reduce.

Temporary fallowing is often a viable option for a water transfer because it is simple to both implement and verify. Rotational fallowing is a type of temporary fallowing that can be applied to larger irrigation districts or canal companies, in which the fallowed fields are rotated through the overall service area, such that no single field is consistently or continuously fallowed. Other agricultural water supply methods seek to maintain irrigation while at the same time reducing the diversion amount and/or the consumptive use amount. A reduction in irrigation diversions, without modifying the underlying cropping practices on the farm, produces only a potential increase in instream flows and typically does not produce any transferrable water.[7] A water transfer typically requires that the consumptive use of water on the farm, or HCU, be reduced through changes in production practices. In order to do this while maintaining a crop, and the same crop acreage, requires either deficit irrigating the crop or switching crops to one that is less water intensive.

Infrastructure methods can include a broad range of activities, including both capital investment in physical infrastructure and/or changing the operation of existing infrastructure, all with the intent and purpose of creating a water supply for transfer. Infrastructure investments that address water losses or farm irrigation practices, such as lining or piping ditches or converting to sprinkler irrigation, are intended to increase the efficiency of water delivery from the water source (diversion) to the crop root zone. These types of infrastructure efficiency improvements can usually provide only a limited benefit for water transfers because they typically do not result in HCU savings, and thus are restricted to cases where increased instream flows are desired or cases where the irrigation improvements are taking place at the downstream terminus of the river basin. Improving irrigation operations, particularly upstream reservoir storage facilities, can create water for transfer by maintaining the same level of agricultural production with reduced stored water releases.

Appendix A provides a more detailed description of the most common *agricultural water supply methods* for water transfers. Table 1 provides an abbreviated listing showing the type(s) of water supply that are commonly generated under each method.

Water transfer methods

Once water is generated for transfer by modified agricultural activities, water transfer methods define how that water is transferred from one use to another. Water transfer methods define the contract structure or agreement framework between the farm source and the alternative demand. Water transfer methods are flexible in that they simply represent the agreed-upon terms for transferring water on a temporary and/or intermittent basis, but are constrained by water right laws in Colorado.

In simple form, a water transfer method is an agreement between two parties providing that one party (the farmer) will provide use of the water right to the other party (the city) under certain agreed-upon conditions. This often takes the form of a permanent sale or temporary lease agreement. If the water transfer happens intermittently, then it is known as an interruptible water supply agreement (IWSA) or an option contract, and often takes the form of a multi-year water lease agreement. Water transfer methods can become more complex by increasing the scale to include multiple parties or by increasing the number of agreements and conditions between the parties.An additional element of water transfer methods involves how to manage the agricultural lands associated with the transfer. In some cases, the agricultural lands appurtenant to the water right(s) are continually managed by the farmer or landowner, even in years that a water transfer is taking place. Another concept is to ensure that the land is preserved for agricultural use by encumbering the land in an agricultural conservation easement. There has been significant activity in Boulder County to preserve agricultural lands in this fashion, and more recently entities have been considering conservation easements as a component of ATMs.[8] For example, the recently passed HB 16-1228 requires that agricultural lands be enrolled in a conservation program in order to be able to utilize the water leasing provisions. Another example is the ATM grant study awarded to the Larimer County Open Space program to implement an ATM by purchasing agricultural lands in the county.[9] Various ideas have been presented on how conservation easements can help to facilitate ATMs between agricultural and municipal parties and environmental interests.[10]

Appendix A provides a more detailed description of the most common *water transfer methods*.

Examples of alternative water transfers

ATMs are a body of activities that represent general frameworks or concepts to be molded to the specific conditions of a place and need. The complexities of both natural water flows (hydrology and hydraulics) and Colorado's administrative system of water rights make it difficult to reproduce a successful ATM under different conditions. Therefore, ATM examples are useful to illustrate and describe how concepts have been implemented, but are not intended represent agreements that can or should be replicated in all areas. The following two sections provide ATM examples from Colorado and other Western states. Table 2 summarizes the example ATMs.

Colorado

The underlying elements that make water transfers and transactions occur include: (1) an inability to secure a new water source for a desired use and/or a regional imbalance between water supplies and demands, and (2) population growth, economic development, and other driving factors that create new and changed water demands. Both of these factors have been increasingly present in Colorado, and therefore it is not surprising that Colorado has

TABLE 2

Examples of alternative water transfers

Location	Water supplier	Agricultural water supply method	Water transfer method	Purpose of transfer	Annual volume transferred (AFY)	Term	Equivalent lease rate ($/AFY)
Colorado	Highline Canal Co.	Temporary fallow	Lease	Municipal	6,800	2 years	$754–$811
	Highline Canal Co.	Infrastructure	Buy and supply	Municipal	1,100	10 years	$152
	Catlin Canal	Rotational fallow	Lease	Municipal	380	10 years	$500
	North Sterling Irrigation District	Deficit irrigation/ temporary fallow	IWSA	Industrial	3,000	25 years	$425
	Various ranches	Temporary fallow	Leases	Upper Basin System Conservation Program	5,600 (avg)	2 years	$223 (avg)
	McKinley Ditch/ Colorado Water Trust	Split season fallow	Purchase	Environmental	175 (est)	Permanent	$42 (est)
	Fort Collins (Water Supply & Storage Co.)	Temporary fallow	Buy and supply	Municipal	1,617	Permanent	—
Other western states	Palo Verde Irrigation District (CA)	Rotational fallow	Lease	Municipal	25,000–118,000	35 years	$175–$340
	Imperial Irrigation District (CA)	Infrastructure/ rotational fallow	Lease to fix	Municipal	100,000	45 years	$258–$594
	Diamond S Ditch Association (AZ)	Infrastructure	Lease	Environmental	2,700	Permanent	$10
	Three Sisters Irrigation District (OR)	Infrastructure	Purchase	Environmental	2,265	Permanent	$73 (est)
	Yuma Mesa Irrigation and Drainage District (AZ)	Rotational fallow	Lease	Municipal	6,800	3 years	$150
	Various sources	Various	Lease	Lower Basin System Conservation Program	63,000	1 year	$99–$253
	Sacramento Valley Districts (CA)	Rotational fallow	Lease	Municipal/ agricultural	22,000–115,000	4 years	$200–$700

ATM = Agricultural water supply method + Water transfer method

Note: Annual volume transferred represents a diversion volume for Environmental water transfers and represents a consumptive use volume for Municipal and Industrial transfers.

experienced a significant amount of water trading activity. Historically, most water transfers in Colorado occurred as permanent sales to new municipal and industrial (M&I) uses, leading to the undesired effect of agricultural dry up along the Front Range. More recently, there have been times and places where M&I users in Colorado have been unable to acquire water supplies as either a new water project or under a permanent sale, and have turned to ATMs to secure water supplies. In addition, several examples of ATMs in Colorado have resulted from State-funded research efforts to test concepts and methods.

1. Rocky Ford—Highline Canal

One of the earliest examples of an ATM in Colorado began in 2003 due to severe drought conditions.[11] The City of Aurora was faced with a significant risk of water supply shortage, and engaged the Highline Canal Company and its shareholders about entering into a short-term lease agreement.[12] The agreement was structured such that Aurora would lease shares from individual shareholders in the system, and the farmer was responsible for fallowing 10 acres for each leased share. The water supply yield from each leased share was uncertain, and a risk carried by Aurora. The leases were implemented in 2004 and 2005. Aurora entered into 124 individual lease contracts, totaling 8,200 irrigated acres or 37% of the ditch service area. Farmer payments totaled $10.6M over the two years, or approximately $649 per acre, per year. Aurora was also responsible for developing a Substitute Water Supply Plan and installing the necessary infrastructure within the Highline Canal Company to meet water measurement and accounting obligations. Aurora has estimated that the Highline water leases carried an annual water cost of $754 per AF if delivered from Twin Lakes Reservoir and $811 per AF if delivered from Spinney Mountain Reservoir.

From 2005 to 2007, Aurora worked with the Highline Canal Company on a Phase II purchase contract, acquiring 2,810 acres of irrigated farm ground, with a promise to either continue farming or revegetate portions of the irrigated land. Approximately 880 acres remain in farming of the original land base, and Aurora set up a 10-year farm lease agreement for the remaining irrigated acres. Aurora invested $1,400 per acre to install more efficient irrigation systems and to install groundwater wells and pumps to provide a new source of supply. Aurora also makes an annual payment to the seller of $50 per acre. In return, Aurora receives 1.25 acre-feet per year (AFY) per acre for its use and provides the farm with 0.5 AFY/acre to supplement an augmentation plan for well pumping.

2. Super Ditch project

The Super Ditch project has had a long history of development.[13] In 2002, the Lower Arkansas Valley Water Conservancy District was formed by concerned farmers and rural citizens who held water rights in the lower Arkansas River. Initial efforts of the LAVWCD were focused on conservation easements and preventing more municipal water acquisitions. Water lease agreements were also explored, particularly after a 2006 workshop that highlighted the rotational fallowing agreement involving the Palo Verde Irrigation District in southern California. An engineering study was completed in 2006 that identified 8 irrigation canals/ditches in the Lower Arkansas Valley that fit necessary qualities for a rotational fallowing program. The Lower Arkansas Valley Super Ditch Company, Inc. (Super Ditch) was formed soon afterward in 2008 with the intent of developing a lease-fallow program for 6 participant ditches. Shareholders of the company are those farmers who enroll acres into the water leases negotiated by Super Ditch, with varying shares issued to each farmer depending on the value of their water right holdings for lease. The Super Ditch Company is intended to act as a facilitator and negotiator on behalf of the participating farmers, for the collective leasing of water to municipalities.

Initial lease negotiations with potential municipal partners started in 2008. In 2010, term sheets were signed with the Pikes Peak Regional Water Authority and City of Aurora. These term sheet never materialized into lease agreements due to administrative and legal hurdles regarding injury concerns from changed water rights. The LAVWCD also pursued two pilot projects with the cities of Fountain and Colorado Springs, which led to HB 13-1248 in 2013. The Catlin Canal was used as the first pilot project, with State Engineer approval granted in January 2015.[14] Under the pilot project, six farms totaling 911 acres were selected for rotational fallowing, with approximately 240 acres (26%) fallowed in 2015. Lease agreements were signed with the Town of Fowler, City of Fountain, and Security Water District. A total of 380 acre-feet were delivered in 2015. From the 2010 term sheets through the 2015 lease agreements, the Super Ditch Company has consistently set a lease price of $500 per AF of delivered water.

The Super Ditch project has received considerable financial support from the state in working to establish a successful rotational fallowing program. The project represents an investment of approximately $2M (through 2010), with funding of about $0.65M from the LAVWCD through its property tax levy and $1.35M from State funding sources, including the Colorado Water Conservation Board and the Arkansas Basin Roundtable. The project has faced significant legal challenges related to injury concerns from downstream water right holders, and has likely provided a clearer path for other fallow-lease projects in the state.

3. Pawnee Power Plant (Xcel Energy)

The Pawnee power station is a coal-fired power plant near Brush, CO that has been operated by Xcel Energy since 1981. The cooling water for the plant is sourced from a set of groundwater wells in the alluvium of the South Platte River. Following the 2002 drought and increased administration of groundwater rights in the South Platte Basin, the augmentation plan that had historically been utilized by Xcel Energy was no longer adequate in certain dry years. Xcel Energy engaged in two interruptible water supply agreements (IWSAs) to provide a more reliable source of augmentation water for its wellfield. In 2005, Xcel entered into an IWSA for up to 3,000 AFY with the North Sterling Irrigation District (NSID) for winter-time augmentation water (November to March). A lease agreement for summer-time water supplies was previously completed with the Fort Morgan Water Company. The NSID formed a separate Point of Rocks Water Company (PRWC) to engage in the water lease, and District landowners could voluntarily enroll their acres into the Company. Approximately 34,403 irrigated acres, or 84% of the District service area, enrolled in the PRWC.

As part of the administrative requirements of the lease agreement, the Xcel wells were added to the NSID well augmentation plan and changes were required for NSID water right holdings. These changes were approved by water court. Due to normal system losses and irrigation efficiencies, NSID has to forego diversion of 4,960 AF in order to provide 3,000 AF of consumptive use to Xcel. This represents about 8.7% of the average-year diversions by NSID. PRWC members would then get a pro-rata reduction in their water deliveries based on the reduced NSID diversions. The lease agreement between Xcel and PRWC was for a 25-year term, with an annual required payment of $150,000 (or $50 per AF) and an additional payment of $425/AF for water delivered to Xcel when the agreement is exercised. To date, Xcel has not exercised its option to lease water from PRWC.[15]

4. Carpenter Ranch & Upper Basin System Conservation Program

The Nature Conservancy purchased the 906-acre Carpenter Ranch in 1996 and currently leases it to a rancher. In 2015, TNC enrolled four hay fields totaling 197 acres on the ranch in the Colorado River System Conservation Program, with the intent of engaging in split-season fallowing operations and only irrigating for the first half of the growing season until July 1. Under the System Conservation Program, projects are approved by the Upper Colorado River Commission and contracts are developed between TNC and the Program funders. As a pilot project, the aim is to understand transaction and water accounting hurdles as opposed to leasing for the sole benefit of the water. TNC also worked with other West Slope farmers and ranchers to participate in the System Conservation Program. Pricing information has not been disclosed by the Program participants. The Upper Basin program was originally funded with $2.75M for system conservation projects. In 2015, the Upper Basin program was reported to fund $1M for 10 projects, with an estimated consumptive use yield of 2,228 AF, resulting in an average project lease price of $449/AF. The 2016 Upper Basin program is expected to fund the balance of $1.75M with an estimated consumptive use yield of 8,970 AF, or an average lease price of $195/AF.[16]

5. McKinley Ditch

In 2008, an irrigated ranch in the Gunnison River Basin had been sub-divided by the landowner, and the landowner was offering to sell the appurtenant water rights in McKinley Ditch. The ranch had historically irrigated 195 acres with 1.5 shares of the McKinley Ditch, which provided for 772 AFY of farm head gate deliveries and 273 AFY of HCU. In 2010, the Colorado Water Trust (CWT) and Western Rivers Conservancy (WRC) entered into a partnership to purchase the land and water rights. In 2012, WRC completed the purchase of the land and water right assets from Montrose Bank following a foreclosure on the property, and in January 2014 CWT purchased the water rights from WRC. CWT then embarked on a plan to utilize the water rights in a split-season fashion, allowing continued use for irrigation in the first part of the growing season but then ceasing diversions and utilizing the water rights for instream flows in the latter part of the season. In September 2014, the CWT sold a “Grant of Flow Restoration Use” to the Colorado Water Conservation Board for $145,640. The grant provides the CWCB with a permanent right to use the McKinley Ditch water rights for instream flow purposes under certain pre-determined conditions each year.[17] In December 2014, CWT and CWCB jointly filed for a change of use in water court to add instream flow uses to the water right. The water court proceedings have not concluded.

6. City of Fort Collins

The City of Fort Collins acquired 26.667 shares of the Water Supply and Storage Company (WSSC) in the 1970s and 1980s as part of its efforts to meet future water demands. A WSSC share provides water from both trans-basin diversions and native Poudre River ditch supplies. Fort Collins had never changed the use associated with the native Poudre River ditch supplies and had always leased the agricultural water rights to farmers on an annual basis. In 2011, Fort Collins filed a change of use application in water court to allow both (existing) irrigation uses as well as new municipal uses on an interruptible basis. A decree was issued in 2015 approving the additional municipal uses, and providing average annual deliveries of 1,617 AF.[18] A unique aspect of the change case was that no permanent agricultural dry up was required to allow municipal use of the ditch shares. On an annual basis, Fort Collins must determine its use of the subject water rights and submit an Annual Operating Plan by April 5 to various stakeholders. In either case, whether for irrigation or municipal use, Fort Collins is required to undertake significant monitoring and accounting of both uses and return flows. This water right change case by Fort Collins represents a unique effort by the city to preserve agricultural use within the decreed water right while also allowing interruptible municipal use by the city.

Fort Collins has also operated a temporary water swap with the North Poudre Irrigation Company (NPIC) and its shareholders in years when the city’s water supply portfolio was diminished due to drought or wildfire. A share in the NPIC consists of direct flow water rights from the Poudre River, known as the Agricultural component, and 4 units in the Colorado-Big Thompson (CBT) Project, known as the Multiple Use component. Fort Collins owns 3,564 shares of NPIC but can only utilize the CBT units or Multiple Use component. In most years, Fort Collins rents the Agricultural component back to farmers within the NPIC system. In 2013, Fort Collins was faced with the potential possibility of not being able to divert direct flows from the Poudre River as a result of poor water quality following a large wildfire in the watershed. Fort Collins engaged NPIC shareholders about a water swap, in which NPIC farmers would provide Fort Collins with their Multiple Use component (CBT) water (2 AF per share), and in return Fort Collins would provide 1.5 times this volume of water back to the farmers using the city's Agricultural component (1 AF per share). The City had significant interest in the swap agreement, and utilized all of its shares to acquire 2,376 AF of additional Multiple Use water supply. A similar water swap involving NPIC was previously utilized by Fort Collins during the drought of 2003.[19]

Other western states

1. Palo Verde Irrigation District (California)

In 2004, Metropolitan Water District of Southern California (MWD) and Palo Verde Irrigation District (PVID) entered into a long-term fallowing agreement to supply MWD with a portion of PVID's Colorado River water entitlement. MWD had a diverse water supply portfolio, but faced water supply shortages and sought to increase its volume of Colorado River water to help meet rapidly growing demand. The program is a 35-year agreement compensating PVID landowners for rotationally fallowing a portion of their irrigated cropland. A total of approximately 26,000 acres are enrolled in program, providing between 25,000 and 118,000 AF annually to MWD. Landowners enrolled in the program fallow a base amount equal to 25% of their total enrolled acres annually. In addition, MWD has the option to call for additional fallowing of up to 100% of total enrolled acres. In order to call additional acres MWD must provide landowners notice at least one year in advance of making the call, and must commit to maintain the call for at least two years. In return for fallowing cropland, landowners received an initial payment of $3,170 per enrolled acre, and annual payments of $602 per water toll acre fallowed escalated at 2.5% annually for the first ten years of the agreement, and escalated according to annual changes in the Consumer Price Index for the remaining years of the agreement.[20,21]

In 2009, the State of California was experiencing a third consecutive year of drought. MWD was already calling 100% of the supplies available under the long-term PVID fallowing agreement, and needed additional water supplies to meet urban demands. In response, MWD and PVID agreed to a one-year emergency fallowing program to supplement the long-term agreement. Under the one-year agreement, landowners were given the option to fallow up to 15% of their lands receiving Priority 1 Colorado River water in exchange for a one-time payment of $1,665 per water toll acre fallowed. In addition, PVID received a one-time payment $35 per water toll acre fallowed. The payment to landowners under the one-year agreement represented a 151% premium over the 2009 payment to landowners under the long-term fallowing agreement. Approximately 13,500 additional acres were fallowed under the emergency fallowing program.

2. Imperial Irrigation District (California)

In 1998, Imperial Irrigation District (IID) and San Diego County Water Authority (SDCWA) approved a water conservation and transfer agreement. SDCWA sought new long-term water supplies from the Colorado River to meet growing demand and expansion of its service area. The agreement provided for water to be conserved by methods chosen by IID and transferred to SDCWA. All water was to be provided by improving efficiency of water use within IID. However, in 2003, IID and SDCWA entered into a new agreement, which was introduced through the Quantification Settlement Agreement (QSA).[22] While IID was originally opposed to land fallowing during the QSA negotiations, the District ultimately agreed to a 15-year fallowing program to eliminate effects on the nearby Salton Sea resulting from water transfers out of the Imperial Valley. Water conserved and transferred from fallowing was scheduled to ramp up during the first 10 years of the agreement and then decline over the next 5 years, as transferred water is increasingly generated from efficiency measures. Efficiency improvements within IID are scheduled to completely replace fallowing by 2018.[23]

The volume of water conserved and transferred increased to 100,000 AF (80% fallowing, 20% efficiency) in 2013. In 2014, the volume remained the same, but the portion comprised of water conserved through efficiency improvements doubled to 40%. The cost of the conserved water was $594/AF in 2014, a 10% increase from 2013.[24] The revenue created by the program was used to pay IID landowners and fund infrastructure improvement. The initial term of the agreement is 45 years, with the option to renew the agreement for an additional 30 years. Prior to the agreement with SDCWA, a similar water conservation and transfer agreement was completed between IID and MWD. The IID-MWD program consisted of MWD funding efficiency improvements within IID, and in return IID would transfer the resulting conserved water to MWD. Projects were started in 1990 and completed by 1998. The program transfers 110,000 AF per year to MWD at a capital cost of $112 million and annual operation and maintenance costs of $5 million per year.[25]

3. Verde River (Arizona)

In 2012, The Nature Conservancy (TNC) completed an infrastructure improvement project in Arizona's Verde River Valley. The Diamond S Ditch Association (DSDA) diverted approximately 12,000 AF from the Verde River annually and delivered it to approximately 80 landowners and 400 acres of land in the Valley. The water was diverted using an earthen dam structure that would wash out during summer rain events and limit DSDA's ability to control diversions. Working with DSDA, TNC funded the construction of two automated head gates which would control diversions based on flow rates to keep water in the river and improve efficiency in DSDA's infrastructure. The cost of implementing the infrastructure improvements was $25,000. In addition, TNC agreed to pay DSDA $10/AF of unused irrigation water annually. Per its agreement with TNC, DSDA agreed to reduce its diversion rate from 30 to 25 cubic feet per second during irrigation season, conserving approximately 2,700 AF. The lease does not have a specified term and will continue for the foreseeable future.

