Meeting Colorado's Future Water Supply Needs

Opportunities and Challenges Associated with Potential Agricultural Water Conservation Measures

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Presented by:

Colorado Agricultural Water Alliance

Contents

Executive Summary

The Colorado Agricultural Water Alliance is an association of agricultural organizations committed to the preservation of irrigated agriculture through the wise use of Colorado's water resources. Agriculture in Colorado currently owns and manages the majority of the state's water rights, putting this water to beneficial use for the production of the state's food, feed, fiber, and bioenergy crops. There is a public perception that agricultural water conservation measures such as canal lining and conversion to sprinklers can easily provide additional water supplies to meet growing demands for urban, industrial, recreation, and environmental water needs in Colorado. To address these perceptions, an analysis of the current scientific literature and the administrative precedents in Colorado was undertaken to identify the opportunities and challenges associated with irrigation water conservation.

Specifically, this document attempts to address the following questions:

- Can "agricultural water conservation" result in transferable yield for new uses?
- Does increasing irrigation efficiency result in transferable yield for new uses?
- Does increasing irrigation efficiency and other conservation practices benefit existing uses?

This document is not a legal brief; it is intended to help foster dialog and a greater understanding of the challenges facing irrigated agriculture in Colorado.

Under current laws and customs, opportunities for producing significant amounts of transferable water for municipal and industrial (M&I) uses through agricultural conservation measures are constrained by certain physical, legal, and economic factors. To understand these limitations, it is essential to separate the concepts of irrigation efficiency and Ag water conservation. Under current Colorado laws and practices, water saved through irrigation efficiency measures, such as upgrading from flood irrigation to sprinklers or water salvaged through removing phreatophytes, cannot be transferred to other uses or used to expand irrigated acres. In this document, **Ag water conservation** refers to practices that reduce historical consumptive use, while **irrigation efficiency** refers to practices that decrease nonconsumptive losses such as runoff or deep percolation of irrigation water.

When considering the potential for agricultural water conservation, it is important to understand the distinctions between saved and salvaged water, as opposed to water that is made available by reducing the consumptive use from irrigated crops. Much of the debate over water conservation indicates that imprecise use of terminology creates confusion and often obscures the real policy considerations. Improvements in irrigation efficiency do not necessarily result in an increase in water available for other uses in Colorado. Saved and salvaged water, as currently construed in Colorado, do not include the concept of water potentially conserved through the reduction of crop consumptive use.

A new term, ***Conserved Consumptive Use Water***, is proposed to describe water that is part of the consumptive use of a water right that is removed from an irrigated cropping system. The transfer of this water, while possible under Colorado water law, has not yet been tested in water court or codified by the legislature.

Approximately one-third of Colorado's irrigated acres have already been converted to more efficient sprinkler or drip systems. In particular, irrigators who rely on deep or nonrenewable groundwater already have significant incentive for water conservation. Reducing the amount of groundwater pumped decreases energy costs as it prolongs the economic life of aquifers. Many Colorado farmers have switched to irrigation systems with enhancements such as drop nozzles, low-pressure delivery systems, irrigation scheduling, minimum tillage, and other techniques to improve on-farm efficiency and reduce pumping requirements.

Water conservation measures, such as converting to more efficient irrigation systems, also have significant limitations. A primary factor is that the amount of water legally transferable is an irrigator's historic consumptive use, not the amount of water diverted. Increasing irrigation efficiency is likely to reduce losses from deep percolation and runoff, but it may or may not materially affect the amount of water consumed by the plant. Much of the water lost to these inefficiencies will return to the river or groundwater system for use by downstream water diverters. The reliance on irrigation return flows is common in Colorado, and downstream water rights holders that relied on historical return flows are entitled to protection from injury that could occur when a water right is changed. For example, it has been estimated that a drop of water in the South Platte River is used several times prior to leaving the state. The old adage “One person’s waste is another person’s water supply” holds true in the river basins of Colorado.

Colorado law and customs are clear that water made available from reduced diversions is not available to the original appropriator for irrigation of additional acreage or transfer to other uses. For agricultural water conservation measures to be successful, these aspects of water in Colorado must be considered.