4. Columbia Basin Water Transactions Program (Columbia River Basin, Oregon)

The Columbia Basin Water Transfer Program (CBWTP) was started in 2002 to address low streamflows caused by withdrawals during the peak of the irrigation season which were negatively affecting native species like salmon, steelhead, and trout. CBWTP uses permanent

The Verde Valley, located in central Arizona near the town of Sedona.

JENNIFER HORN/WIKIMEDIA

acquisitions, leases, efficiency improvement projects, and other incentive-based approaches to restore instream flows.[26]

From 2012 to 2014, the Deschutes River Conservancy (DRC, a CBWTP local entity) purchased 3.33 cubic foot per second (cfs) of water in Whychus Creek which was conserved as the result of converting the Three Sisters Irrigation District (TSID) canal to an underground pipeline. TSID consists of nearly 8,000 irrigated acres, and it had historically used a 3.9-mile canal to transport water from Whychus Creek to its service area. TSID paid for a portion of the infrastructure improvement and chose to sell 3.33 of the 10 cfs conserved by the project to DRC from 2012 to 2014 to benefit flows in Whychus Creek. DRC purchased approximately 850 AF for $1,180/AF in 2012 and 2013, and 565 AF for $2,340/AF in 2014.

5. Yuma-Mesa Irrigation and Drainage District (Arizona)

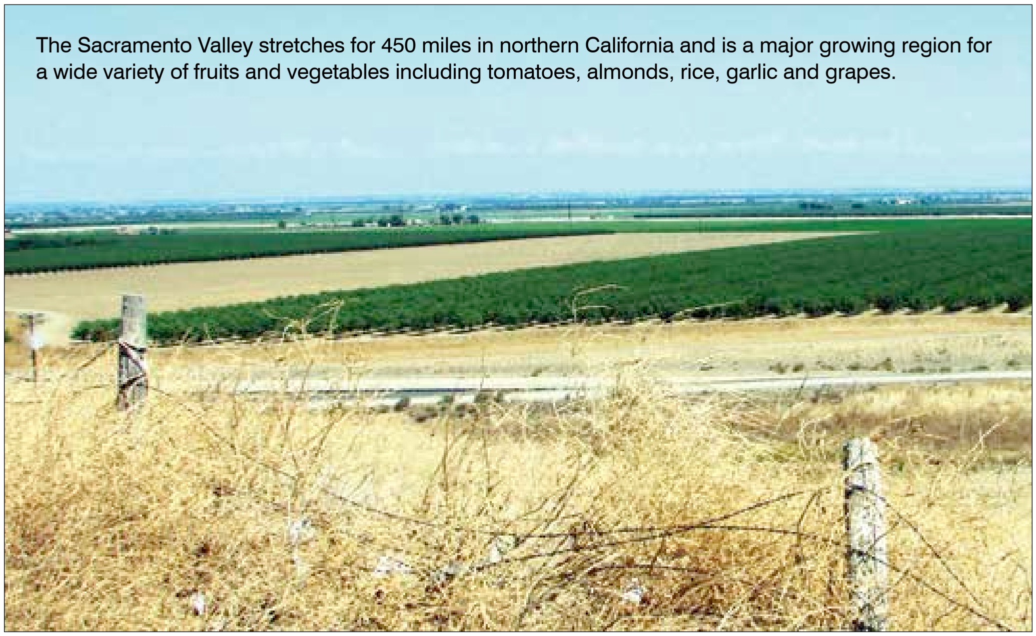
In 2013, the Yuma Mesa Irrigation and Drainage District (YMIDD) and the Central Arizona Groundwater Replenishment District (CAGRD) entered into a short-term, pilot fallowing program to replenish groundwater in central Arizona stemming from growth in CAGRD's member lands and service areas. The pilot program had an initial 3-year term, with the possibility of a 3-year extension, and a goal of establishing a long-term fallowing program (30–45 years). Under the program, landowners voluntarily enrolled land that had been irrigated in 4 of the 5 years preceding the program. Each year, landowners could substitute fallowed acreage with new acreage to be fallowed, so long as it qualified under the historical irrigation requirement. Landowners were allowed to enroll up to 25% of their land, which was later increased to 30% to approach the 1,500-acre target enrollment. A total of approximately 1,400 acres were enrolled in the program each year, which represented less than 10% of the total irrigated acres in the District. The program conserved approximately 6,800 AF annually. Landowners received a payment of $750 per enrolled acre, or approximately $150/AF during the first year of the agreement. The payment was escalated at the greater value of 2% or the annual changes in the Consumer Price Index.

6. System Conservation Program (Lower Colorado River Basin)

In 2014, the U.S. Bureau of Reclamation (USBR) and four large municipal water providers implemented the Colorado River System Conservation Program. The Program provided $8.25 million for water conservation projects aimed at generating additional water supplies in the Lower Colorado River Basin system by reducing water uses and/or increasing supplies for storage in Lake Mead. The program solicited proposals from agricultural, municipal, and industrial Colorado River water right holders. In the Lower Basin, six projects were approved during the first round of proposals in 2015 with an estimated consumptive use savings of 63,000 AF. In Arizona, three projects provided approximately 40,000 AF through infrastructure improvements and reduced diversions to agricultural and municipal entities. In California, 5,000 AF was conserved through the conversion of farms from flood to drip irrigation. In Nevada, 15,000 AF of water was conserved by dedicating flows of the Muddy and Virgin Rivers as "system" water instead of using such flows to create Intentionally Created Surplus credits. The cost range across these six projects was $99 to $253/AF of conserved water.

7. Sacramento Valley Districts (California)

In 2012, several water districts in Northern California's Sacramento River Valley entered into single-year water transfer agreements with a collection of Central Valley water districts collectively known as the Westside Districts. The purpose of the transactions was to provide supplemental water to meet the Westside Districts' water supply needs as a result of drought conditions. The Sacramento Valley districts had substantial State Water Project (SWP) allocations and landowners in the districts agreed to fallow portions of their land historically used for the cultivation of rice to conserve water for the transfer. Each year, SWP notifies its



The Sacramento Valley stretches for 450 miles in northern California and is a major growing region for a wide variety of fruits and vegetables including tomatoes, almonds, rice, garlic and grapes.

DON GRAHAM/WIKIMEDIA

contractors of projected allocations to allow for near-term water supply planning. During the drought period, no contractors received full allocations, causing some districts with highdemand and inflexible crops to seek supplemental water supplies to meet demand. The Sacramento Valley districts and participating landowners collectively determined the number of acres available for fallowing to identify the volume of water that could be conserved and transferred. Under the transfers, the volume of conserved water was calculated by applying the consumptive use associated with rice, 3.3 AF per acre, to the number of acres fallowed. In 2012, approximately 71,000 AF were transferred at a price of $200/AF. In 2014, the Sacramento Valley districts transferred approximately 115,000 AF at a price of $500/AF. In 2015, shortages affected the volume available from the Sacramento Valley districts, and the volume of conserved and transferred water was reduced to 22,000 AF at a price of $700/AF.

Past research on alternative water transfers in Colorado

Although a limited number of ATMs have been implemented in Colorado, there has been a significant amount of research into the potential use of ATMs across the state. The majority of funding for this research has come from the Colorado Water Conservation Board (CWCB) through a grant program established in 2007. The following sections provide a summary of the grant program, and describe some of the important findings from the research to date.

ATM grant program

Senate Bill 07-022 authorized the CWCB to establish a grant program to research and develop ATMs in Colorado, and appropriated $4.75M to the ATM grant program. To date, most of this funding has been utilized to conduct research on potential ATMs across the state. An initial round of projects (2009–2011) highlighted the following barriers to ATM implementation: (1) high transaction costs for water transfers, (2) water right administration uncertainties, (3) municipal water provider preference for long-term water supply certainty and permanence, and (4) infrastructure needs and water quality issues. A second round of projects (2011–2012) focused on addressing these barriers, either through new projects or a continuation from earlier projects.[27] A third round of projects (2013-2015) is ongoing, and is focused on helping to implement specific ATM projects. So far, the only project funded through the grant program

TABLE 3

Summary of projects, CWCB ATM Grant Program

Application year	Recipient	Project name	Funding award	Status
2008	Lower Arkansas Valley Water Conservation District	Rotational Land Fallowing and Water Leasing Program	$320,000	Completed
2008	Colorado Corn Growers Association	Alternative Agricultural Water Transfer Measures for Preservation of Colorado Irrigated Agriculture	$349,650	Completed
2008	Farmers Reservoir and Irrigation Company	Alternative Agricultural Water Transfers	$202,500	Completed
2008	Parker Water & Sanitation District	Lower South Platte Irrigation Research and Demonstration Project	$477,500	Completed
2008	Colorado State University	Land Fallowing in the Arkansas	$78,489	Completed
2010	Parker Water and Sanitation District	Lower South Platte Irrigation Demonstration Project	$320,166	Completed
2011	Colorado River Water Conservation District	Compact Water Bank	$180,000	Completed
2011	East Cherry Creek Valley Water Conservation District	Maintaining Agricultural Productivity on Formerly Irrigated Lands	$111,030	Completed
2011	Colorado Corn Growers Association	FLEX Market Model Project	$158,365	Completed
2011	Colorado Water Innovation Cluster	Lake Canal Demonstration Project	$135,105	Completed
2011	The Nature Conservancy	Use of ATMs to Meet Nonconsumptive and Consumptive Needs in the Yampa	$132,000	Completed
2011	Upper Arkansas Water Conservancy District	Building & Assessing Accounting & Administrative Tools for Lease Fallowing	$121,500	Completed
2013	Lower South Platte Water Conservancy District	Water Cooperative	$300,477	In progress
2013	Conejos Water Conservancy District	Use of ATMs to Increase Supplies for Conejos Basin Ag, Municipal, and Enviro Purposes	$124,734	In progress
2013	Colorado State University	Implementation of Deficit Irrigation Remedies, Demonstration & Outreach	$124,734	Completed
2013	Ducks Unlimited	FLEX Water Market - Education & Implementation Phase	$120,250	Completed
2013	Colorado River Water Conservation District	Water Bank Feasibility—Phase 2	$180,000	Completed
2013	Lower South Platte Water Conservancy District	Northeast Colorado Water Cooperative Implementation	$173,900	In progress
2014	Colorado Water Institute - CSU	Poudre Basin Water Sharing Working Group, Efforts Leading to Agreements	$86,940	Completed
2014	Colorado River Water Conservation District	No Chico Brush Agricultural Water Research Project	$173,080	In Progress
2014	Colorado River Water Conservation District	Colorado Water Bank Working Group	$180,000	In progress
2015	Lower Arkansas Valley Water Conservation District	Leasing Catlin Canal Pilot Project Implementation	$173,781	In progress
2015	Larimer County	Open Space ATM Pilot Project	$178,425	In progress
			Total: $4,402,626	

TABLE 4

Summary of example ATM projects/scenarios from ATM grant studies

Project	Water owner (from)	Water user (to)	Agricultural water supply method	Water transfer method	Volume of transfer (AFY)
TNC-Yampa	Irrigator	Instream flow	Temporary fallow	CWCB Instream Loan	122–889
TNC-Yampa	Irrigator	Irrigator	Temporary fallow	Direct lease	20–424
FRICO	Burlington Canal, FRICO Barr Lake	City of Thornton	Infrastructure	Shared water bank	466
FRICO	Burlington Canal, FRICO Barr Lake	South Adams County Water and Sanitation District	Infrastructure	Shared water bank	1,736
Parker	Farmland near Iliff, CO	Parker Water and Sanitation District	Fallow	N/A	700–900
CCGA-ATMs	Platte Valley Irrigation Co.	City of Aurora	Fallow	IWSA/FLEX Model	300–1,670
CCGA-ATMs	Lower South Platte farms	Upstream M&I users	N/A	Water bank (water cooperative)	400–2,000
CCGA-ATMs	DT Ranch	Town of Wiggins	Temporary fallow	IWSA	175
CCGA-FLEX Model	Lower Lathan Ditch Co.	None specified Potential for multiple users	Temporary fallow	IWSA/FLEX Model	1,800
CCGA-FLEX Model	Platte Valley Irrigation Co.	Several municipal users	Temporary fallow	IWSA/FLEX Model	1,600
CWIC-Lake Canal	Lake Canal	TNC, Fort Collins natural areas	Fallow	IWSA	200
LAVWCD	Catlin Canal	Municipal users	Rotational fallow	Direct lease	500

ATM = Agricultural water supply method + Water transfer method

resulting in an ATM water transfer is the Catlin Canal Pilot Project in the Arkansas River Basin, which is related to the Super Ditch effort. Table 3 (page 24) provides a listing of projects funded under the ATM grant program and their current status. It is estimated that approximately $375,000 (or about 8%) remains available for grants from the original appropriation.

Table 4 summarizes some of the example ATMs that have been investigated in the course of the CWCB grant studies. Several studies found feasible ATM projects located on the Colorado Front Range, involving specific municipal and agricultural entities. It is worth noting, however, that most of the identified “feasible” ATMs have not been implemented since the study date. The feasibility of specific ATMs under the grant studies was often evaluated from a legal and engineering perspective, and financial feasibility was absent from most of the studies. The two case studies included in this study focus on financial questions surrounding ATMs on the Front Range, and therefore represent a useful addition to past studies under the ATM grant program.

Agricultural water supply methods

The ATM grant program has focused a large part of its funding on better understanding the feasibility of agricultural water supply methods. Summary findings and examples are provided in the following bullet points for each agricultural water supply method:

- **Temporary fallow.** This type of supply method was the most common method evaluated in the ATM grant studies. In general, this method works well in Colorado and can be accomplished under current state water laws and practices. Temporary fallowing is well-suited for many of the ATM water transfer methods that have been studied, including the

FLEX Market approach, Interruptible Water Supply Agreements (IWSAs), and direct leases (see Table 4 for a list of studies). An important but often over-looked aspect of temporary (and permanent) fallowing is the land use practices of the idled lands, and one of the ATM grant studies specifically evaluated opportunities on the Colorado Front Range.[28] The study evaluated the feasibility and costs of dryland farming and revegetation across southern Weld and Morgan counties. Another ATM study utilizing a Colorado State University (CSU) irrigation demonstration project in eastern Colorado (near Iliff) recommends the use of a dryland cover crop instead of fallow or idled ground.[29] In addition, the latest funding to the Colorado River Water Bank Working Group is being utilized in part to conduct research on the lingering effects on pasture and hay yields in years after fallowing, through demonstration plots on the Western Slope.[30]

- **Rotational fallow.** This method has received considerable study in the Arkansas River Basin as part of the Super Ditch effort. The initial 2011 study report showed legal, technical, and economic feasibility of the rotational fallowing concept.[31] Following legal hurdles, a pilot project for the Catlin Canal was initiated in 2015 and resulted in successful water transfers. The Catlin Canal pilot project involved three municipal water providers, six farms, and the Catlin Canal Company with annual leases of 500 acre-feet.[32] In the Northern Front Range, rotational fallowing has received less study, with some example crop rotations described for the CSU irrigation demonstration field study near Iliff.

- **Deficit irrigation.** Deficit irrigation was studied intensely as part of the CSU irrigation demonstration project near Iliff, with a variety of in-field and remote sensing tools applied to estimate reduced evapotranspiration (ET) with reduced irrigation. The research findings show approximately 30% less crop ET with a 50% reduction in applied irrigation. Alfalfa and other deep-rooted crops may not be conducive to deficit irrigation if they are able to utilize shallow groundwater. The challenge with deficit irrigation stems from water right administration, with inherent difficultly in simultaneously exercising an irrigation right and also transferring a component of the right to another use. Deficit irrigation impacts on ET and yield are also being studied on the Western Slope demonstration projects through the Colorado River Water Bank Working Group.

- **Crop switching.** This method has not received much attention in the ATM grant studies. Similar to deficit irrigation, there are inherent difficulties from a water rights administration standpoint of both irrigating a crop and transferring water to another use with the same water right in the same year. While not addressing the viability of crop switching specifically, the CSU irrigation demonstration projects and the study of dryland cropping potential both provide useful information for the consideration of crop switching practices and potential reductions in crop consumptive use.

- **Infrastructure.** Many ATM studies presented a need for new infrastructure to allow ATM concepts to be implemented. Such infrastructure projects have included pumps and pipelines to convey water from the lower South Platte River area upstream to municipal demand areas, and the construction of recharge ponds or wetlands for well augmentation uses.[33] One study looked at the possibility of expanded use of existing reservoir facilities owned and operated by agricultural water users.[34] The general conclusions are that some infrastructure is often needed to implement ATM concepts, whether it is temporary storage facilities or much larger water conveyance systems. Relevant to infrastructure, WestWater completed a study on the Colorado Western Slope looking at the economic returns of capital infrastructure projects which increase irrigation efficiency.[35] The study found that, in general, average farm returns do not justify investments in infrastructure improvements absent outside funding assistance, such as Federal or State grants or an environmental water transaction.

The ATM grant program has developed some software tools to assist farmers and agricultural water right holders in evaluating the potential economic benefits of water lease agreements compared to continued agricultural use of the water right. The Agricultural Lease Evaluation Tool (AgLET)was developed as user-friendly Excel spreadsheet that can evaluate three ATM concepts: (1) rotational fallowing, (2) temporary fallowing (or IWSAs), and (3) deficit irrigation.[36] Default county-based data are available, or users can input their own farm-specific costs and returns. AgLET estimates impacts to crop yields, production costs, and sale revenues under each ATM and under baseline continued cropping conditions. Colorado State University (CSU) Extension has held training sessions and currently maintains the AgLET tool. A more applied tool is the Lease Fallow Tool (LFT)which was developed by CSU and the Colorado Department of Water Resources.[37] The LFT is intended to simplify and streamline the evaluation of HCU and return flows for lease-fallow projects, and was developed as a result of legislative action under HB 13-1248. The tool conducts a parcel-specific water balance using an Irrigation System Analysis Model.

Water transfer methods

There have been a variety of water transfer methods studied under the ATM grants. Summary findings and examples are provided in the following bullet points for each water transfer method:

- **Regional water bank.** The concept of a water bank has been intensively studied in the Colorado River Basin of Colorado, primarily led by the Colorado River District and The Nature Conservancy. The basic concept is to create a regional water bank which would have deposits of water into the bank from fallowed or deficit irrigated West Slope farmlands and withdrawals of water from the bank to meet certain higher-value demands. One particular type of demand is a number of existing trans-basin diversions to the Colorado Front Range that are at risk under a scenario in which post-1922 priority water rights in Colorado are curtailed under a Colorado River Basin Compact call. The Water Bank Working Group was created, and the project is now under its third round (phase) of funding from the ATM grant program. Recently, the Working Group has shifted its focus toward implementing specific pilot projects, including one with the Grand Valley Water Users Association.[38]

The U.S. Bureau of Reclamation's Government Highline Canal north of Grand Junction, Colorado.

AFOXLAND/WIKIMEDIA

A “shared water bank” concept was studied on the Front Range using existing storage infrastructure owned by the Farmer Reservoir and Irrigation Company (FRICO) more effectively by allowing municipal entities to deposit water into unutilized space in the reservoir.[39] Another water bank concept has been explored along the lower South Platte River. The Northeast Colorado Water Cooperative was formed and received an ATM study grant to pursue the idea of establishing a water bank to exchange augmentation credits.[40] The project is still in progress, with efforts to encourage water users to participate in the Cooperative.

- **Public water bank.** While several studies have looked at a regional or administrative water bank concept (summarized above), a public water bank involving public funds used for agricultural water right acquisitions has not been studied. The concept of a conservation easement held by a county or state agency is similar to the public water bank concept, with the additional need for a water lease agreement to make it an ATM. The Larimer County Open Lands project has recently been started under the ATM grant program to explore this concept, with one farm purchase currently underway.[41] Outside of the ATM grant program, Boulder County Open Space has completed numerous agricultural land purchases and is starting to consider ATM concepts for use of the associated water rights.[42] The Poudre Water Sharing workgroup has also expressed some interest in exploring a public water bank concept. To date, little study has been applied to this water transfer method.

- **Buy and supply.** The buy and supply method has not been studied under the ATM grant program. The Poudre Water Sharing workgroup made significant mention of it as a new ATM method that needed further study. One of the possible scenarios studied by the Poudre Water Sharing workgroup was a particular version of the Buy and Supply concept in which a municipality purchases the agricultural water right and then enters into lease agreements with irrigators. This concept is very similar to the status-quo of permanent water right acquisitions by municipalities along the Front Range, and therefore should provide some level of comfort on the municipal side. Supporting this, one ATM study concluded that the ATMs most likely to be implemented by municipalities were either a Buy and Supply arrangement or a long-term IWSA arrangement.[43] Similar to a public water bank, a land parcel might be enrolled in a conservation easement to preserve its agricultural use while water is intermittently used by a municipal entity. The Larimer County Open Lands ATM project is an example of a buy and supply project currently in progress.

- **Split-season leases.** Most of the research on split-season leases has occurred on the Colorado Western Slope. Studies on split-season leasing have been included in the Colorado River Water Bank project and the Yampa ATM project, but no specific projects or studies under the ATM grant program have been targeted at split-season leases.[44,45] In practice, split-season leases have been implemented by the Colorado Water Trust on the McKinley Ditch and by The Nature Conservancy on Carpenter Ranch.

- **IWSA/option contract.** This method represents the most commonly studied water transfer method, and the method most commonly applied when discussing ATMs. In Colorado, several legislative actions have made IWSAs easier to implement by avoiding water court and providing flexibility in the use of agricultural water rights. One of the inherent problems with IWSA transfers is that they must fill a water supply niche for municipalities, a demand sector that places significant value on long-term water supply certainty and permanence.[46] Other problems noted in many of the ATM studies include high transaction costs to change water use in water court, which are similar to costs for permanent water right acquisitions, and differing viewpoints on the term length of the IWSA, with municipal entities desiring long-term and agricultural entities desiring short-term agreements.[47] Some of the most feasible uses of IWSAs seem to be as intermittent supplies for well augmentation and environmental instream flow uses.[48,49]

- **Purchase/lease.** Direct leases are differentiated from IWSAs by being either a single-year water transaction or a continuous year to year transfer of water. Direct leases have been studied and implemented as ATM concepts for environmental instream flow purposes. Examples include the Yampa River Basin study and activities of the Colorado Water Trust and The Nature Conservancy, all of which have taken place on the Western Slope. On the Front Range, there are several examples of municipalities who have entered into direct lease agreements to fulfill both short-term and long-term gaps in their water supply portfolios but not all of these direct leases are considered to be ATMs. Some examples include the WISE project in the South Denver Metro area, the three municipalities participating in the Catlin Canal pilot project in the Arkansas Basin, and several municipalities who have utilized leases to fulfill well augmentation plans.
- **Lease to fix.** The ATM grant program has not studied the Lease to Fix concept, and there are few known examples of this type of transaction across the Western U.S. The Lease to Fix concept involves improving irrigation efficiency and/or operations, such that water is generated for permanent or long-term transfer without negatively impacting agricultural production. A prominent reason why this water transfer method is difficult to implement in Colorado is that water transfers are tied to the HCU portion of a water right, and not the water losses experienced in irrigation conveyance and application. Therefore, fixes to an irrigation system often do not yield HCU that can be transferred. Despite this hurdle, the Lease to Fix concept is still considered to be viable for certain situations in Colorado where irrigation improvements can lead to mutually beneficial water transfers between agricultural, environmental, and municipal partners.

Municipal selection process

Introduction

The application of ATMs in Colorado is burdened by a limited set of examples and a water court system that is slow, costly, and rigid when seeking changes of water rights. Despite these well-known obstacles, a greater obstacle to broader adoption of ATMs might be reluctance from municipalities. Most successful examples of ATMs in Western states originated from the demand side, with an entity seeking a particular type of flexible or unique water supply and willing to engage agricultural water users to fulfill such a need. The one known exception to this is the Super Ditch project in the Arkansas River Basin, in which the farming community has been the driving force behind the ATM effort. On the Colorado Front Range, it could be that municipalities, who represent the bulk of new water demands, are simply not interested in pursuing ATM water supplies. By their nature, ATMs provide a type of water supply that is often more complicated to develop and manage when compared to a new water supply reservoir or a permanently changed water right. Therefore, a fundamental question regarding ATMs on the Colorado Front Range remains: *Why should municipalities pursue ATMs?*

One aspect of answering this question is to compare ATMs with other water supply acquisition options. Comparisons should include water supply metrics (such as quantity, reliability, and certainty) as well as financial metrics. These types of comparisons are difficult to complete using generalized information, and therefore a component of this study was to select two municipal water providers as case studies to evaluate the viability of ATMs. This section of the report provides some background information on how the municipal partners were selected as case studies, and subsequent sections provide the analytical approach and results for each case study.

Data and analysis

The potential application of ATMs to a particular municipal water provider should consider both water supply and demand characteristics. On the water supply side, most ATMs require that agricultural water rights and uses are located in relatively close proximity to, or can be accessed and utilized by, the municipality. On the water demand side, a variety of factors should be considered. The municipality should be growing and in need of new water supplies, and should be in a position to utilize agricultural water rights. The following sections describe the data sources that were compiled and the analysis that was completed to evaluate the applicability of ATMs to Front Range municipalities.

Selection factors and data sources

The data sources listed in Table 5 (page 31) were compiled to represent water supply and demand conditions for the evaluation of ATMs for Front Range municipalities.

Analysis

The data sources listed in Table 5 were evaluated to prioritize municipalities in terms of the likely ability of ATMs to meet water demands. Each item in Table 5 was divided into three

TABLE 5

Data sources and selection factors for municipal selection

Category	Item	Data source(s)	Consideration
Demand-side data	Potable water deliveries	1	Represents the size of the municipal water system. Larger systems are considered to have more capacity to blend ATMs into existing water portfolios and have more resources to investigate and pursue ATM options. Smaller systems are considered to have less resources but potentially more direct need for ATMs due to limited water supply options.
	Raw water sources	1	Municipalities that do not currently source at least some of their raw water from irrigation water rights are likely limited in their future ability to do so.
	Number of ditches	1, 2	Represents the number of ditches in which the municipality has shares or ownership. A greater number of ditches provides more flexibility in evaluating ATM options.
	Treatment plant	1	The location and ownership of water treatment plants are important considerations. Treatment plants located upstream of or distant from irrigation water rights make ATMs more challenging. Municipalities that purchase treated water from other providers also make ATMs more challenging.
	Water purchase activity	2	Represents the growth in water demand, indicated by the volume of water right purchases completed by the municipality over the last 10 years.
	Water lease activity	2	Represents the comfort level or usefulness of temporary water supplies, indicated by the volume of water leased in the last 10 years, with the municipality as the lessee or off-taker
	New project participation	3	Represents the need for new water supplies, the need for short-term (bridge) water supplies, and the potential disinterest in pursuing ATMs for long-term water supplies
Supply-side data	Ditch service area	4	Ditches with small service areas likely provide more limited opportunities for ATMs, both in terms of ditch organization and volume of available water for transfer.
	Municipal ownership	1, 2	Represents the number of municipalities holding shares on a ditch. A greater number of municipalities could mean more competition for the ditch shares and also more flexibility in ATMs

Data sources: (1) Water conservation (efficiency) plans and other water supply planning documents available online, (2) Waterlitix water transactions database, (3) Project planning documents and websites, (4) GIS analysis using ditch service areas and irrigated acreage data from CDSS.

categories representing potential ATM suitability. The category division criteria and the results of the analysis are presented in Appendix C, which includes separate tables for supply-side and demand-side factors. Appendix D presents a set of maps showing candidate water districts and municipalities on the Front Range, colored by ATM applicability.

Selection results

The analysis described in the previous section was used to prioritize municipalities for potential selection as case studies. A total of 66 municipal water providers were initially identified on the Colorado Front Range. This total was reduced to 35 municipal water providers based on the following criteria:

- Owns shares (or water rights) in at least one irrigation ditch;
- Operates a water treatment plant (alone or in partnership) and/or does not purchase treated water from another entity as a sole source of supply; and
- Provides at least 1,000 AFY of water deliveries.

The list of 35 municipal water providers was further ranked based on supply-side factors, participation in regional water projects, among other factors. While not a definitive list, the following tiers (or groups) of municipalities were compiled to prioritize outreach efforts for the project. Municipalities are not listed in order of priority within each tier.

First Tier: City of Brighton, Centennial WSD, East Larimer County WD, Town of Erie, City of Evans, City of Fort Lupton, City of Fort Morgan, City of Fountain, City of Thornton, Town of Windsor

Second Tier: Fort Collins Utilities, City of Broomfield, Colorado Springs Utilities, Fort Collins-Loveland WD, Town of Frederick, City of Lafayette, City of Louisville, North Weld County WD, City of Westminster

Third Tier: City of Arvada, City of Aurora, City of Boulder, Town of Castle Rock, City of Greeley, Little Thompson WD, City of Longmont, City of Loveland, City of Northglenn, Pueblo Water Works, Security WD.

A total of 9 municipalities from the first two tiers (above) were contacted to assess their interest in participating as case studies for the project. Most of these municipalities were interested in the project, and the potential of ATMs, although willingness to act as a case study was more limited. Two case study participants were identified: City of Fountain and Town of Windsor.

Notable findings from selection process

In conducting research on municipal water demands and evaluating the potential interest in ATM concepts, several interesting themes emerged which are relevant to report for this study. The water supply geography of the Colorado Front Range places many neighboring municipalities in similar situations with regard to water supply needs and future options for supply acquisition. Related to this geographic theme, municipal interest in ATM concepts appears to be tied to whether or not there are other (non-ATM) water supply options. Finally, even if there are more traditional options being pursued, it is likely that some municipalities will need to pursue interim water supplies while longer-term projects are being developed.

Looking northeast towards Fort Collins, Colorado from the Horsetooth Reservoir Area.

Location differences

The Colorado Front Range can be divided into four geographic areas with similar water supply conditions and opportunities:

1. Northern Front Range/South Platte Tributaries

This area extends from Boulder and Erie on the southern boundary up to north Fort Collins and Wellington on the northern boundary. The Northern Front Range is characterized by a relatively robust water supply. Several major tributary rivers and creeks drain east out of the Rocky Mountains and provide a water source for large agricultural and municipal uses. Municipal uses have largely been built from the water supply projects of the Northern Colorado Water Conservancy District (Northern Water), which include the Colorado-Big Thompson (CBT) project and the Windy Gap projects. A large amount of irrigated agriculture is present in this area as well and a large number of irrigation ditches remain active.

2. North Metro Denver

This area extends from Boulder and Erie on the northern boundary south to Lakewood, downtown Denver, and Aurora as a southern boundary. The North Denver Metro area has been historically developed as Denver suburbs and industrial areas. Water supply sources providing for this growth have included irrigation ditch companies diverting from Clear Creek and large trans-basin water supply projects from the Western slope. Westminster, Thornton, and Northglenn have acquired large holdings of the Farmers Reservoir and Irrigation Company (FRICO) to fuel development. Most of the large water providers in this area have developed expansive and robust water supply portfolios.

3. South Metro Denver

This area extends from downtown Denver on the northern boundary to Woodmoor, Monument, and other northern Colorado Springs communities on the southern boundary. Historically, most of the municipalities in this area relied upon non-renewable Denver Basin groundwater supplies. More recently, municipalities have been working to transition to more renewable water supplies. The South Denver Metro area represents one of the most water-stressed areas of the Front Range, with limited renewable water supply options available and continuously growing demands. As a result, water infrastructure projects, such as Rueter-Hess Reservoir, Chatfield Reservoir reallocation, and the WISE Project, continue to be pursued.

The Rueter–Hess Reservoir sits behind the Frank Jaeger Dam near the Town of Parker, Colorado.

PATRICK MCKAY/WIKIMEDIA

4. Southern Front Range/Arkansas River Basin
The Southern Front Range area extends from the north suburbs of Colorado Springs south to Pueblo and surrounding communities along the Arkansas River. This area could be considered more rural than the other Front Range areas, with a relatively small number of municipalities outside of the two large cities of Colorado Springs and Pueblo. The Colorado Springs area is naturally water short, and municipalities have had to be active and creative to build sufficient water supply portfolios to meet demands. Much of the water supplied to the Colorado Springs area comes from the Arkansas River through various projects, including the recently constructed Southern Delivery System pipeline. In the Pueblo area along the Arkansas River, municipal water demands have been met from agricultural water right purchases and infrastructure projects.

The underlying water supply and demand forces that drive municipal interest in ATMs vary across these areas. The Northern Front Range represents a viable area to implement ATMs because there is an abundance of irrigation ditches and water rights and steady land development scattered across many small municipalities. This contrasts with the South Denver Metro area which is also experiencing growth but lacks the natural surface water features and nearby irrigation water uses that are found north of Denver. The South Denver Metro area likely has an interest in ATM type projects but ATM opportunities are considered more limited. The Southern Front Range has fewer communities, and at least historically most of the municipal water demands were focused in Pueblo and Colorado Springs. As evidenced by the Super Ditch project, the smaller communities in the Southern Front Range might represent one of the most likely places to implement ATMs because municipalities have very few water supply options and agricultural water rights remain present in the Arkansas Valley.

Risk tolerance

Municipal interest in ATMs is considered to be largely a function of risk tolerance. Both in Colorado and other Western states, municipalities have been more interested in discussing ATM water supplies when more traditional water development project supplies are not available and the municipality is forced to pursue water supplies that are perceived to be higher risk. This has been the case for Aurora, which engaged in temporary agricultural water leases during a severe drought but subsequently developed a complex and expensive dedicated water supply known as the Prairie Waters Project. Similarly, Southern Front Range communities have been lessees under the Super Ditch project because they have limited alternative water supplies. Another example is in the South Denver Metro area, where several municipalities have entered into a long-term lease agreement for water supplies under the WISE Project, because it represents a unique renewable water supply for the area. In the Northern Front Range, there has been a notable lack of temporary or short-term lease agreements for municipal supply, because the area is generally rich in water and agricultural water rights, although this situation might be changing. The ATM examples for Fort Collins Utilities show a desire to supplement core water supplies, but not necessarily support the development of new water taps. From this perspective of risk, ATM water supplies are considered a second or third tier water supply option. Therefore, a municipality's likely level of interest in ATMs can be best characterized by understanding the water supply options available to it.

Bridge water supplies

Several municipalities in the Northern Front Range have historically been reliant on the CBT project, and have simply acquired additional CBT units to meet growing municipal water demands. These same municipalities are also participants in the planned Northern Integrated Supply Project (NISP) and/or the Windy Gap Firming Project, both of which are being developed by Northern Water as a future source of municipal water supply in the Northern Front Range. Assuming that these planned projects are constructed, there remains a need for Northern Front

Range municipalities to explore ATM concepts, at least in the short-term. At the current rate at which CBT units are being purchased for M&I uses, and considering how many CBT units remain in agriculture as small-holdings available for sale, there is a general expectation that the ability to acquire new CBT units will erode in the next 5–7 years. This would remove the water supply growth option on which many Northern Front Range municipalities have relied. The estimated completion date for the Windy Gap Firming Project is 2021 and for NISP is 2030. This leaves several municipalities with a 7 to10 year window during which project water supplies will not be available to meet new demands, and these municipalities will need to consider "bridge" supplies. Several ATM concepts could be pursued to provide these bridge water supplies, and therefore Northern Front Range communities should be good candidates to explore ATMs, at least on a short-term basis.

Analytical framework

Water supply and demand balance

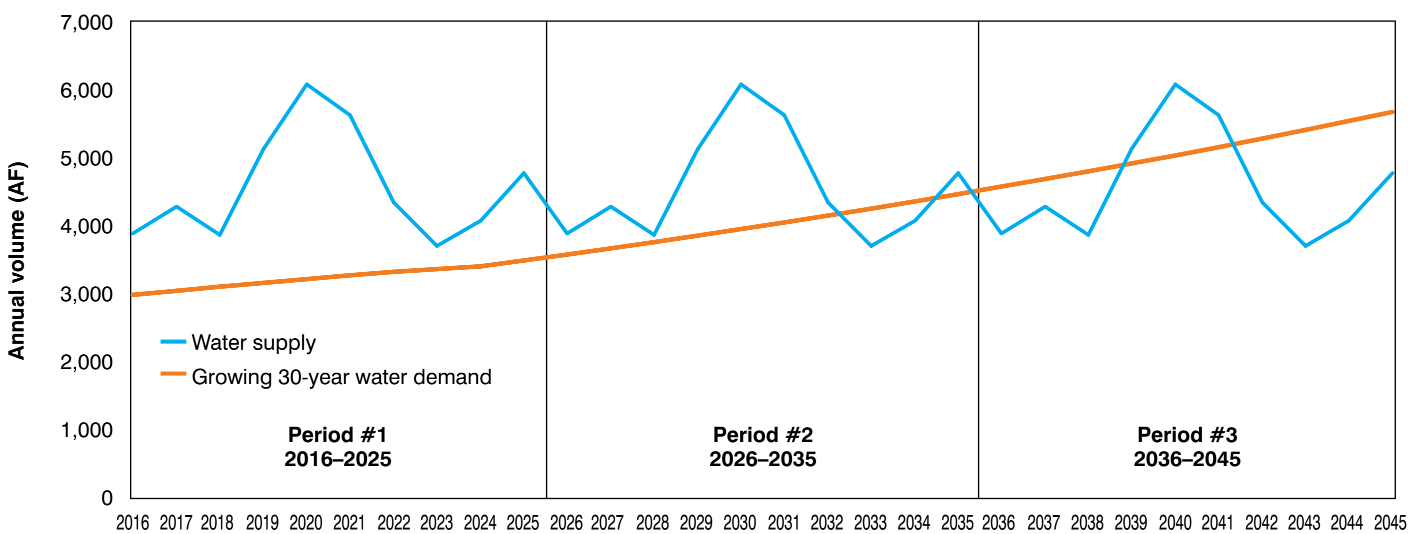
The case study analysis of municipal water supply options, and the viability of ATMs, begins with identifying the water supply needs of the municipality. The need for additional water supplies can take many forms, depending on the existing water supply portfolio, projected growth, and other factors. Our case studies are built around an analysis of water supply and demand specific to a municipality, to quantify and characterize the types of water shortages that the municipality may experience. In this analysis, a water supply and demand balance was developed at a monthly time-step over multiple years, to identify drought periods and seasonal shifts in water supply and demand.

Water supply fluctuations are an important aspect of water supply planning, particularly when evaluating the types of intermittent water leases that are inherent in many ATM concepts. Most municipalities make water acquisition decisions based on the predicted water supplies in a drought period. Additional "safety factors" might also be considered to insure against water shortages. To respond to unforeseen and/or short-term drought situations, municipalities often have a drought management plan which restricts water uses by customers under tiers that relate to different levels of available water supply.

Various methods are often employed to simulate natural water supply fluctuations in water supply planning. For this study, a simple approach was applied by considering the water supply conditions from the past 30 years (1986–2015). Over this 30-year historical period, the municipal

FIGURE 2

Illustration of water supply and demand balance



Below-averagewater supply repeats every10 years. Shortages occur when demand exceeds supply.

water supply was modeled based on current water rights ownership. A 10-year period was selected as providing the lowest water supply based on a 10-year running average. For future conditions, this 10-year historical period was then repeated in three successive blocks to create a 30-year future projection (2016–2045). This simple approach preserves historical variability while also identifying shortages (and water acquisition targets) based on below-average water supply conditions. Future water demands were then estimated over a 30-year period based on population projections and per-capita water use rates. Over the future period, shortages result from a combination of dry-year water supplies and a growing municipal water demand. This approach is illustrated in Figure 2 (page 37).

The shortage analysis feeds directly into an analysis of the water supply options, including ATM water supplies, available to alleviate such shortages. As shown in Table 1 (page ##), different ATMs provide different types of water supplies to address shortages. Some ATM frameworks are more applicable to meeting intermittent water supply needs, such as dry-year shortages, while others can potentially provide consistent, firm water supplies each year.

Water source alternatives

For this analysis, water source alternatives are developed to address the specific shortages identified for each case study. The intent is to make useful comparisons between water source alternatives that fulfill a similar purpose for the municipality. The analysis includes both traditional water sources, such as changed agricultural water rights and reservoir projects, and ATM water sources.