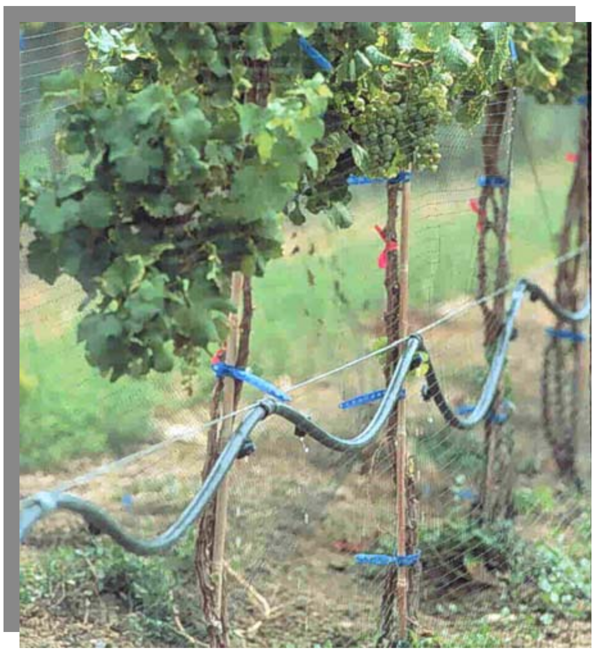
Reductions in crop consumptive use (conserved consumptive use water) only occur when: 1) Irrigated acres are decreased, 2) crop selection is changed from a summer crop to a cool season crop, 3) crop selection is changed to one with a shorter growing season, 4) deficit irrigation is practiced, applying some amount less than full or historical evapotranspiration over the growing season, or 5) evaporative losses from the field surface are reduced as a result of conservation tillage, mulching, and or drip irrigation that are a component of the evapotranspiration from applied irrigation water. It is important to recognize that reducing agricultural water consumptive use will limit crop yields and may increase producer exposure to risks such as irrigation system failure, pests, or drought. Implementing water conservation measures usually results in increased equipment, labor, and management costs that must be borne either by the irrigator or by those who benefit from the conserved water.

Increased and enhanced use of irrigation water conservation measures may be beneficial in certain areas of Colorado if the basin scale impacts are evaluated as part of the adoption process. Increased agricultural water conservation could potentially result in a voluntary reduction in the diversion of water to the farm, creating benefits such as improved water quality, allowing more water to remain in the streams, reduced waterlogging of soils, and reducing energy costs for pumping, but may not result in water that can be legally transferred to other uses. If the use of water conservation measures can improve water supply availability without causing injury to downstream users or the environment, then the result may be improved water supplies for agriculture and other uses.

The Colorado Ag Water Alliance believes that water conservation is only one component in meeting Colorado's future water needs. Better use of existing surface and groundwater storage resources and the development of new storage to meet water demands in the future and during drought years will be required to compensate for existing agricultural shortages and future M&I demands. In order for agricultural water conservation to play a meaningful role in meeting the state's future water needs, a number of legal and administrative issues must be resolved and sufficient financial incentives offered to mitigate the increased risk and loss of productive capacity that occur under reduced water supplies. Furthermore, an in-depth basin-by-basin analysis of agricultural water conservation will need to be conducted to gauge the opportunities to obtain transferable water within the constraints of Colorado’s interstate compacts and priority system.

Section 1
Purpose

Agricultural irrigation is widely recognized as one of the most significant uses of water in Colorado. Statewide, about 80 to 85 percent of Colorado's annual water use is attributable to agricultural production. This has led to a public perception that implementation of agricultural water efficiency/conservation measures can easily provide additional water supplies to meet growing demands for urban, industrial, recreation, and environmental water needs in Colorado. The reality is that opportunities for producing significant amounts of transferable water for municipal and industrial (M&I) uses through agricultural water conservation measures are limited by certain physical, legal, and economic factors. It is important to recognize that agricultural water conservation may increase agricultural producer exposure to risks such as irrigation system failure or drought. In addition, water conservation measures often result in increased equipment, labor, and management costs that must be borne either by the irrigator or by those who benefit from the conserved water.



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This document examines the opportunities and challenges associated with implementing water conservation measures as a source of future water supply. This report is intended as a guide to evaluate the role agricultural water conservation measures may play in addressing Colorado's future water supply needs. While there are limitations associated with developing significant amounts of transferable water for new uses from agricultural conservation, there are also some opportunities that can and should be explored. There are also select opportunities to implement local/site-specific agricultural improvements that can reduce costs and provide environmental or ecological benefits. These topics and others are discussed in greater detail below.

Report Organization

Acknowledgement:

This paper was developed in consultation with Todd Doherty and Rick Brown of the Colorado Water Conservation Board (CWCB), Reagan Waskom of the Colorado Water Institute (CWI); and Kelly DiNatale of Camp Dresser & McKee, Inc. (CDM). The Colorado Ag Water Alliance gratefully acknowledges their contributions to the preparation of this manuscript.