For this study, not all ATM frameworks were evaluated. Several agricultural supply methods and water transfer methods which make up ATMs are not relevant to the two municipal case studies or would be overly complex to evaluate, requiring more assumptions than factual information. For the case study analyses, the ATMs shown in Table 6 (page 38) were selected as relevant and applicable to the municipal case studies, and were evaluated as ATM water sources.

Financial analysis framework

A financial analysis for each case study was completed to compare the costs of alternative water sources (both traditional and ATM varieties) to address identified water shortages. The financial analysis contains the following assumptions:

- A 30-year planning horizon (2016-2045) that includes all major costs associated with a particular water source. Costs included the following:
  - Acquisition costs for buying permanent water supplies;
  - Transfer costs associated with successfully changing the necessary elements of a water right through either water court or State Engineer administrative processes;
  - Annual costs associated with owning and/or operating a water supply;
  - Annual costs for leasing temporary water supplies, which, depending on the source alternative, may include fixed payments to hold an option and variable payments when the option is exercised;
  - Capital costs associated with infrastructure to ensure a similar reliability and applicability between water source alternatives.
- Cost items were escalated annually over the 30-year planning period, based on relevant historical cost or price trend data.

- All future annual costs were discounted to a present value using a discount rate of 4% which is intended to reflect the time value of money for the municipalities based on municipal bond interest rates.[50]

- Future capital and permanent acquisition costs were scheduled to occur in the middle (5th year) of each 10-year period for meeting any permanent supply acquisition needs during that 10-year period.[51] This was done to minimize the effect on the net present value calculation of the year in which a shortage was modeled to occur under the assumed 10-year hydrology.

TABLE 6

Selection of ATM frameworks for case studies

Category	Inclusion	Name	Comments
Agricultural water supply methods	Considered in case study analysis	Full season fallow	This is a commonly applied concept, both in Colorado and other Western states
		Rotational fallow	This is a commonly applied concept, both in Colorado and other Western states
		Regulated deficit irrigation	This concept has been the subject of ATM grant research, and can be evaluated with available cropping information.
	Not considered	Crop switching	Crop switching is a relatively untested and unutilized ATM concept, and it is not considered to be easily implemented within Colorado water laws and policies.
		Split season fallow	The case studies did not show a consistent need for new water supplies during a part of the irrigation season.
		Infrastructure	Infrastructure improvements would require more extensive engineering analysis for both the municipal entity and the surrounding irrigation districts or ditch companies.
Water transfer methods	Considered in case study analysis	Buy and supply	This concept has received recent attention along the Front Range as part of county land conservation and open space programs.
		IWSA/option contract	This is a commonly applied concept, both in Colorado and other Western states
		Purchase/lease	This is a simple and common type of transfer method
	Not considered	Lease to fix	This concept requires detailed information on the water use conditions of the irrigation district or ditch company.
		Regional water bank	Water banks can take on a variety of forms, and involve a range of administrative requirements and costs. Water banks do not exist along the Colorado Front Range, and therefore there is uncertainty regarding how such a bank would function. Water banks are represented by short-term lease agreements, typically with reduced administrative costs.
		Public water bank	The concept of a public water bank has many unknown elements that are beyond the scope of this study.

ATM = Agricultural water supply method + Water transfer method

- When the acquisition of permanent water supplies to meet future shortages resulted in surplus water supplies under normal to wet years, excess supplies held by the municipality were assumed to not be leased to outside entities.[52]
- The number of future years (or period) in the analysis is an important consideration when comparing different water supply alternatives. Figures 3 and 4 provide an illustration of how changes in rates and period of analysis can impact the costs of water leases as compared to upfront purchases.[53]
  - As the annual escalation in lease rates increases, leasing water supplies becomes more expensive in the long-term and the number of years to reach a break-even cost with an

FIGURE 3

Effect of lease rate escalation on comparable costs

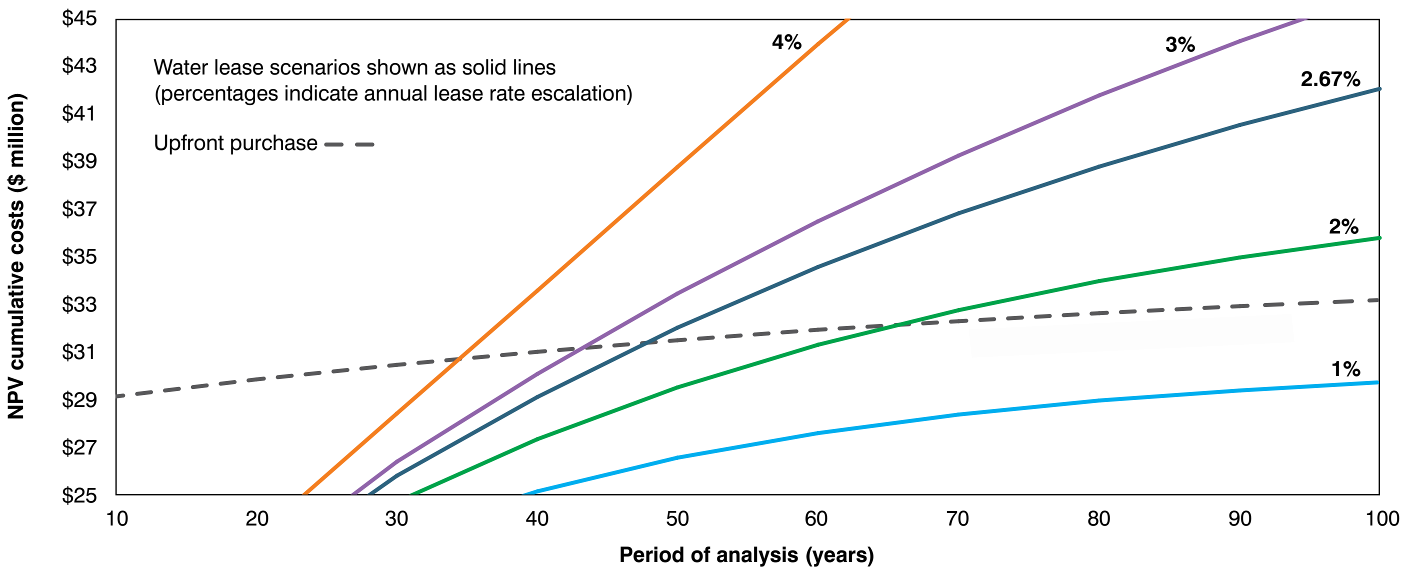
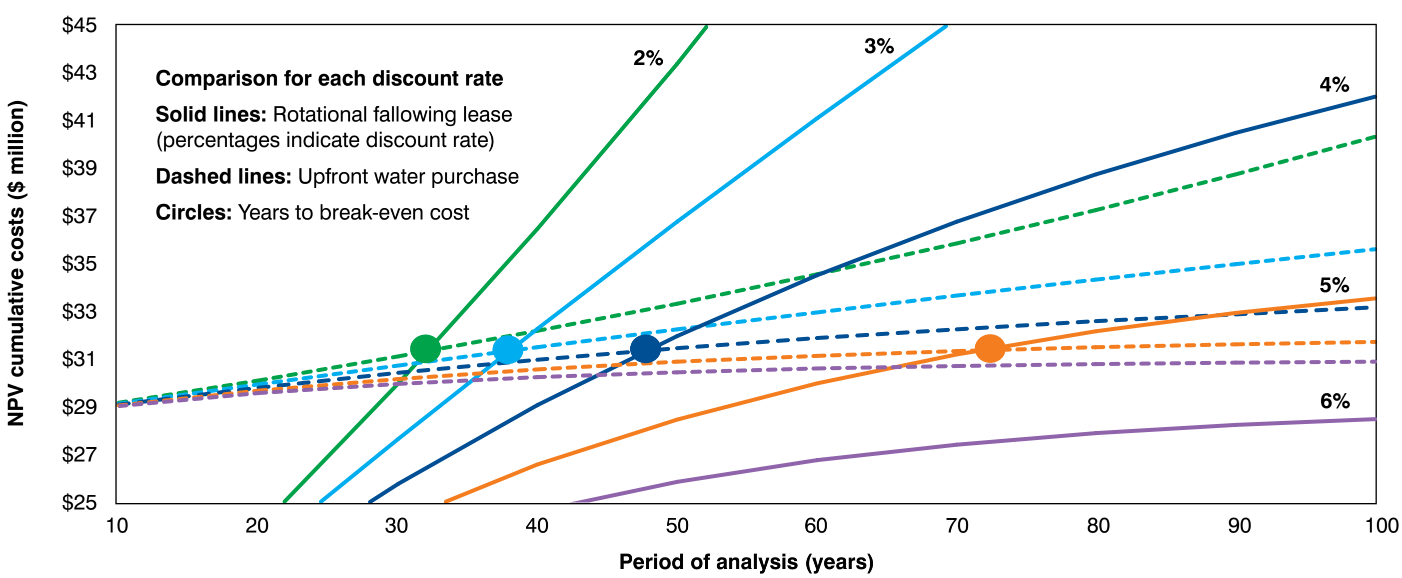


FIGURE 4

Effect of discount rate on comparable costs



upfront water purchase decreases. The opposite is also true, with water leasing becoming less expensive in the long-term as the annual escalation in lease rates decreases.

- As the discount rate increases, leasing water supplies becomes less expensive relative to an upfront water purchase, and the number of years to reach a break-even cost increases. The opposite is also true, with a lower discount rate encouraging an upfront water rights purchase.

- For this analysis, the selected analysis period of 30 years does not capture the long-term costs of each water supply alternative, particularly alternatives with high annual costs. To address this issue, an equivalent annual cost (EAC) was calculated for each water supply alternative, using the following formulas:[54]

$$NPV_{30Y} = \sum_{30} \frac{TotalCost_n}{(1 + R_{Discount})^n}$$

$$Cost_{Terminal} = \frac{AnnualCost_{Avg10}}{R_{Discount} - R_{Escalation}}$$

$$NPV_{Terminal} = \frac{Cost_{Terminal}}{(1 + R_{Discount})^{31}}$$

$$EAC = (NPV_{30Y} + NPV_{Terminal})\, R_{Discount}$$

Where:
NPV_{30Y} : Net Present Value of Total Costs over a 30-year Period
n : Select Year of the 30-Year Analysis
$R_{Discount}$: Discount Rate
$Cost_{Terminal}$: Terminal Cost, or the Indefinite Cost after Year 30 of Future Annual Costs

$AnnualCost_{Avg10}$: Average of Annual Costs for Last 10-Year Period (2036–2045)
$R_{Escalation}$: Annual Escalation Rate for Annual Costs
$NPV_{Terminal}$: Net Present Value of Terminal Cost
EAC: Equivalent Annual Cost ($/year)

More specific details on the cost assumptions and inputs included in the financial analysis of each case study are provided in Appendices F and H.

CASE STUDY 1

Town of Windsor

Introduction

The Town of Windsor is located along the northern Front Range, east of Interstate 25 between the cities of Greeley to the south and Fort Collins to the northwest. Windsor has experienced rapid growth over the last two decades, with its population tripling from 1995 to 2014. Figure 5 provides a graphic of annual population for Windsor.[55] Windsor experienced a very high growth rate from 1994 to 2008, averaging an increase of 8.2% per year. Annual growth during the last several years has been close to 3.3%, on average.

Considering its size and past growth, Windsor is representative of many northern FrontRange municipalities, particularly those located along the Interstate 25 corridor between North Denver and Fort Collins. In terms of water supply planning, Windsor is also a good representation of the northern Front Range region, for the following reasons:

- It is located in close proximity to many irrigation ditches, which include both small ditch systems and large, complex systems serving tens of thousands of acres;
- It is closely tied to the water projects of the Northern Colorado Water Conservancy District (Northern Water), including the existing Colorado-Big Thompson (CBT) Project and the planned Northern Integrated Supply Project (NISP).

The Town of Windsor has completed several relevant water planning studies in the past few years that provided some of the baseline information for the analysis.

FIGURE 5

Windsor population growth 1980–2014

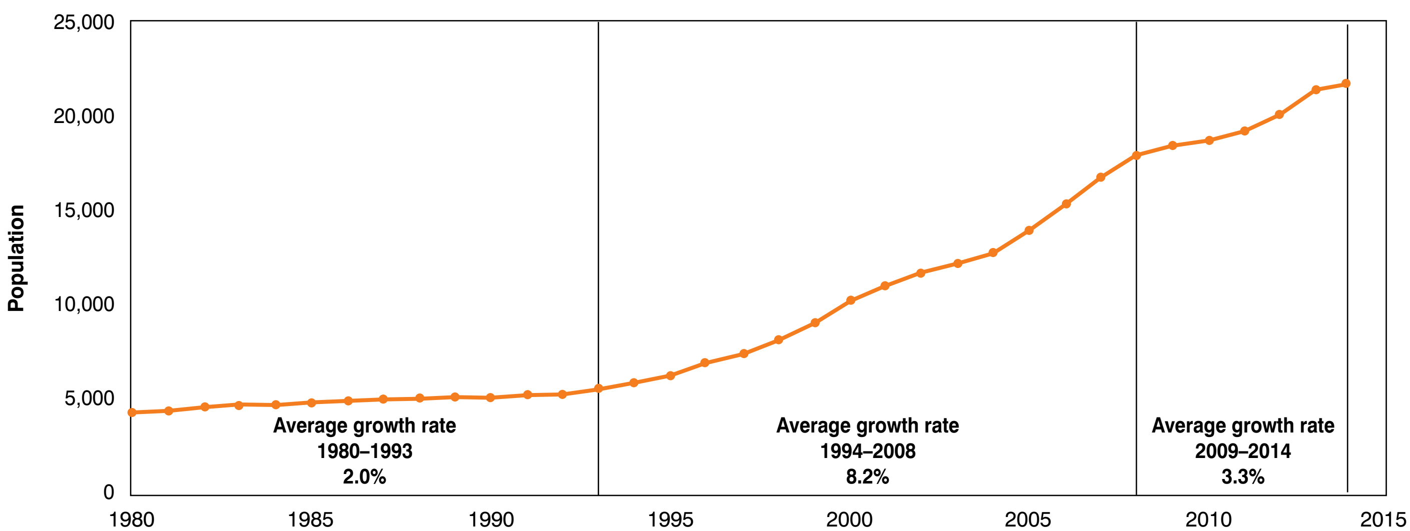
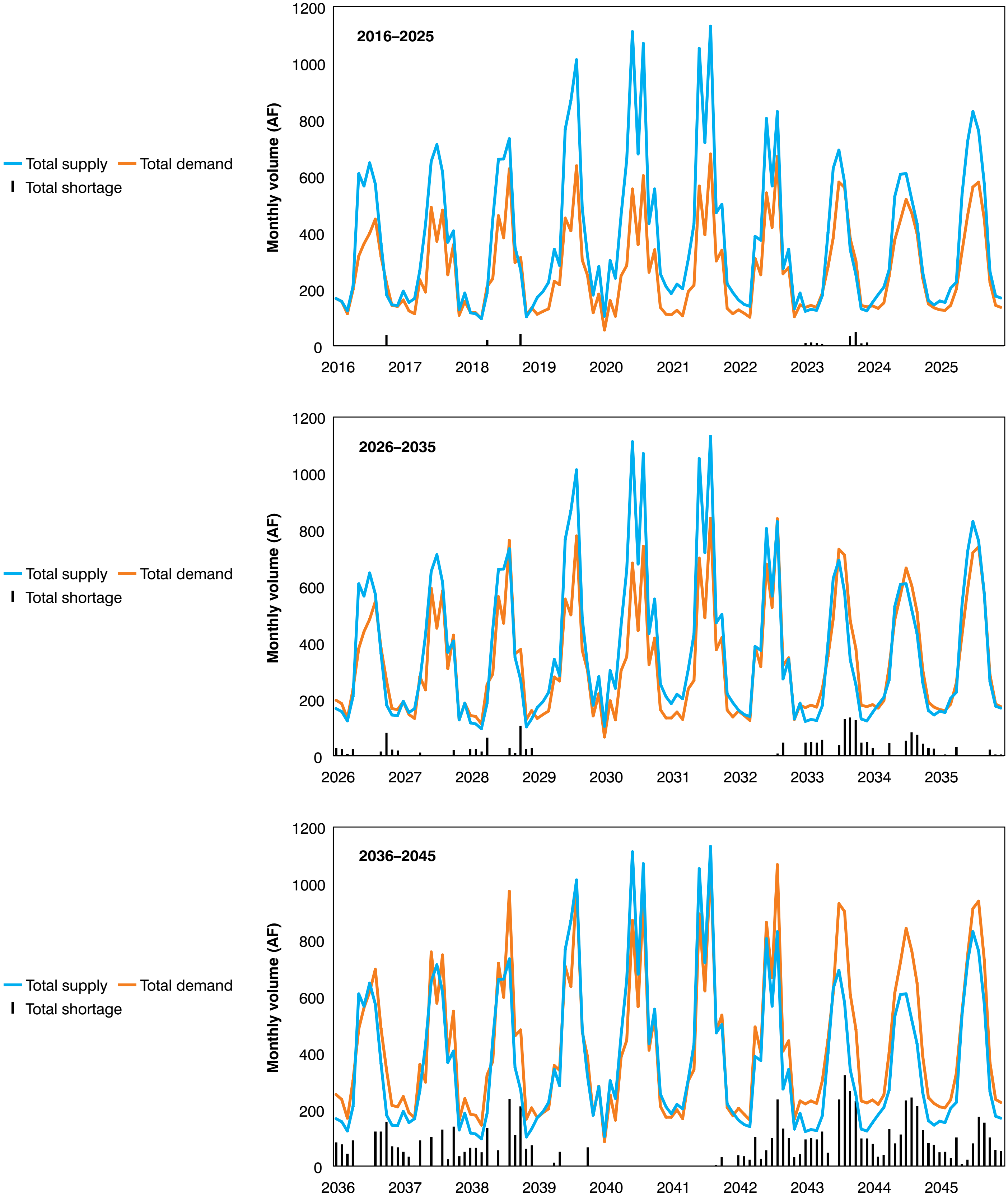


FIGURE 6

Windsor monthly water shortage estimates



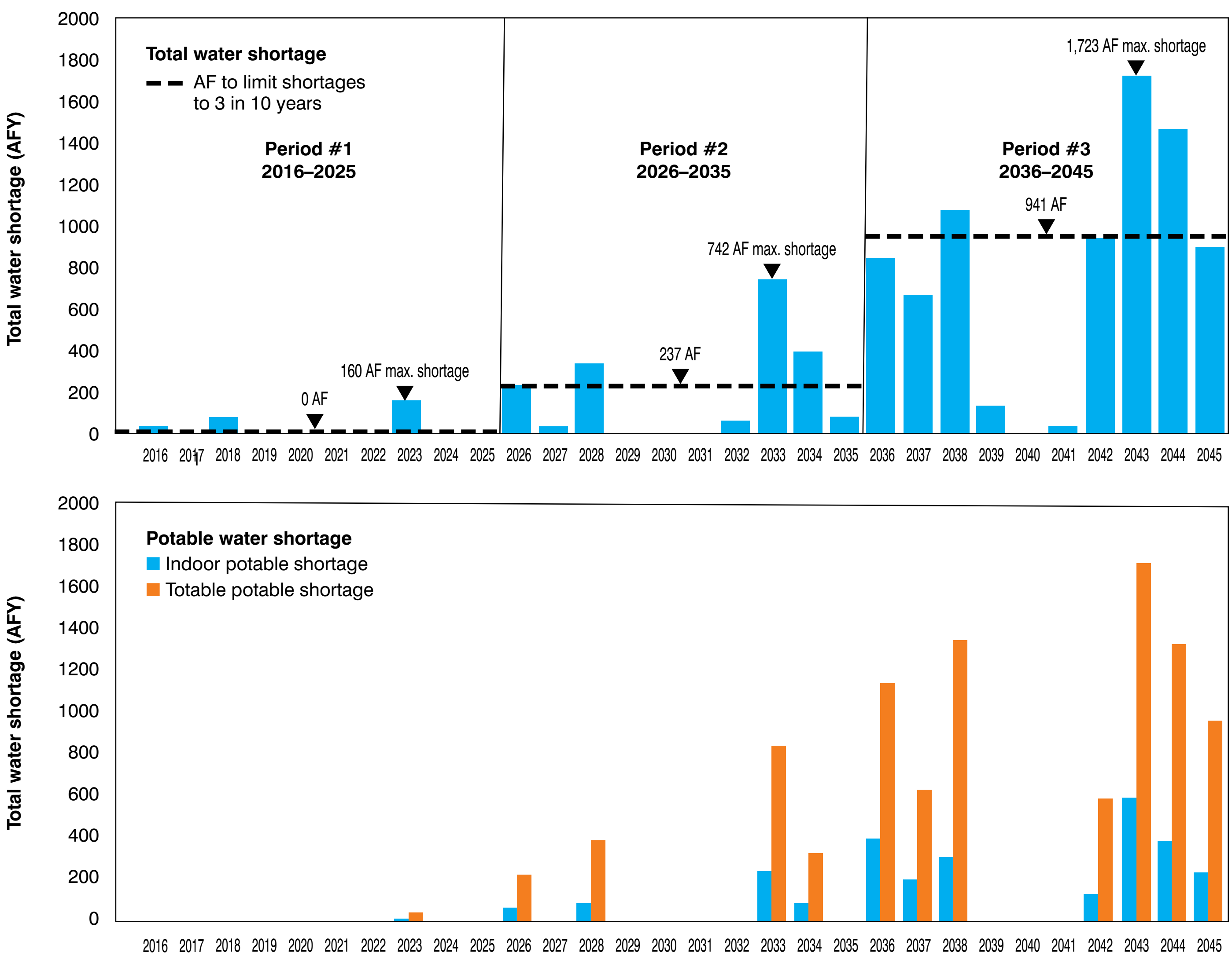
Unless otherwise noted, information for this case study was obtained from the following reports:[56]

- 2009 Potable Water Master Plan
- 2010 Non-Potable Water Master Plan
- 2015 Municipal Water Efficiency Plan Update

Water shortages were calculated by comparing future water supply and demand estimates on a monthly time step, as described in detail in Appendix E. Figure 6 (page 42) provides a summary of total monthly water supply, demand, and shortage data over the 30-year projection period. Figure 7 shows annual shortage data, divided by type of demand. Total shortages reflect the data in Figure 6, and compare total water supplies against total water demands. The other graph in Figure 7 divides shortages into potable and non-potable types, by comparing water supplies and demands specific to each type. For this study, total shortages were used to quantify water supply acquisition needs for Windsor. The maximum annual shortage was estimated as 1,723 AF.

FIGURE 7

Windsor annual water shortage estimates



The shortage graphs indicate the following water supply needs for Windsor in each of three 10-year future periods:

- **2016–2025:** No permanent water supply acquisitions were found to be necessary. Temporary water supplies are necessary to cover 3 years of drought. The maximum shortage during this period was 160 AFY, and therefore 160 AFY of temporary water supply is needed.
- **2026–2035:** Permanent water supply acquisitions of 237 AFY to address increase in demands, estimated as the volume necessary to reduce remaining shortages to no more than 3 years out of the 10-year period. An additional volume of temporary water supplies to cover 3 years of drought. The additional temporary water supply was estimated as 505 AFY.
- **2036–2045:** Permanent water supply acquisitions of 704 AFY to address increase in demands, estimated as the volume necessary to reduce remaining shortages to no more than 3 years out of the 10-year period. An additional volume of temporary water supplies to cover 3 years of drought. The additional temporary water supply was estimated as 782 AFY.

Alternative water sources

Projections of future water shortages were made to identify the types and timing of future water supply needs of Windsor. For this study, both traditional and ATM water supply sources were evaluated to meet the various types of shortage identified. Windsor currently requires that potable water sources be conveyed to the Soldier Canyon water treatment plant near Horsetooth Reservoir. Non-potable water sources can be more localized to Windsor, with ditches serving parks and outdoor water uses in housing subdivisions. Based on the shortage modeling, Figure 5 provides a summary of anticipated water acquisitions required by Windsor. Water sources to meet these acquisition needs are summarized in Table 7 (page 45), and described below.

Alternative 1: CBT and NISP

This alternative closely matches a status quo scenario for Windsor, based on its historical water acquisitions and its current investments in the Northern Integrated Supply Project (NISP). The

Horsetooth Reservoir, part of the Colorado-Big Thompson Project, is located in Larimer County in northern Colorado.

KEN GALLAGER/WIKIMEDIA

TABLE 7

Summary of Windsor water source alternatives

No.	Alternative name	Type	Permanent water acquisition Period #1 (2016–2025)	Permanent water acquisition Period #2 (2026–2035)	Permanent water acquisition Period #3 (2036–2045)	Leased water supplies Period #1 (2016–2025)	Leased water supplies Period #2 (2026–2035)	Leased water supplies Period #3 (2036–2045)	Capital infrastructure costs	Other
1	CBT and NISP	Traditional	Buy 340 AF of CBT units	Buy 1,383 AF of yield in NISP	—	—	—	—	—	—
2A	Upfront Purchase of Poudre River Rights	Traditional	Buy 1,723 AF of ditch rights			-			Gravel pit storage	-
2B	Incremental Purchase of Poudre River Rights	Traditional	Buy 160 AF of ditch rights	Buy 582 AF of ditch rights	Buy 981 AF of ditch rights				Gravel pit storage	-
2C	Purchase and Lease Poudre River Rights	ATM	-	Buy 237 AF of ditch rights	Buy 704 AF of ditch rights	Option lease of 160 AF of ditch rights	Option Lease of 505 AF of ditch rights	Option Lease of 782 AF of ditch rights	Gravel pit storage	
3	Rotational Fallowing with Poudre River Rights	ATM	-			Option Lease of 160 AF of ditch rights	Fixed lease of 237 AF of ditch rights, and option lease of 505 AF of ditch rights.	Fixed lease of 941 AF of ditch rights, and option lease of 782 AF of ditch rights	Gravel pit storage	
4	Buy and Supply	ATM	Buy 114 acres of irrigated farmland	Buy 416 acres of irrigated farmland	Buy 701 acres of irrigated farmland				Gravel pit storage	Farm lease revenue
5	Groundwater Wells	Mixed	Develop 160 AF well capacity	Develop 582 AF well capacity	Develop 981 AF well capacity	Fixed lease of 160 AF for augmentation	Fixed Lease of 742 AF for augmentation	Fixed Lease of 1,723 for augmentation	Gravel pit storage	

following paragraphs describe how the CBT and NISP supplies were integrated into Windsor's water supply portfolio over a 30-year future.

- **CBT units.** In recent history, most of the municipalities along the northern Front Range have met all or most of their water supply needs by acquiring CBT units. The result has been a steady change in CBT ownership, with about 70% of all 310,000 units currently owned by municipal water providers, homeowner's associations, and industrial water users, all of which are users who are unlikely to sell CBT units. The remaining 93,000 units of CBT that are currently in agricultural use can be divided into individual owners and irrigation companies. While a complete inventory of ownership has not been found, it is estimated that approximately 10,000 to 15,000 units are individually owned outside of irrigation ditch companies. In recent years, roughly 1,200 units have been traded annually. At this rate of transfer, small blocks of CBT units under individual ownership will be available for another 8 to 12 years. At this future point in time, only larger blocks owned collectively by irrigation ditch companies will remain, and these units are expected to be more difficult to acquire due to varied ownership interests. Another limiting factor is that Northern Water limits CBT acquisitions to ensure that CBT water sources remain a supplemental water supply for municipalities.[57] For most municipalities, this means that new developments (demands) can acquire CBT units and donate them to the municipality, but the municipality cannot purchase CBT units in anticipation of future demand growth. For this analysis, it was assumed that Windsor would continue to acquire CBT units into its water rights portfolio through 2025, at which point it was assumed that CBT unit acquisition would no longer take place. A total of 340 AF of new CBT water supplies were ssumed to be permanently acquired in the year 2020 (the midpoint year of the first 10-year planning block), to cover all modeled shortages until NISP comes online in 2030.

- **NISP.** The Northern Integrated Supply Project (NISP) has been stalled in the Federal permitting process since 2004. A Supplemental Draft Environmental Impact Statement (EIS) was released in 2015, and current schedules indicate a Final EIS in 2017 and a Record of Decision in 2018. Based upon previous timelines, NISP is not likely to provide water to its participants until 2030.[58] Any legal challenges or significant design changes would likely delay this date even further.[59,60] Windsor is currently participating in NISP at a water supply yield level of 3,300 AFY, or 8.25% of the planned 40,000 AFY project yield. For this analysis, information from the Final EIS (and supporting technical memorandums) was used to simulate the annual water deliveries from NISP.[61] Windsor's potential annual water deliveries from NISP were estimated to range from 1,177 to 7,950 AFY, with an annual average of 3,456 AFY. The planned yield of NISP for Windsor exceeds the modeled shortages over the 30-year future period, and therefore unit (per acre-foot) costs were applied to ensure that the results were comparable with other water supply alternatives. The total volume of NISP deliveries was estimated to be 1,383 AF (calculated as 1,723 AF of maximum shortage minus 340 AF of CBT units acquired). NISP was assumed to come online as a water source in the year 2030, but Windsor's debt payments for NISP were assumed to start in 2016 to match the bond term with the 30-year modeling period.

Alternative 2: Poudre River water rights purchases and leases

There are various demands in Windsor that could be met by purchasing Poudre River ditch company shares. For non-potable water demands, the purchase and transfer of rights associated with those ditches that are located within and near Windsor's developments could be used to meet outdoor water demands. Any purchase and transfer of Poudre River ditch shares would involve a change application in water court. The water right transfer process would be relatively straight-forward for non-potable uses as the water rights would continue to be used for irrigation uses near their historic places of use and served via the same ditch system. For potable water demands, a couple of options exist. First, Windsor could purchase Poudre River ditch company shares and exchange the associated water rights upstream into the Poudre River canyon so that they can be diverted into the Pleasant Valley Pipeline and conveyed to the Soldier Canyon treatment plant. For this study, it is assumed that the exchange capacity on the Poudre River is relatively good, although this is an important factor to analyze. Second, Windsor could purchase Poudre River ditch company shares and then convey those water rights to a new regional water treatment plant located closer to Windsor. Windsor would likely have a pro-rata share in the ownership and capacity of the regional water treatment plant.

To ensure that Poudre River ditch share acquisitions provide a similar level of water supply reliability compared to other water source alternatives, ditch share acquisitions were priced at a level that represents ditch companies that have both direct flow and storage water rights. Three different scenarios or options were modeled under this alternative:

- **Alt. 2A, upfront purchase:** Windsor purchases sufficient Poudre River irrigation water rights in the first year (2016) to meet the maximum annual shortage within the 30-year period. A total of 1,723 AFY would be acquired in 2016 through permanent sales.

- **Alt 2B, incremental purchases:** Windsor purchases Poudre River water rights in 10-year increments, based on the maximum annual volume of shortage within each of three 10-year planning blocks. The intermittent purchases total 1,723 AF, divided as follows: 160 AF in 2020, 582 AF in 2030, and 981 AF in 2040.
- **Alt 2C, purchase and lease:** Windsor purchases a sufficient volume of Poudre River water rights in 10-year increments such that remaining shortages occur in no more than 3 out of 10 years (as described previously). Under this scenario, permanent water right acquisitions totaled 941 AF. The remaining shortages were met through interruptible water supply agreements (IWSA), or option contracts. Each IWSA was modeled around a 10-year period, with the option price (10%) paid each year on the maximum volume of shortage within each 10-year period and the lease rate (or strike price) paid in years when a shortage was modeled.

Alternative 3: Rotational fallowing agreements

Instead of permanently acquiring Poudre River water rights, Windsor could engage in water supply agreements with one or more local ditch companies to provide both permanent and temporary water supplies under rotational fallowing agreements. This alternative was modeled similar to Alternative 2C described above. A rotational fallowing agreement was modeled as providing two supplies: (1) a firm annual water supply for Windsor under a fixed volume (take or pay) contract, and (2) an intermittent water supply for Windsor under an IWSA. Under the fixed volume contract, the permanent water supply needs (shortages) for Windsor were leased such that shortages were reduced to 3 years in each 10-year period. Under the IWSA component, the remaining shortages were leased when they occurred and a fixed option payment (10%) was paid each year on the maximum delivery within each 10-year period.

Under this alternative, Windsor would enter into an agreement with shareholders of one or more Poudre River ditch companies, and those shareholders would rotate which farmlands were fallowed to provide both a fixed and variable water supply volume to Windsor each year. The participating ditch company would have to be of sufficient size to ensure that the fallowed lands represent a fairly small fraction of the overall irrigated area, such that ditch operations would not be grossly affected by the program. For this analysis, it was assumed that the fallowed land could not exceed 10% of the total irrigated lands within an irrigation ditch company. Based on the ditch company tabulation in Appendix E, the following ditch companies would be viable options for a rotational fallowing agreement: New Cache, North Poudre Irrigation Co., Water Supply & Storage Co., and Larimer & Weld Canal.

Alternative 4: Buy farmland to supply water

Another alternative to the permanent acquisition of irrigation water rights is the concept of "buy and supply." In this alternative, Windsor would purchase sufficient irrigated farmland to provide a transferrable water supply to meet estimated shortages. The water rights appurtenant to the farmland would undergo a water court change of use process, and then be available as an "on call" water supply to meet annual shortages. As with other Poudre River ditch sources, it was assumed that the irrigation water rights appurtenant to the purchased farmland could be exchanged upstream and delivered into Windsor's system. As with other alternatives, farmland purchases were divided into three blocks over the 30-year modeling period. In each 10-year block, the acreage of irrigation farmland to be purchased was calculated as the maximum estimated shortage within the 10-year period, divided by an average crop consumptive use of 1.4 AFY per acre (see Appendix F). For this analysis, the farmland purchase was divided into two pieces, dryland farms and irrigation water rights, to handle variability in water rights pricing. The water rights were priced to be reliable supplies (direct flow and storage) from the Poudre River, and a water court change in use (to provide both municipal and irrigation uses) was included as part of the acquisition costs. In the 30-year period, a total of 1,723 AF of water rights were modeled as acquired, associated with farmland purchases of 1,230 acres. Based on the underlying assumptions, water would be available for full or partial irrigation on the purchased farmland in 90% of the modeled years, and Windsor would receive farm rent payments as a source of revenue to offset the investment cost.

Alternative 5: Groundwater wells

Windsor could expand upon its current use of alluvial groundwater by adding new wells. Windsor currently operates 12 wells, with depths ranging from 26 to 40 feet and pumping capacities ranging from 100 to 600 gallons per minute (gpm).[62] Existing wells have augmentation plans to mitigate impacts from out of priority pumping, and any new well would require a similar augmentation plan to operate. Wells were developed to provide an additional 1,723 AF of water supply for Windsor, which would mean an additional 36 wells developed over the next 30 years. Well development was divided into three periods, corresponding with the three, 10-year modeling periods. Wells were assumed to be augmented by leasing Poudre River irrigation water rights under a fixed (take or pay) contract for the maximum estimated shortage in each 10-year period. Gravel pit storage was also included in this alternative to allow leased water supplies to be retimed, and provide greater reliability of the well supplies. The wells were assumed to require more advanced water treatment compared with other surface water source alternatives, based on previous pilot studies completed in Windsor. Approximate additional costs associated reverse-osmosis treatment were incorporated into the analysis.

TABLE 8

Estimated cost inputs for Windsor alternative water sources

Source	Subcategory	Term	2016 acquisition cost ($/AF)	Annual appreciation	2016 transfer cost ($/AF)	2016 annual cost ($/AF)
CBT units	—	Purchase	$36,700	5%	$260	$60
Poudre Ditch shares	NPIC	Purchase	$27,300	5%	$5,000	$75
	WSSC	Purchase	$8,500	5%		$45
	New cache	Purchase	$5,000	5%		$50
	Average direct flow rights	Purchase	$5,100	5%		$50
	Average direct and storage rights	Purchase	$7,700	5%		$50
	Crop based	Lease	-	2.67%	$1,000	$474
Farmland	Dry farmland	Purchase	$3,000 per acre	5%		$67
	Irrigated farmland*	Purchase	$14,550 per acre	—	—	—
	Irrigated farmland	Lease	—	2.67%	—	$91 per acre
New groundwater wells	Wells	Purchase	$850	3%	—	$110
	Advanced treatment	—	—	3%	—	$400
	Augmentation	Lease	—	2.67%	$1,000	$130
Gravel pit storage	—	Purchase	$7,400	3%	—	—
Northern Integrated Supply Project	Fixed cost	Purchase	$11,891	3%	—	$63
	Variable cost	Annual	—	3%	—	$78

*Irrigated farmland acquisition cost shown in the table is calculated based on the dry farmland cost ($ per acre) plus the average direct flow and storage water right costs ($ per AF) multiplied by a transferrable consumptive use of 1.5 AF per acre. This irrigated farmland acquisition cost is provided for illustration only, and the analysis utilized the separate dryland and water right costs.

Cost inputs

The financial analysis is intended to make monetary comparisons between the various alternative water sources defined in the previous section. The costs attributed to each source were intended to provide a reasonably similar water supply for Windsor, in terms of reliability and applicability to Windsor's current water system. For any of the alternative water sources, there may be additional costs associated with using the water supply that would emerge under a more detailed analysis.

Many of the alternative water sources are based upon similar water sources and water rights, and therefore costs, with variations in how the water is transferred to the Town of Windsor. Cost inputs to the financial analysis are summarized in Table 8 (page 48). Appendix F provides details on the development of each of these cost inputs.

Financial analysis

The financial analysis is intended to make monetary comparisons between the various alternative water sources defined in the previous section. The assumptions included in the financial analysis are defined under the Analytical Framework section of this report.

Equivalent annual cost comparison

Figure 8 and Table 9 (page 50) provide a comparison of equivalent annual costs for each of the water supply alternatives. A mix of water right purchases and leases from the Poudre River (Alt. 2C) was estimated to have the lowest annual cost, at $1.0M. More traditional water supply acquisitions, such as NISP or the purchase of Poudre River ditch shares, were estimated to have slightly higher annual costs, ranging from about $1.3M to $1.4M. The buy and supply alternative had annual costs of $1.4M, making it more expensive than comparable water right purchases on the Poudre River. Rotational fallowing was found to have higher annual costs of about $1.5M, which is influenced by the large terminal cost of continued water leasing inherent in this alternative. Groundwater wells were estimated to have the highest annual cost at $1.7M, which reflects the high annual cost of advanced treatment and augmentation. On a unit basis, equivalent annual costs vary from about $590 to $1,000 per AFY, based on a maximum acquisition of 1,723 AFY.

FIGURE 8

Comparison of equivalent annual costs for Windsor alternatives

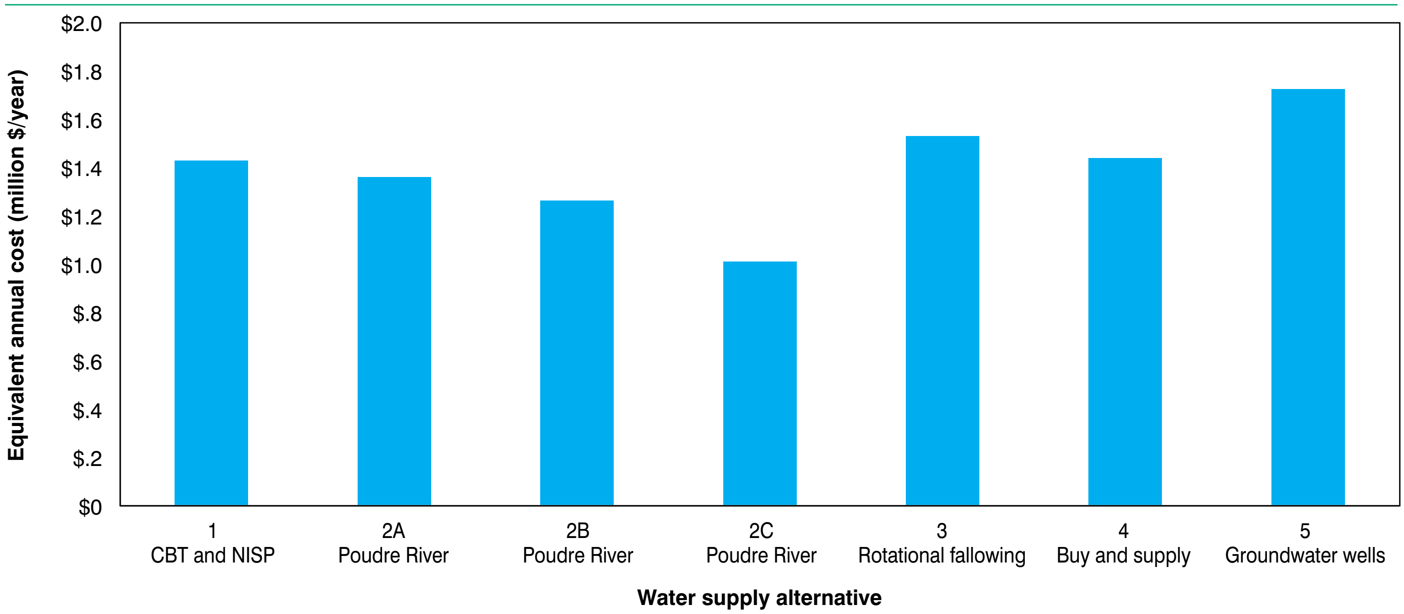


TABLE 9
Summary of costs for Windsor alternatives

Alternative	Name	Net present value 30-year costs: Capital	Annual	Total	Equivalent annual cost	Unit annual cost ($/AFY)
1	CBT and NISP	$26,359,135	$2,222,594	$28,581,729	$1,431,212	$831
2A	Poudre River, buy in 2016	$27,164,613	$2,074,392	$29,239,005	$1,363,218	$791
2B	Poudre River, buy in blocks	$26,944,649	$703,447	$27,648,096	$1,266,193	$735
2C	Poudre River, buy and lease	$17,125,037	$1,591,080	$18,716,117	$1,012,920	$588
3	Rotational fallowing	$10,248,077	$5,106,619	$15,354,697	$1,532,254	$889
4	Buy and supply	$30,102,592	$838,684	$30,941,276	$1,440,979	$836
5	Groundwater wells	$7,312,903	$6,263,887	$13,576,790	$1,728,721	$1,003

The division between capital and annual costs varied between alternatives, as shown in Table 9. For water right purchase alternatives (1, 2, 4), capital (acquisition) costs made up about 90% of total costs. For the other alternatives that expanded use of leased water supplies (3, 5), annual costs represented a greater share (30% to 50%) of total costs. As described in the Analytical Framework section, those alternatives with significant annual costs have a relatively high equivalent annual cost over the long term.