Section 2
Introduction

Water conservation and efficiency measures that reduce irrigation water diversions or consumptive use may occur by:

1. Increasing the efficiency of water application

2. Reducing crop consumptive use

3. Reducing phreatophytes along ditches and canals

4. Decreasing delivery losses from the river headgate to the farm field in ditches, canals, and diversion structures

5. Reducing non-beneficial evaporative losses

These measures may be helpful to farmers, other water users, and the environment in a number of situations, including:

- Drought
- High pumping costs
- Irrigation system problems
- Interruption in surface water supplies
- Declining groundwater levels
- Compact compliance
- Alluvial well water restrictions
- Urban water transfers
- Need for additional instream flows

Water conservation and efficiency measures, however, also have significant limitations. A primary factor is that the amount of water that is legally transferable is an irrigator's historical consumptive use, not the amount of water diverted. Another factor is that in a change of use, downstream water rights holders are entitled to the stream conditions that existed at the time of their appropriation. When water is diverted from a river or stream, a portion of the water percolates through the soil or runs off the field and eventually flows back to the river to be used by downstream water users. However, under Colorado water law, irrigators are under no obligation to continue inefficient practices to continue seepage or waste flows. For agricultural water conservation and efficiency measures to be successful, these aspects of water in Colorado must be taken into consideration.

Implementing agricultural water conservation and efficiency measures may also result in unforeseen effects, both negative and positive, on stream systems. Any large scale agricultural water conservation initiative could have potential effects on an entire river system, including downstream water users, compact delivery requirements, groundwater aquifers and the users relying upon them, riparian environment, water quality, and others. Opportunities for agricultural water conservation exist where the conserved water is returned to the stream system and is available for instream flows or diversion or appropriation by others. In these instances, should incentives for landowners and/or irrigators be created, or should government step in to pay for some of these initiatives? Additional potential benefits and limitations are discussed in more detail below.

Potential Benefits of Agricultural Water Conservation and Efficiency

The Colorado Statewide Water Supply Initiative (SWSI) report noted that the benefits of agricultural water conservation and efficiency measures may include:

1. Increased ability to deliver water to crops can stretch existing supplies. This benefit would apply to irrigators unable to meet full crop needs that would benefit if additional water could be more effectively and efficiently delivered to their crops.

2. Reduced non-crop consumptive use and evaporative losses. Some of the consumptive use and losses may be due to tailwater from irrigation ponding at the end of fields and evaporating, rather than returning as surface or groundwater return flows.

3. Increased instream and return flows. Historical agricultural return flows are a vital part of the flows in all basins, and downstream surface water diverters and downstream states have relied on these return flows. These return flows, in addition to satisfying downstream water rights, also create delayed flows that can have instream and riparian environmental benefits and maintain aquifers for domestic and irrigation wells.

4. Improved water quality that results from diminished leaching and runoff. As less water moves across the landscape, there is less opportunity to move nutrients, pesticides, sediments, and other contaminants. Additionally, reducing the amount of water applied to the land will reduce the amount of soluble salts applied via irrigation water and may prolong field productivity.

Limitations of Agricultural Water Conservation Uses

The SWSI and other reports also highlight factors that limit the extent to which agricultural water conservation can be used to deliver additional water to meet other needs:

1. Typically, any water that is generated by water conservation measures, such as canal lining or the conversion to more efficient irrigation practices, can only be

used on lands for which the appropriation was originally made. Selling or delivering conserved water to other users or new lands could constitute an improper expansion of use under current laws.

2. Water conservation options that result in additional water from irrigated agriculture are limited to those that reduce evaporation or crop consumptive uses. As a result, management practices that result in improved irrigation efficiency do not necessarily yield transferable supplies. Diverted water that is not consumed by senior appropriators belongs to the stream system and, thus, other water right holders.

3. Wide-scale adoption of water conservation practices designed to increase diversion efficiencies has the potential of altering basin hydrology by reducing the magnitude and timing of return flows.

4. Another possible unintended consequence of basin-wide increases in diversion efficiency is increased consumptive irrigation water use. This would occur as a consequence of irrigators, operating within their decrees, using the conserved water from more efficient diversions to fill shortages. Increased consumptive use would affect basin hydrology and eventually result in reduced return flows. Conversion to improved irrigation efficiency systems, e.g., flood to sprinklers, may result in an increase in consumptive use and less return flow to the stream.

5. The potential for future agricultural water conservation in Colorado varies greatly among basins. More importantly, policy initiatives designed to encourage conservation should be based on how water is used at the basin level rather than at the individual farm level. Also, impacts of water conservation strategies on interstate compact obligations must be considered.

6. Much of the irrigation infrastructure in Colorado river basins dates from the late 1800s and could benefit from upgrading. However, under current water law, there is little personal incentive for irrigators to invest in upgrading irrigation infrastructure.

7. Major canals that are currently unlined support extensive vegetation resulting in significant conveyance losses in the form of non-crop consumptive use.

Many other reports and studies have concluded that opportunities to meet future water supply needs with agricultural water conservation measures are limited and potentially can result in injury to vested Colorado water rights, wetlands, groundwater levels, and streamflows. These reports, which have been used in developing this paper, include:

- Memorandum to South Platte Task Force. Anne Castle and Bill Caile, Holland and Hart. July 12, 2007.