Sensitivity analysis

One of the ATM approaches (Alt. 2C) was found to provide cost savings relative to more traditional water right acquisition approaches, while the other two ATM approaches (Alts. 3 and 4) were found to carry additional costs. This finding is based upon informed assumptions regarding lease rates, sale prices, and rates of appreciation over time. Modifying assumptions regarding how fast lease rates and sale prices change in the future could result in a different ordering of water supply alternatives from least to most cost. Appendix I provides the results of a sensitivity analysis, which is useful to illustrate the impact of the cost input assumptions on the relative costs of the water supply alternatives. Increasing the discount rate by 1% can shift rotational fallowing (Alt. 3) to become less costly than the permanent water supply acquisition alternatives, and similarly decreasing the discount rate by 1% causes rotational fallowing to become more than twice the cost of permanent acquisition alternatives. The results clearly show the sensitivity of long-term costs to rather subtle changes in assumed cost and economic inputs.

CASE STUDY 2

City of Fountain

Introduction

The City of Fountain is located directly south of Colorado Springs along Interstate 25. Fountain has experienced rapid growth over the last two decades, with its population tripling from 1984 to 2014. Figure 9 provides a graphic of annual population for Fountain.[63] Fountain experienced a very high growth rate from 1994 to 2008, averaging an increase of 5.3% per year. The last few years have seen annual growth of about 2.6%, on average.

Population growth in Fountain is often tied to the number of personnel stationed at Fort Carson, located directly northwest of Fountain. Fort Carson currently has about 26,000 active duty soldiers on the base, along with approximately 15,000 spouses and 22,000 children, for a total population of approximately 63,000.[64] Many of the Fort Carson personnel and their families live off-base in the surrounding communities, including Fountain. Following the Base Realignment and Closure (BRAC) in 2005, Fort Carson was planning to gain 8,500 new troops and some portion of this new Army population was assumed to reside in Fountain.[65,66] More recently, cuts in defense spending have caused concern about the loss of personnel at Fort Carson.[67]

Fountain is representative of many growing communities around Colorado Springs and the southern Front Range. In terms of water supply planning, Fountain is a good representation of the southern Front Range region, for the following reasons:

- It relies heavily upon large trans-basin diversion and storage projects which bring reliable water supplies to a relatively water short region.

FIGURE 9

Fountain population growth 1980–2014

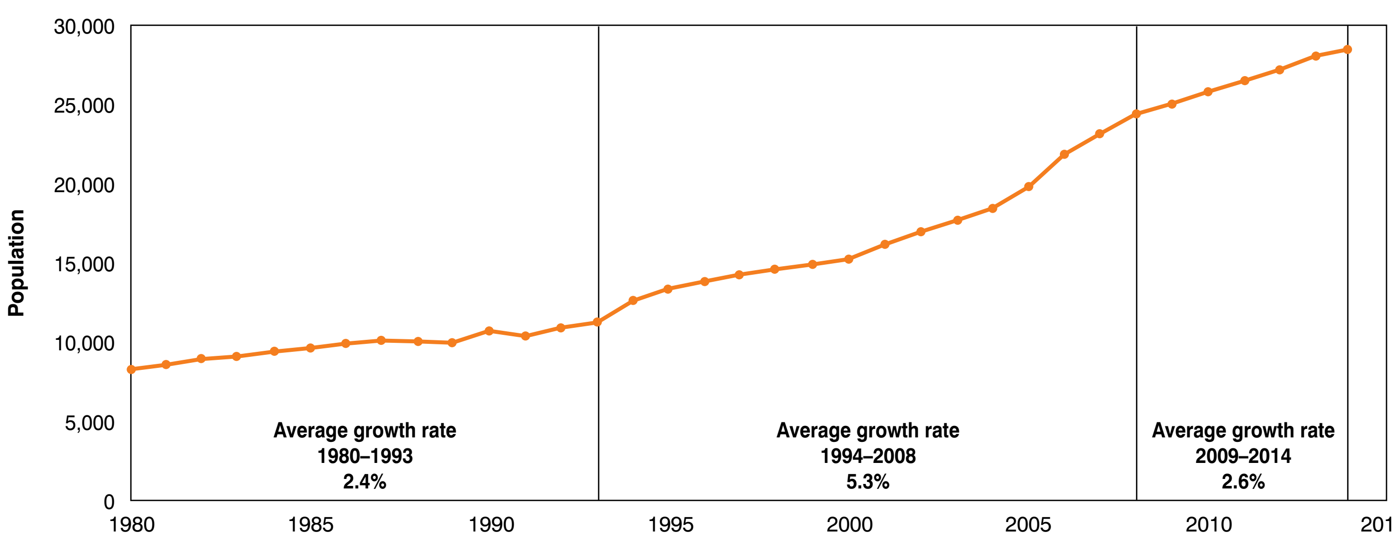
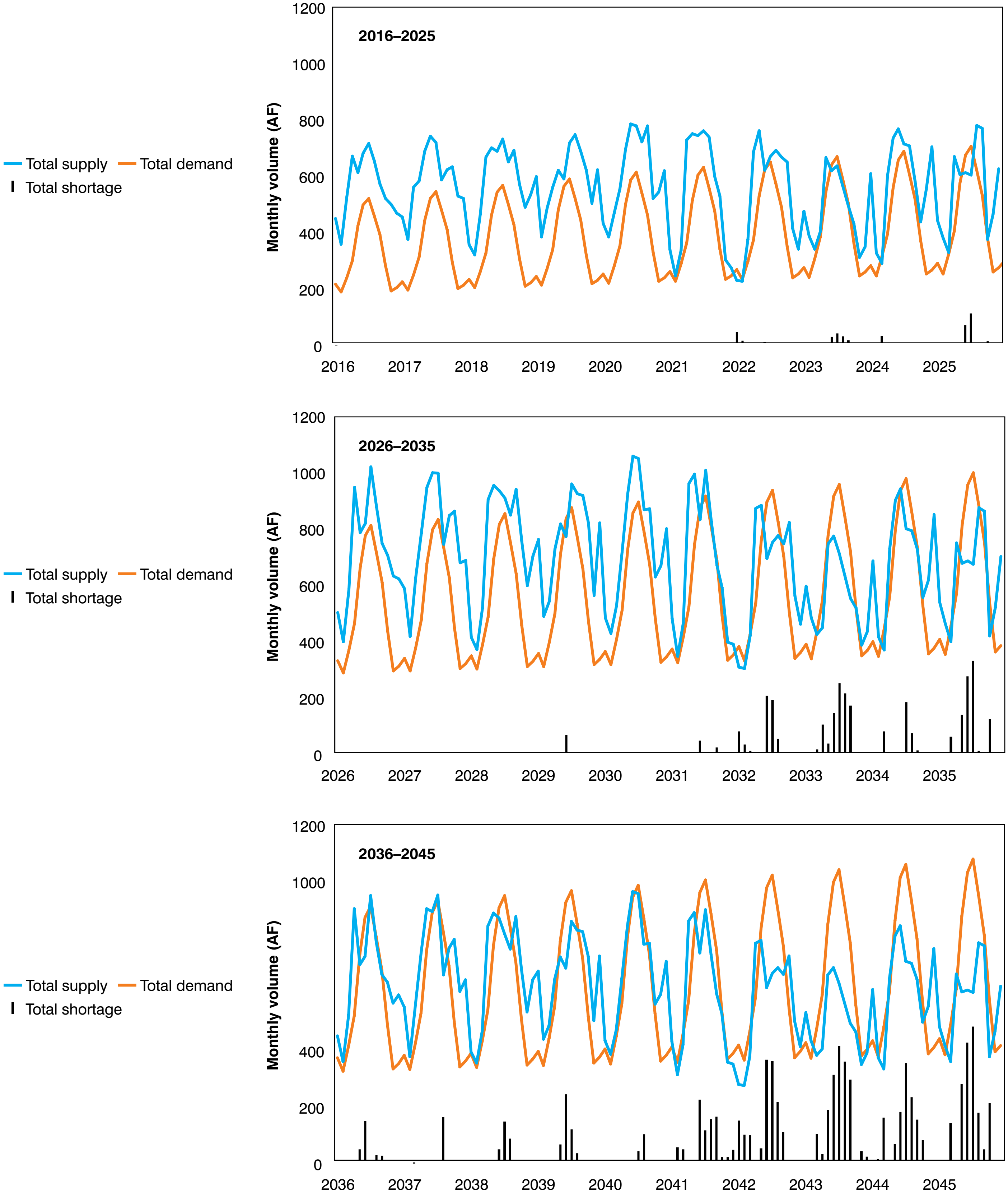


FIGURE 10

Fountain monthly water shortage estimates



- It has historically relied upon local groundwater wells as a secondary source of supply, but water quality concerns limit the usefulness of groundwater resources in meeting future water demands.
- It is located in close proximity to a limited number of small irrigation ditch systems.
- It has been creative in identifying potential new water supplies and open to utilizing leased and temporary water supplies to meet its water needs.

The City of Fountain has completed several relevant water planning studies over the past decade that largely provided the baseline information for the analysis. Unless otherwise noted, information for this case study was obtained from the following reports:[68]

- 2006 Water Master Plan
- 2009 Water Conservation Plan
- 2013 Peak Day Water Supply Planning

In addition, Fountain has been a participant in several regional water supply projects, and the planning and permitting studies for these projects provided additional baseline information. These regional projects include the following:

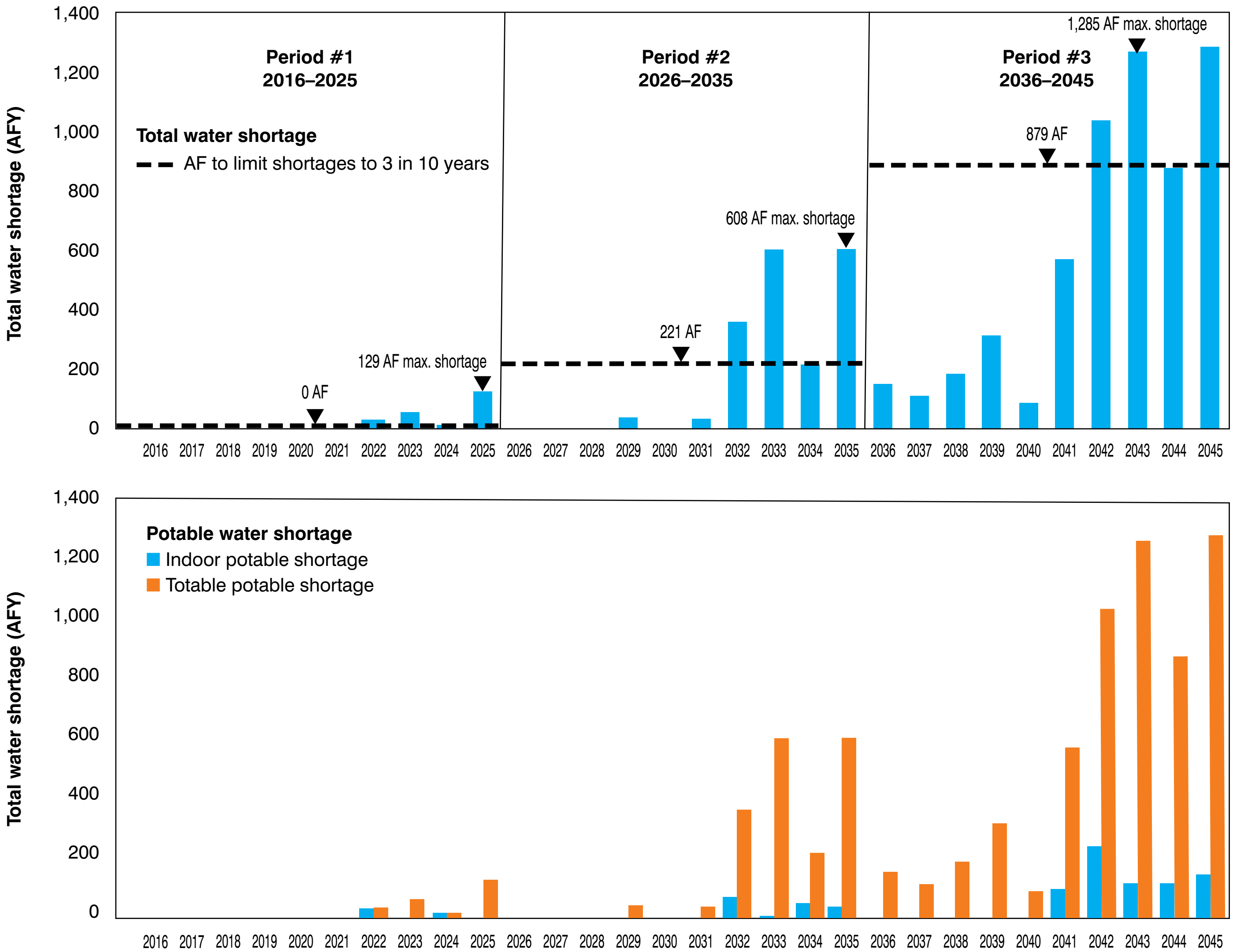
- Southern Delivery System
- Catlin Canal Pilot Project (Super Ditch)
- Pikes Peak Regional Water Authority

Future water shortages were estimated by comparing future water supply and demand estimates on a monthly timestep, as described in detail in Appendix G. Importantly, the shortage calculations assume that Fountain will seek to acquire a total gravel pit storage capacity of 4,500 AF, which was estimated to provide sufficient exchange capacity to fully utilize the recently acquired SDS pipeline capacity. This additional gravel pit storage capacity was assumed to be required for all future water acquisition options for Fountain. Figure 10 (page 52) provides a summary of total monthly water supply, demand, and shortage data over the 30-year projection. Figure 11 (page 54) shows annual shortage data. Total shortages reflect the data in Figure 10, and compare total water supplies against total water demands. For this study, total shortages were used to quantify water supply acquisition needs for Fountain. The maximum annual shortage was estimated as 1,285 AFY.

The shortage graphs indicate the following water supply needs for Fountain in each of three 10-year future periods:

- **2016–2025:** Permanent water supply acquisitions of 19 AFY to address increase in demands, estimated as the volume necessary to reduce remaining shortages to no more than 3 years out of the 10-year period. An additional volume of temporary water supplies to cover 3 years of drought. The maximum shortage during this period was 129 AFY, and therefore 110 AFY of temporary water supply is needed.
- **2026–2035:** Permanent water supply acquisitions of 202 AFY to address increase in demands, estimated as the volume necessary to reduce remaining shortages to no more than 3 years out of the 10-year period. An additional volume of temporary water supplies to cover 3 years of drought. The additional temporary water supply was estimated as 387 AFY.

FIGURE 11
Fountain annual water shortage estimates



• **2036–2045:** Permanent water supply acquisitions of 659 AFY to address increase in demands, estimated as the volume necessary to reduce remaining shortages to no more than 3 years out of the 10-year period. An additional volume of temporary water supplies to cover 3 years of drought. The additional temporary water supply was estimated as 405 AFY.

Alternative water sources

Projections of future water shortages were made to identify the types and timing of future water supply needs of Fountain. For this study, both traditional and ATM water supply sources were evaluated to meet the various types of shortage identified. The modeled shortages assume additional gravel pit storage capacity for Fountain and maximum use of the SDS pipeline capacity. At an assumed gravel pit storage capacity of 4,500 AF, current water rights and contracts held by Fountain are fully utilized and adding further gravel pit storage alone will not provide additional water supplies to reduce shortages. Therefore, additional water sources would need to be acquired and various alternatives are presented in this section.


The Arkansas River at Moffat Street in Pueblo, Colorado.

USGS

Fountain currently utilizes its rights and conveyances from Pueblo Reservoir (including FVA and SDS contracts) as a primary source of water supply. To meet peak seasonal demands and as an emergency supply source, Fountain also utilizes its alluvial groundwater wells and contracts. In the future, it was assumed that Fountain would continue to utilize both of these water sources. Both Pueblo Reservoir water supplies and groundwater well water supplies will require additional conveyance infrastructure to tie into Fountain's existing water system. Previous water planning studies for Fountain have found that the total capital and operational costs associated with each of these two sources are roughly equivalent.[69] The financial analysis of alternative water sources focuses on source water acquisition. Additional capital and operational costs associated with conveyance, treatment, and distribution are not considered. Water sources to meet these acquisition needs are summarized in Table 10, and described below.

Alternative 1: Fountain Creek water rights purchases and leases

Additional water right acquisitions on Fountain Creek were assumed to represent a continuation of historical practices by Fountain. As shown in Appendix G, Fountain has acquired a significant portfolio of irrigation water rights sourced from Fountain Creek, which the city utilizes for either groundwater well augmentation or exchange into Pueblo Reservoir. In the future, additional Fountain Creek water right acquisitions were assumed to be conveyed for use in Pueblo Reservoir, requiring additional gravel pit storage capacity to facilitate exchanges along the Arkansas River. Any purchase and transfer of Fountain Creek irrigation water rights would involve a change application in water court. The water right transfer process would seek a decree for direct municipal use, exchange into the Arkansas River, and well augmentation; similar to what Fountain has sought in previous Fountain Creek change cases.

As described in Appendix H, a significant price discrepancy exists between shares in the Fountain Mutual Irrigation Company (FMIC) and other Fountain Creek ditches. Appendix H also indicates that either type of irrigation water right from Fountain Creek has a sufficient undeveloped volume (still in agricultural use) to meet estimated shortages. For this analysis, the lower-priced Fountain Creek irrigation water rights were assumed to be acquired by Fountain. The alternative acquisition costs for FMIC shares would more than double costs for this alternative.

Three different scenarios or options were modeled under this alternative:

- **Alt. 1A, upfront purchase:** Fountain purchases sufficient Fountain Creek irrigation water rights in the first year (2016) to meet the maximum annual shortage within the 30-year period. A total of 1,285 AFY would be acquired in 2016 through permanent sales.
- **Alt 1B, incremental purchases:** Fountain purchases Fountain Creek water rights in 10-year increments, based on the maximum annual volume of shortage within each of three 10-year planning blocks. The intermittent purchases total 1,285 AFY, divided as follows: 129 AFY in 2020, 479 AFY in 2030, and 677 AFY in 2040.
- **Alt 1C, purchase and lease:** Fountain purchases a sufficient volume of Fountain Creek water rights in 10-year increments such that remaining shortages occur in no more than 3 out of 10 years. Under this scenario, permanent water right acquisitions totaled 880 AFY. The remaining shortages were met through interruptible water supply agreements (IWSA), or option contracts. Each IWSA was modeled around a 10-year period, with the option price (10%) paid each year on the maximum volume of shortage within each 10-year period and the lease rate (or strike price) paid in years when a shortage was modeled.

Alternative 2: Arkansas River water rights purchases and leases

The City of Fountain has not historically acquired irrigation water rights on the Arkansas River through permanent sales. Fountain has recently entered into water lease agreements for Arkansas River supplies under Super Ditch and the Catlin Canal pilot project. Additional water right acquisitions on the Arkansas River are considered to provide a similar water supply as Fountain Creek water rights, with an associated need to exchange the water rights upstream into Pueblo Reservoir for use by Fountain. Irrigation water rights that include some form of storage were found to have a 50% price premium over rights with only direct flow (see Appendix H). For this analysis, Fountain was assumed to acquire Arkansas River water rights for direct flow only, and also construct gravel pit storage to allow exchange of the rights.[70]

The same three scenarios or options were modeled under this alternative:

- **Alt. 2A, upfront purchase:** Fountain purchases sufficient Arkansas River irrigation water rights in the first year (2016) to meet the maximum annual shortage within the 30-year period. A total of 1,285 AFY would be acquired in 2016 through permanent sales.
- **Alt 2B, incremental purchases:** Fountain purchases Arkansas River water rights in 10-year increments, based on the maximum annual volume of shortage within each of three 10-year planning blocks. The intermittent purchases total 1,285 AFY, divided as follows: 129 AFY in 2020, 479 AFY in 2030, and 677 AFY in 2040.
- **Alt 2C, purchase and lease:** Fountain purchases a sufficient volume of Arkansas River water rights in 10-year increments such that remaining shortages occur in no more than 3 out of 10 years. Under this scenario, permanent water right acquisitions totaled 880 AFY. The remaining shortages were met through interruptible water supply agreements (IWSA), or option contracts. Each IWSA was modeled around a 10-year period, with the option price (10%) paid each year on the maximum volume of shortage within each 10-year period and the lease rate (or strike price) paid in years when a shortage was modeled.

Alternative 3: Rotational fallowing agreements

Instead of permanently acquiring Arkansas River water rights, Fountain could engage in water supply agreements with one or more ditch companies to provide both permanent and temporary water supplies under rotational fallowing agreements. In the Arkansas River Basin, this alternative has precedence with the Super Ditch project and Catlin Canal pilot project. This

The Bessemer Ditch located outside of Pueblo, Colorado.

USGS

alternative was modeled similar to Alternatives 1C and 2C described above. A rotational fallowing agreement was modeled as providing two supplies: (1) a firm annual water supply for Fountain under a fixed volume (take or pay) contract, and (2) an intermittent water supply for Fountain under an IWSA. Under the fixed volume contract, the permanent water supply needs (shortages) for Fountain were leased such that shortages were reduced to 3 years in each 10-year period. Under the IWSA component, the remaining shortages were leased when they occurred and a fixed option payment (10%) was paid each year on the maximum delivery within each 10-year period.

Under this alternative, it was assumed that the Lower Arkansas River Water Conservancy District (LARWCD) would continue to pursue and develop the Super Ditch Company to provide rotational fallowing lease agreements for regional municipalities. Fountain would enter into an agreement with the Super Ditch Company, and participating farmers in the Company would rotate which farmlands were fallowed to provide both a fixed and variable water supply volume to Fountain each year. Previous studies have indicated that 8 ditch companies in the lower Arkansas River are viable candidates for the Super Ditch rotational fallowing concept, with available water supplies of over 200,000 AFY in most years.[71]

Two alternatives were evaluated for rotational fallowing, differentiated by the need for Fountain to develop exchange capacity with gravel pit storage facilities. Currently, the LARWCD is pursuing exchange rights along the Arkansas River, to provide water in Pueblo Reservoir to lessees. Their efforts remain in water court at the present time. Considering this uncertainty, the following two alternatives were developed:

- **Alt. 3A, exchange provided:** Fountain does not have to develop gravel pit storage, because the lease agreements from LARWCD provide the water in Pueblo Reservoir.
- **Alt 3B, exchange developed:** Fountain develops a total of 1,285 AF of gravel pit storage over the 30-year period in order to provide exchange capacity and transfer the leased water supplies on the Arkansas River up to Pueblo Reservoir.

Alternative 4: Buy farmland to supply water

Another alternative to the permanent acquisition of irrigation water rights is the concept of “buy and supply”. In this alternative, Fountain would purchase sufficient irrigated farmland to provide a transferrable water supply to meet estimated shortages. The water rights appurtenant to the farmland would undergo a water court change of use process, and then be available as an "on call" water supply to meet annual shortages. For this analysis, it was assumed that Fountain would seek to acquire Fountain Creek irrigated farmland near its service area and city boundaries. As with other Fountain Creek ditch sources, it was assumed that the irrigation water rights appurtenant to the purchased farmland could be exchanged upstream and delivered into Pueblo Reservoir.

Similar to other alternatives, farmland purchases were divided into three blocks over the 30-year modeling period. In each 10-year block, the acreage of irrigation farmland to

TABLE 10

Summary of Fountain water source alternatives

No.	Alternative name	Type	Permanent water acquisition			Leased water supplies			Capital infrastructure costs	Other
			Period #1 (2016–2025)	Period #2 (2026–2035)	Period #3 (2036–2045)	Period #1 (2016–2025)	Period #2 (2026–2035)	Period #3 (2036–2045)		
1A	Upfront Purchase of Fountain Creek Rights	Traditional	Buy 1,285 AF of ditch rights (2016)	—	—	—	—	—	Gravel pit storage	—
1B	Incremental Purchase of Fountain Creek Rights	Traditional	Buy 129 AF of ditch rights	Buy 479 AF of ditch rights	Buy 677 AF of ditch rights	—	—	—	Gravel pit storage	—
1C	Purchase and Lease Fountain Creek rights	ATM	Buy 19 AF of ditch rights	Buy 202 AF of ditch rights	Buy 659 AF of ditch rights	Option lease of 110 AF of ditch rights	Option lease of 387 AF of ditch rights	Option lease of 405 AF of ditch rights	Gravel pit storage	—
2A	Upfront purchase of Arkansas River rights	Traditional	Buy 1,285 AF of ditch rights (2016)	—	—	—	—	—	Gravel pit storage	
2B	Incremental Purchase of Arkansas River Rights	Traditional	Buy 129 AF of ditch rights	Buy 479 AF of ditch rights	Buy 677 AF of ditch rights	—	—	-—	Gravel pit Storage	
2C	Purchase and Lease Arkansas River Rights	ATM	Buy 19 AF of ditch rights	Buy 202 AF of ditch rights	Buy 659 AF of ditch rights	Option lease of 110 AF of ditch rights	Option lease of 387 AF of ditch rights	Option lease of 405 AF of ditch rights	Gravel Pit Storage	
3A 3B	Rotational Fallowing with Arkansas River Rights	ATM	—	—	—	Fixed lease of 19 AF of ditch rights, and option lease of 110 AF of ditch rights	Fixed lease of 202 AF of ditch rights, and option lease of 387 AF of ditch rights	Fixed lease of 659 AF of ditch rights, and option lease of 405 AF of ditch rights	-— Gravel pit storage	— —
4	Buy and Supply	ATM	Buy 78 acres of irrigated farmland	Buy 290 acres of irrigated farmland	Buy 410 acres of irrigated farmland	-—	—	—	Gravel pit storage	Farm lease revenue
5	Groundwater Wells	Traditional	Develop 129 AF well capacity	Develop 479 AF well capacity	Develop 677 AF well capacity	Leases for augmentation of annual pumping	Gravel pit storage	—		

be purchased was calculated as the maximum estimated shortage within the 10-year period, divided by an average crop consumptive use of 1.65 AFY per acre (see Appendix H). For this analysis, the farmland purchase was divided into two pieces, dryland farms and irrigation water rights, to handle variability in water rights pricing. The water rights were priced from Fountain Creek, and a water court change in use (to provide both municipal and irrigation uses) was included as part of the acquisition costs. In the 30-year period, a total of 1,285 AFY of water rights were modeled as acquired, associated with farmland purchases of 779 acres. Based on the underlying assumptions, water would be available for full or partial irrigation on the purchased farmland in 90% of the modeled years, and Fountain would receive farm rent payments to offset the cost of the farm purchase.

Alternative 5: Groundwater wells

Fountain has historically used groundwater sources to meet approximately 30% of its annual water demands. Groundwater use is limited to the summer season to meet the additional demands from outdoor water uses. Fountain sources groundwater from local wells in the city and from wells in neighboring areas through lease contracts (Venetucci wells). Fountain has indicated that it would prefer to maintain its groundwater sources for peaking and supplemental uses, but not as a primary water supply. Recent concerns about groundwater quality in the area will likely bolster this viewpoint. However, previous water supply planning studies for Fountain have explored the use of local groundwater as a primary water source, by developing new well fields in the southern part of the city, and viewpoints may change over the 30-year planning period. Therefore, as an alternative and point of comparison, groundwater wells were considered as a possible water supply for Fountain.

Fountain currently operates 4 wells in the city with a combined production capacity of approximately 2 million gallons per day (mgd), and has a lease contract for use of the Venetucci wells for a guaranteed supply of 135 AFY and a potential supply of up to 1,350 AFY. All groundwater wells used for municipal purposes by Fountain have augmentation plans to mitigate impacts from out of priority pumping, and any new well would require a similar augmentation plan to operate. Existing water rights held by Fountain were assumed to be sufficient to meet future well augmentation requirements. Wells were developed to provide an additional 1,285 AFY of water supply for Fountain, which would mean an additional 86 shallow alluvial wells developed over the next 30 years. Well development was divided into three periods, corresponding with the three 10-year modeling periods. Gravel pit storage was also included in this alternative to allow augmentation water supplies to be retimed, and provide greater reliability of the well supplies. The wells were assumed to have localized reverse osmosis treatment, and additional costs were included for this higher level of treatment compared to water sourced from Pueblo Reservoir.

Cost inputs

The financial analysis is intended to make monetary comparisons between the various alternative water sources defined in the previous section. The costs attributed to each source were intended to provide a reasonably similar water supply for Fountain, in terms of reliability and applicability to Fountain's current water system. For any of the alternative water sources, there may be additional costs associated with using the water supply that would emerge under a more detailed analysis.

Many of the alternative water sources are based upon similar water sources and water rights, and therefore costs, with variations in how the water is transferred to the City of Fountain. Cost inputs to the financial analysis are summarized in Table 11 (page 60). Appendix H provides details on the development of each of these cost inputs.

TABLE 11

Estimated cost inputs for Fountain alternative water sources

Source	Subcategory	Term	Acquisition cost ($/AF)	Annual appreciation	Transfer cost ($/AF)	Annual cost ($/AF)
Fountain Creek	FMIC	Purchase	$15,700	3%	$3,000	$50
	Other ditches	Purchase	$7,000	3%		
	Water rights	Lease	—	5%	$1,000	$350
Arkansas River ditch rights	Direct Flow	Purchase	$6,000	6%	$3,000	$50
	Direct flow and storage	Purchase	$9,000	11%	$3,000	$50
	—	Lease	—	2.67%	$1,000	$350
Gravel pit storage	-—	Purchase	$5,800	3%	—	—
Farmland	Irrigated farmland	Purchase	$2,000 per acre	5%	6% per transfer	$62
	Irrigated Farmland	Lease	—	2.67%	—	$57 per acre
New groundwater wells	Wells	Purchase	$4,667	3%	—	$21
	Additional treatment	—	—	—	—	$670
Super Ditch	—	Lease	—	2.67%	—	$500

Financial analysis

The financial analysis is intended to make monetary comparisons between the various alternative water sources defined in the previous section. The assumptions that went into the financial analysis are defined under the Analytical Framework section of this report. The analysis is divided into two sections: a comparison of total costs, and a review of factors leading to differences in total cost.

Equivalent annual cost comparison

Figure 12 (page 61) and Table 12 (page 61) provide a direct comparison of equivalent annual costs for each of the water supply alternatives. The least expensive alternative was found to be Fountain Creek water acquisitions when purchased in blocks, which had an annual cost of $0.6M. The relatively low cost of this alternative is a reflection of the modest appreciation rate for Fountain Creek water rights.[72] If Fountain Creek water rights were purchased upfront in 2016 or as a mix of purchased and leased water supplies, the annual cost was estimated be about $0.8M. Buy and supply of Fountain Creek farmland had an annual cost of $0.75M, which was more expensive than one of the three Fountain Creek water supply alternatives. Arkansas River water right purchases had consistent annual costs in the range of $0.7M to $0.8M across all types of acquisition. Rotational fallowing represented a significant cost increase, with an estimated annual cost of $1.0M to $1.3M. This cost increase is attributable to the relatively high terminal cost associated with indefinitely leasing water supplies. Groundwater well annual costs were estimated to be about $1.7M, representing the highest cost among the water source alternatives. The high costs for groundwater wells was largely driven by the high annual costs associated with well augmentation and advanced treatment.

On a unit basis, equivalent annual costs varied from $500 to $1,380 per AFY, based on a maximum acquisition of 1,285 AFY. Capital costs for both water right acquisition and infrastructure (gravel pit storage) made up the majority of costs for most of the water supply alternatives, as shown in Table 12. For most alternatives, acquisition costs made up about 90% of total costs. The two exceptions are rotational fallowing, and groundwater wells.

FIGURE 12

Comparison of equivalent annual costs for Fountain alternatives

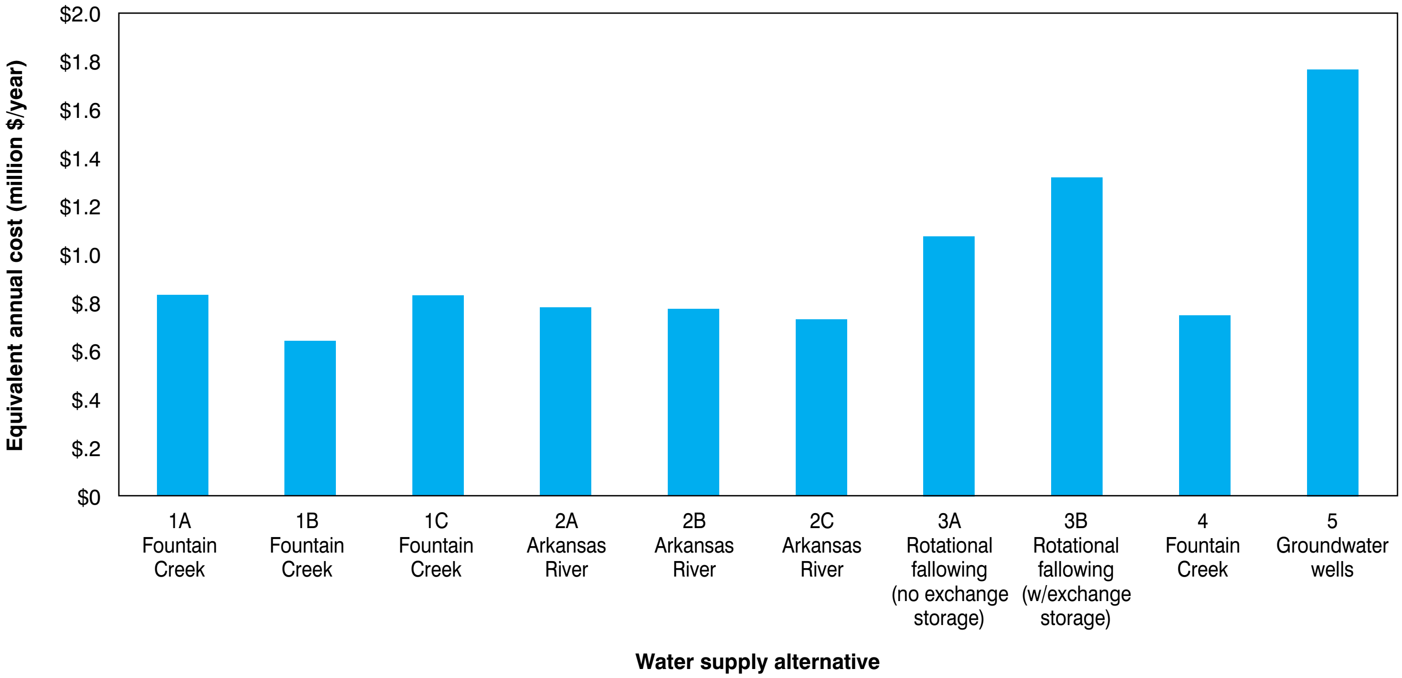


TABLE 12

Summary of costs for Fountain alternatives

		Net present value 30-year costs				
Alternative	**Name**	**Capital**	**Annual**	**Total**	**Equivalent annual cost**	**Unit annual cost ($/AFY)**
1A	Fountain Creek, buy in 2016	$15,942,465	$1,547,736	$17,490,201	$835,803	$650
1B	Fountain Creek, buy in blocks	$13,218,881	$549,792	$13,768,673	$644,885	$502
1C	Fountain Creek, buy and lease	$8,762,926	$3,170,406	$11,933,332	$833,641	$649
2A	Arkansas River, buy in 2016	$14,706,615	$1,547,736	$16,254,351	$784,392	$610
2B	Arkansas River, buy in blocks	$16,535,716	$549,792	$17,085,508	$778,133	$606
2C	Arkansas River, buy and lease	$13,713,656	$1,036,730	$14,750,386	$733,599	$571
3A	Rotational fallowing (no exchange storage)	$0	$5,148,846	$5,148,846	$1,079,712	$840
3B	Rotational fallowing (with exchange storage)	$6,020,904	$5,148,846	$11,169,750	$1,323,147	$1,030
4	Fountain Creek, buy and supply	$14,527,339	$790,119	$15,317,458	$750,536	$584
5	Groundwater wells	$7,855,204	$6,510,063	$14,365,267	$1,772,795	$1,380

Sensitivity analysis

The ATM approaches were not found to provide any significant cost savings relative to more raditional water right acquisition approaches, and rotational fallowing (Alt. 3) was found to carry additional costs. This finding is based upon informed assumptions regarding lease rates, sale prices, and rates of appreciation over time. Modifying assumptions regarding how fast lease rates and sale prices change in the future could result in a different ordering of water supply alternatives from least to most cost. Appendix I provides the results of a sensitivity analysis, which is useful to illustrate the impact of the cost input assumptions on the relative costs of the water supply alternatives. Increasing the discount rate by 1% can shift rotational fallowing (Alt. 3) to become comparable in cost to the permanent water supply acquisition alternatives, and similarly decreasing the discount rate by 1% causes rotational fallowing to become almost four times the cost of permanent acquisition alternatives. The results clearly show the sensitivity of long-term costs to rather subtle changes in assumed cost and economic inputs.

Summary of findings

ATMs in Colorado

Flexible and temporary water transfers, inherent in ATMs, are often viewed as difficult to accomplish within the confines of Colorado's water rights system. A variety of recent laws have been aimed at making temporary and flexible water transfers more doable, with less oversight in water court. These laws have allowed for water transfers to take place under a Substitute Water Supply Plan (SWSP), an Interruptible Water Supply Agreement (IWSA), pilot rotational fallowing programs, multiple use decrees, water banks, and other methods. Collectively, these recent laws have made it potentially easier and less-costly to transfer an agricultural water right to new uses, at least on a temporary and intermittent basis. These laws are largely the legal foundation on which ATMs are intended to be built in Colorado.

Municipal interest in ATMs is considered to be largely a function of cost and risk tolerance. Both in Colorado and other Western states, municipalities have been more interested in discussing ATM water supplies when more traditional water development project supplies are not available, and the municipality is forced to pursue leased water supplies. Examples of this concept include Aurora, Super Ditch participants, and the South Metro Water Authority. From this perspective of risk, ATM water supplies are considered to be viewed as a second or third tier water supply option. Therefore, a municipality's level of interest in ATMs can likely be well characterized by understanding the water supply options available to it.

Municipal selection process

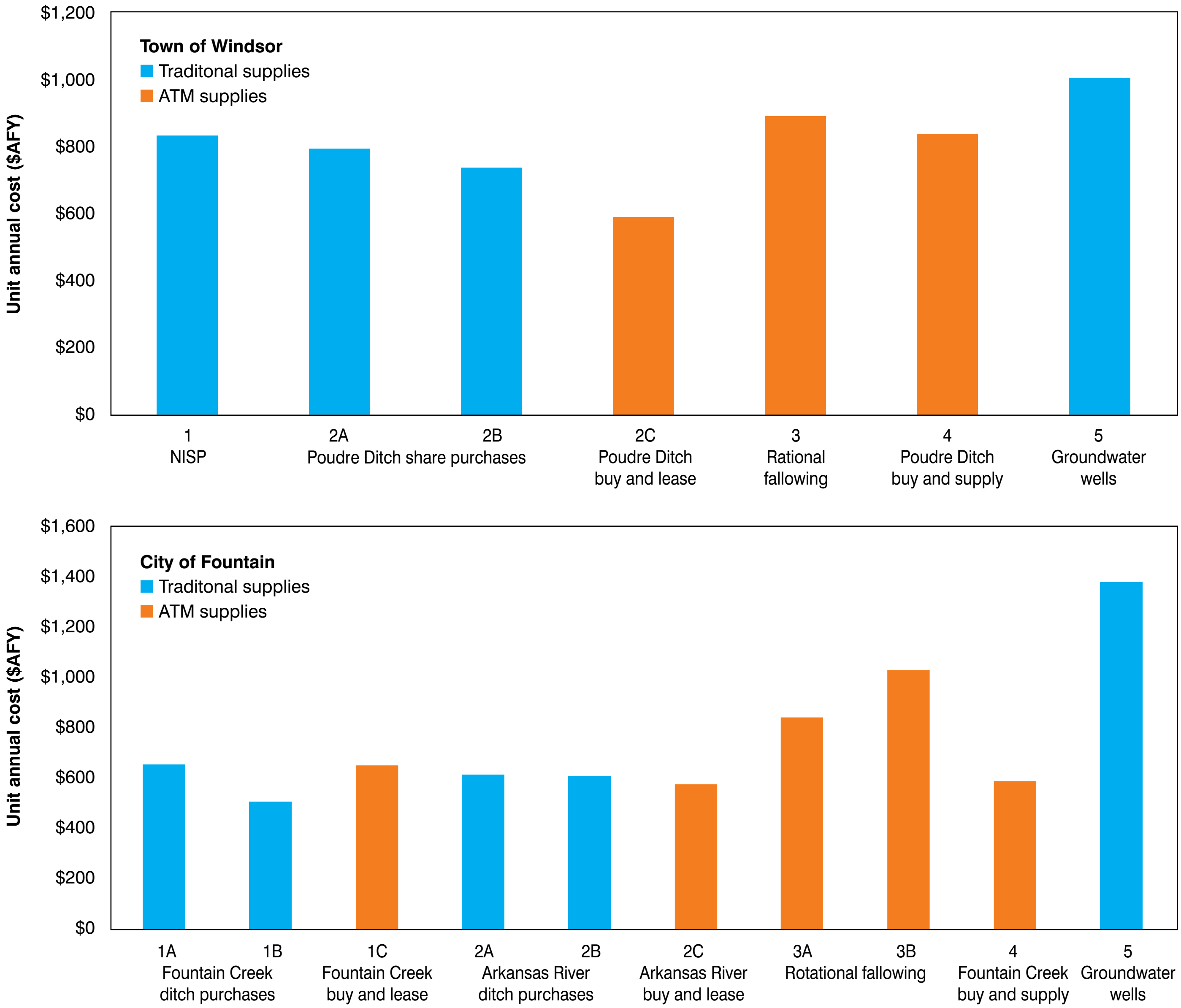
A screening analysis was undertaken to evaluate what conditions would likely influence municipal interest in an ATM, and to compile a list of municipalities that met such conditions. A total of 66 municipal water providers were initially identified on the Colorado Front Range. This total was reduced to 35 municipal water providers based on water source and demand size criteria. This prioritized listing of 35 municipalities indicates that there are a limited number of municipal demand entities on the Front Range who could be looked at to help meet state policy goals of expanded use of ATMs. Two case study participants were identified: City of Fountain and Town of Windsor. Both of these participants provide good representation of municipalities along the Front Range, based on the following characteristics: fairly rapid population growth and development, located in close proximity to several irrigation ditches, and historical reliance upon large-scale regional water projects for much of their water supply.

Case study results

The two case studies represented independent evaluations of future water shortages and the potential water supplies (both traditional and ATM types) that could be acquired to address such shortages. A financial analysis of water supply alternatives was completed based on a 30-year model of all major costs associated with each particular water source; including costs for acquisition, transfer, annual ownership and operations, leasing, and infrastructure tied to

FIGURE 13

Cost comparison of water acquisition options for two case-studies



reliability and flexibility in use. A terminal cost value was incorporated to account for the long-term annual costs, which is particularly relevant to leased water supplies. For Windsor, one ATM approach in which water rights are both purchased and leased to address projected shortages was found to provide small cost savings relative to more traditional water right acquisition approaches. Other ATM approaches such as rotational fallowing and buy and supply approaches were found to have greater long-term costs compared with permanent acquisitions and traditional sources of supply. For Fountain, many of the ATM water supply alternatives had similar estimated costs when compared with permanent water right acquisitions. Rotational fallowing was found to have higher equivalent costs, due to the long-term cost of continuous leasing of water supplies. In both case studies, groundwater development was found to have the highest cost, due mostly to the costs associated with augmentation and advanced treatment. Results of the financial analysis for the two case studies are summarized in the graphs below.

The assumed rates of appreciation and discounting utilized in this analysis influence the comparisons between water supply alternatives, and the results were found to be quite sensitive to assumed economic inputs.

Recommendations

Based on the information compiled and developed through this project, the following recommendations are made toward expanding the use of ATMs in Colorado:

- There have been a series of laws passed in recent years that make it possible to structure an ATM type of water agreement within the bounds of Colorado water law. In many cases, an ATM agreement can legally be implemented, and the higher hurdle to overcome is identifying parties to voluntarily agree to enter into an ATM agreement. Efforts should be focused on motivating parties through the creation of incentives and programs that reduce the costs associated with ATMs.

- Most ATMs inventoried in Colorado and the other Western states were initiated from the demand side, with an entity seeking temporary and/or intermittent water sources that could be provided through an ATM type of water transaction or agreement. This should encourage and focus efforts to implement ATMs toward the demand side as a starting point, with outreach to municipalities, industrial water users, and environmental organizations.

- The pool of potential ATM participants on the Front Range is somewhat limited. This study identified 35 municipal water providers across the Front Range who would be potential candidates for participating in an ATM agreement. This number is small enough that each one of these municipalities could be analyzed for ATM opportunities and contacted to become informed about such opportunities. Past examples of ATMs being implemented also indicate that outreach efforts should be focused on those municipalities that have limited options for new water sources.

- The financial analysis results show that ATM water supplies can represent similar costs when compared against more traditional permanent water acquisition supplies. However, ATMs which are structured entirely as lease agreements, such as under a rotational fallowing program, were found to have significantly higher costs over the long-term. Financial incentives may be required for municipalities to see the long-term financial benefit of ATM water supplies compared with permanent water acquisition options.

- The higher long-term (or indefinite) costs associated with leased ATM water supplies might be one area for water leaders in Colorado to address in order to incentivize participation by municipalities in ATM projects. Reducing the cost of leased water supplies might be explored through a number of ideas including: direct subsidies, creation of an institution (such as a water bank) to both reduce transaction costs and motivate participation by agricultural users by reducing lease terms, and/or development of shared infrastructure projects that could benefit water supply options or water exchanges.

- Water supply risk is believed to be a significant roadblock to municipal acceptance of ATM supply sources. Potential cost savings, particularly in the short term, could encourage municipalities to explore the limited use of ATMs to fill some portion of their water supply portfolios, which over time may lead to a greater level of comfort with leased water supplies in the municipal sector. To the extent possible, water leaders should educate the municipal water community about water leasing opportunities and support pilot projects where needed to begin to build a greater level of comfort and an informed perspective on future water supply options.

Notes

[1] These principles represent a very brief overview and abbreviation of Colorado water law. The Colorado Foundation for Water Education provides an expanded introduction in the*Citizen's Guide to Colorado Water Law* (4th Edition, 2015).

[2] These issues of consumptive use and return flows are often evaluated and quantified as part of water transfer proceedings in water court, and absent such a proceeding, there is often uncertainty because state water administration of water right diversions does not address these two issues.

[3] For an expanded discussion on HCU and "use it or lose it" laws in Colorado, see the Colorado Water Institute Report No. 25, *How Diversion and Beneficial Use of Water Affect the Value and Measure of a Water Right*, February 2016.

[4] Instream flows can be defined for both environmental and recreational purposes. Recreational water use is often referred to as a Recreational In-Channel Diversion (RICD).

[5] Water transfers sourced from agricultural water rights are the most common type of transfer because the vast majority of decreed water rights in Colorado and other Western US states are for irrigation uses, and because municipal and industrial water rights are considered less amenable to temporary or permanent reductions in use.

[6] All water rights in the state are protected from abandonment while being utilized under specified water transfer programs, but only water rights in Water Divisions 4, 5, and 6 (the West Slope basins) are protected from reductions in HCU calculations.

[7] Instream flow benefits of diversion reductions are only realized for the stream reach between the point of diversion and the location of return flows. For more on this topic, see Colorado Agricultural Water Alliance report entitled*Opportunities and Challenges Associated with Potential Agricultural Water Conservation Measures* (Feb. 11, 2008) and the Colorado Water Institute newsletter entitled*Agricultural Water Conservation* (November/December 2015).

[8] Boulder County. http://www.bouldercounty.org/os/openspace/pages/posacres.aspx. Visited November 30, 2016.

[9] CWCB Memo from Craig Godbout, ATM program manager. *Larimer County Open Space ATM Pilot Project*. September 3, 2015.

[10] Peter Nichols. February 2012. *Using Conservation Easements to Secure Future Municipal Supplies*. Presentation to the IBCC Alternative Ag Transfer Subcommittee.

[11] An earlier ATM is the water exchange between the Farmers Reservoir and Irrigation Company (FRICO) and the City of Northglenn in the 1970s; which is noted in the DiNatale Water Consultants March 2012 report entitled*An Evaluation of Alternative Agricultural Water Transfer Methods in the South Platte Basin*.

[12] Aurora Water. August 21, 2014. *Alternative Transfer Methods Arkansas Basin*. Presentation at Colorado Water Congress by Tom Simpson.

[13] Peter Nichols. June 30, 2011. *Development of Land Fallowing—Water Leasing in the Lower Arkansas Valley*. Report for the Colorado Water Conservation Board.

[14] Leah Martinsson. LAVWCD Attorney. Presentation given at DARCA ATM Workshop. December 2015.

[15] Jim Yahn. North Sterling Irrigation District Manager. *Alternative Transfer Methods, A Case Study*. DARCA ATM Workshop. December 2015.

[16] Information from Denver Water. *Pilot projects to boost Colorado River levels given green light*. August 14, 2015. Newsroom. http://www.denverwater.org/AboutUs/PressRoom/ and Dan Arnold. May 9, 2016 CLE presentation on the System Conservation Program. Visited November 30,2016.

[17] CWCB Agenda Item Memo. August 28, 2014. *Proposed Acquisition of Interest in Water on the Little Cimarron River*. http://cwcb.state.co.us/environment/instream-flow-program/. Visited November 30, 2016.

[18] Case No. 2011CW265. Issued July 1, 2015.

[19] Phone call with Susan Smolnik at Fort Collins Utilities. May 10, 2016.

[20] A water toll acre refers to an acre of land that had been historically irrigated prior to the implementation of the fallowing program.

[21] *Landowner Agreement for Fallowing in the Palo Verde Irrigation District between Metropolitan Water District of Southern California and Palo Verde Irrigation District*. August 16, 2004.

[22] *Imperial Irrigation District: Water Conservation* http://www.iid.com/water/water-conservation. Visited November 30,2016.

[23] It should be noted that irrigation efficiency improvements can provide for transferrable water supplies in the case of IID because it is a terminal use for Colorado River diversions, with no downstream water rights or uses, and is located outside of the Colorado River Basin.

[24] Imperial Irrigation District. *Quantification Settlement Agreement Implementation Report 2014*.

[25] IID Water Resources Unit. IID and MWD Water Conservation Program. *Final Program Construction Report*. April 2000.

[26] *Columbia Basin Water Transactions Program.* http://cbwtp.org/jsp/cbwtp/program.jsp. Visited November 30,2016.

[27] CDM Smith. Technical Memorandum. *Alternative Agricultural Water Transfer Methods Grant Program Summary and Status Update*. November 2012.

[28] DiNatale Water Consultants. June 2013. *Alternatives to Permanent Dry Up of Formerly Irrigated Lands*. CWCB ATM grant provided to East Cherry Creek Valley Water & Sanitation District.

[29] N. Hansen, J. Chavez, L. Garcia, and B. Lytle. *2014 Final Report of the Lower South Platte Irrigation Research and Demonstration Project*. ATM grant provided to Parker Water & Sanitation District.

[30] CWCB Memo. November 19, 2014. *Colorado Water Bank Working Group ATM Grant Application.*

[31] Peter Nichols. June 30, 2011. *Development of Land Fallowing—Water Leasing in the Lower Arkansas Valley* (2002–2011).

[32] CWCB Memo. May 5, 2015. From Craig Godbout, ATM Grant Program Manager. *Rotational Fallowing—Leasing Catlin Canal Pilot Project Implementation and Operations Program in the Arkansas River Basin, ATM Grant Request*.

[33] Several examples: (1) Colorado Corn Growers Association and others. *Completion Report: Development of Practical Alternative Agricultural Water Transfer Measures for Preservation of Colorado Irrigated Agriculture*. May 2011; (2) Parker Water & Sanitation District and others. 2014 Final Report of the Lower South Platte Irrigation Research and Demonstration Project; (3) Colorado Corn Growers Association and others. *FLEX Market Model Project Completion Report*. June 30, 2013.

[34] DiNatale Water Consultants. March 2012. *Water Partnerships: An Evaluation of Alternative Agricultural Water Transfer Methods in the South Platte Basin*. ATM grant provided to FRICO.

[35] WestWater Research. August 2014. *Financial Analysis of Capital Improvements to Irrigation Infrastructure, Colorado Western Slope*. Prepared for Environmental Defense Fund.

[36] AgLET was developed by Harvey Economics with input from CSU. Documented in May 2011 Completion Report for the Colorado Corn Growers Association ATM grant study.

[37] See website: http://water.state.co.us/DataMaps/ModelingCDSS/Pages/LeaseFallowTool.aspx. Visited November 30,2016.

[38] Colorado River District Memo. April 5, 2016. *Colorado River Compact Water Bank*. From Dan Birch to Board of Directors.

[39] DiNatale Water Consultants. March 2012. *Water Partnerships*. ATM grant provided to FRICO.

[40] Lower South Platte Water Conservancy District. ATM Grant Application. May 2013.

[41] Loveland Reporter-Herald. Pamela Johnson. March 19, 2016. *Larimer to pioneer ag, water-sharing agreement, Natural Resources Department plans to buy Berthoud farm*.

[42] City of Boulder. Request for Proposal. RFP #38-2016. *Open Space Environmental Water Sharing Feasibility Analysis*. Issued March 30, 2016.

[43] DiNatale Water Consultants. March 2012. *Water Partnerships*. ATM grant provided to FRICO.

[44] MWH. *Colorado River Water Bank Feasibility Study*. Phase 2. March 2013. Prepared for Colorado River Water Conservation District.

[45] The Nature Conservancy. March 2014. *Yampa Basin Alternative Agricultural Water Transfer Methods Study*. Final Report.

[46] DiNatale Water Consultants. March 2012. Totals for Colorado Municipalities. https://demography.dola.colorado.gov/population/population-totals-municipalities/. Visited November 30,2016.

[47] Colorado Corn Growers Association. Completion Report: *Development of Practical Alternative Agricultural Water Transfer Measures for Preservation of Colorado Irrigated Agriculture*. May 2011.

[48] Colorado Corn Growers Association. *FLEX Market Model Project* Completion Report. June 30, 2013.

[49] Colorado Water Innovation Cluster. *Lake Canal Alternative Agricultural Practices and Instream Flow Demonstration Project*. Proposal submitted to CWCB. November 26, 2010.

[50] Current 20-yr A-rated municipal bond interest rates are around 2.5% and have been declining consistently from a high of 6.75% in early 2009. Based on reporting by WM Financial Strategies. Town of Windsor issued a 20-yr, $16M bond in 2015 at an interest rate of 5%. City of Fountain Water Utility issued a series of 30-yr bonds totaling about $4M in 2015 at an interest rates varying from 3.0% to 3.65%

[51] A simple economic analysis indicated that placing capital costs in the 5th year of a 10-year period was a good approximation (within 3–5%) of net present value, compared against taking the average of net present values when capital costs are assumed to occur in each of the 10 years in a period.

[52] Water leasing by Front Range municipalities has historically been mixed. Some municipalities are active lessors of surplus annual water supplies, including ditch shares that have not been through water court and project supplies (such as CBT), and municipalities typically set lease rates to recover ditch assessment and ownership costs. Leasing of fully-consumable effluent (sourced from trans-basin supplies) is more common and market lease rates are typically higher.

[53] Figures 3 and 4 assume the following: (1) all cost inputs and escalation rates as defined for the Town of Windsor case study, unless otherwise noted; (2) an Upfront Purchase of 1,723 AF in 2016 as one point of comparison; (3) a Rotational Fallowing lease of varying volumes based on the simulated 2036-2045 period, up to a maximum of 1,723 AF, repeated for every 10 years over the 100-year model. The purpose was to compare a water right purchase with a water right lease acquisition for the same volume of supply over a 100-year period.

[54] This analysis applies the same discount rate to each water supply alternative which inherently assumes that they carry equal risk.

[55] Colorado Department of Local Affairs. *Population Totals for Colorado Municipalities*. https://demography.dola.colorado.gov/population/population-totals-municipalities/. Visited November 30,2016.

[56] All reports prepared for Town of Windsor by Clear Water Solutions Inc. located in Windsor.

[57] Limitations on Ownership of Allotment Contracts for Domestic and Municipal Purposes. http://www.northernwater.org/docs/About_Us/EventsAndPresentations/PolicySUMMARIES_March18_2015.pdf. Visited November 30,2016.

58 This 2030 completion date is estimated based on the following: (1) an approximate project timeline published in Feb. 2009 of NISP construction beginning in 2013 and concluding with Galeton Reservoir in 2023, or a 10-year construction timeline; (2) a Dec. 2014 media report that estimated a final EIS permit in 2016 and construction starting in 2019; and (3) a more recent timeline that estimates a final EIS issued in 2017, which would put start of construction in 2020 and end of construction in 2030. The Draft EIS indicates that Glade Reservoir could fill prior to the construction of Galeton Reservoir, using surplus water from the CBT system and/or leases from agricultural uses on the Poudre River system.

59 Save the Poudre has indicated that a legal battle is inevitable. http://www.savethepoudre.org/stp-correspondence/2015-11-30-fundraiser.html. Visited November 30,2016.

60 The NISP project continues to undergo design changes in 2016, including a modified release and re-diversion of water through Fort Collins and a revised site for Galeton Reservoir due to the presence of oil and gas wells at the original site.

61 http://www.nwo.usace.army.mil/Missions/Regulatory-Program/Colorado/EIS-NISP/. Visited November 30,2016.

62 Windsor Non-Potable Water Master Plan.

63 Colorado Department of Local Affairs. *Population Totals for Colorado Municipalities*. https://demography.dola.colorado.gov/population/population-totals-municipalities/. Visited November 30,2016.

64 Pikes Peak Area Council of Governments. July 2013. *Fort Carson Regional Growth Plan*. Final Transition Report.

65 U.S. Army Corps of Engineers. *Fort Carson Transformation, Environmental Impact Statement*. June 2007. Prepared by CH2M Hill.

66 Fountain's 2006 Water Master Plan assumed the following: (10,000 new Army personnel at Fort Carson) x (40% living off-base) x (37% of off-base living in Fountain) x (3.7 persons per household) = 5,500 new people in Fountain related to the expansion of Fort Carson.

67 U.S. Army. Fort Carson Structure Changes. 2015. http://posting.csindy.com/media/pdf/fort_carson_installation_specific_impacts__as_of_8jul15_.pdf. Visited November 30,2016.

68 All reports are available on the City of Fountain Water Department website: https://www.fountaincolorado.org/department/index.php?structureid=16. Visited November 30,2016.

69 The 2006 Water Master Plan for Fountain (by Black & Veatch) compared the (not yet completed) SDS pipeline project to expanded use of alluvial groundwater wells. The total capital and O&M costs for 2.2 MGD of treated water was found to be $56M for SDS participation and $48M to $88M for local wells with reverse-osmosis treatment. The study concluded that "the cost opinion for the City's participation in SDS is of the same order of magnitude as that for developing wells and RO treatment…"

70 It is possible that Fountain could acquire direct flow and storage irrigation rights on the Arkansas River and be able to achieve the same desired exchange without gravel pit storage, but this analysis would have to be completed specifically for a given ditch water right.

71 P. Nichols. June 30, 2011. *Development of Land Fallowing—Water Leasing in the Lower Arkansas Valley*. Report for the CWCB. The 8 ditches are Rocky Ford Highline, Oxford Farmers Ditch, Otero Canal, Holbrook Canal, Fort Lyon Storage & Canal, Catlin Canal, and Bessemer Ditch.

72 Fountain Creek water right sale prices were assumed to escalate at 3% annually compared to an assumed discount rate of 4%, resulting in water right purchases becoming cheaper over time.

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