- SWSI Phase 2 Technical Round Table Report on Alternatives to Permanent Agricultural Dry-up prepared for the Colorado Water Conservation Board. CDM (Camp Dresser & McKee Inc.). November 2007.

- Statewide Water Supply Initiative Report prepared for the Colorado Water Conservation Board. CDM (Camp Dresser & McKee Inc.). November 2004

- Citizen's Guide to Colorado Water Law and Citizen's Guide to Water Conservation. Colorado Foundation for Water Education. 2004.

- 1992 Report to the Legislature, "An Analysis of Salvaged Water Issues in Colorado." Colorado Water Conservation Board.

- Irrigation Water Conservation: Opportunities and Limitations in Colorado. Colorado Water Resources Research Institute Report #190. 1996.

- Best Management Practices for Colorado Corn. CSU Extension Bulletin XCM574A, February 2003.

Section 3
Agricultural Water Use

Irrigators who rely on groundwater already have significant incentive to conserve water. Reducing the amount of water pumped decreases energy costs and prolongs the economic life of aquifers. Many Colorado farmers have switched to irrigation systems with enhancements such as drop nozzles, low-pressure delivery systems, irrigation scheduling, minimum tillage, and other techniques to improve on-farm efficiency and reduce pumping requirements. Widespread adoption of these technologies in compact-limited basins such as the Arkansas, South Platte, and Rio Grande may result in changed return flow patterns, reduced groundwater recharge, and potential for downstream impacts.

Approximately one million of Colorado's three million irrigated crop acres have already been converted to sprinkler and drip systems. Figure 3-1 shows the location of agricultural irrigated and cultivated lands.

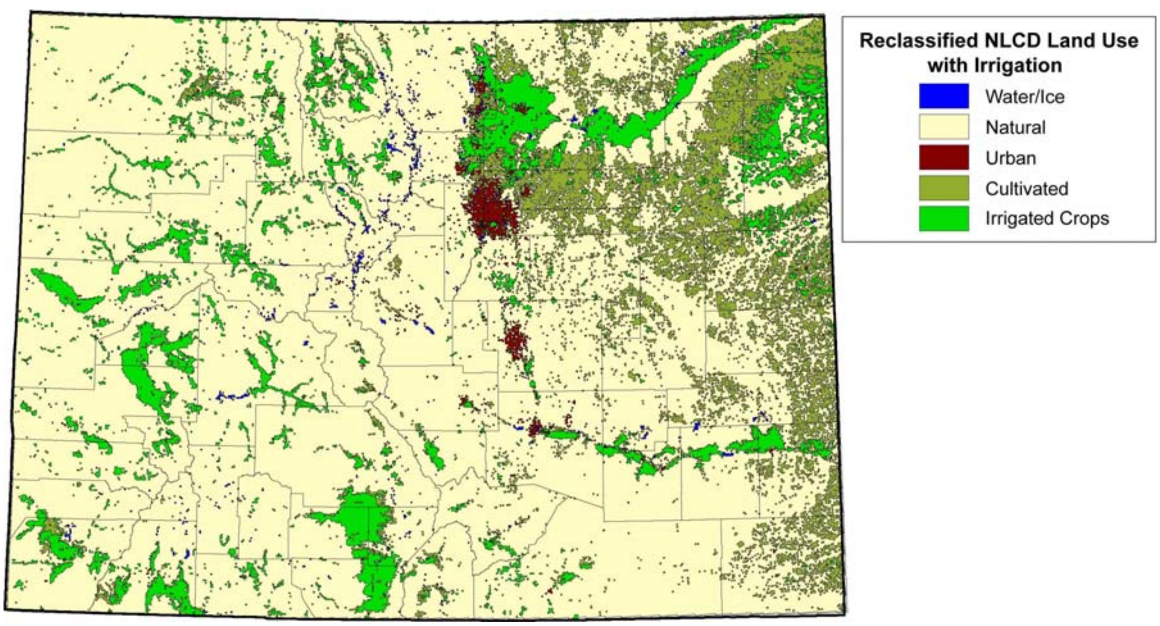


Figure 3-1
Agricultural Irrigated and Cultivated Lands

Water conservation has its own terminology that must be understood when discussing options and limitations. Irrigation water applied to cropland consists of the following major components:

1. Total water diverted from the river or aquifer to irrigate the field
   - Includes crop consumptive use + water required to compensate for system inefficiency (nonbeneficial evaporative losses, return flows including deep percolation, and surface runoff)

2. Water taken up from soil by the crop
   - Crop Transpiration + Evaporation = Evapotranspiration (ET)
   - Season-long Evapotranspiration – Effective Precipitation = Potential Consumptive Use (CU)

3. Water lost from non-crop consumptive use
   - Evaporation from areas not under crop
   - Consumptive use from plants not under crop land
   - Deep percolation not returned to stream

When considering the entire water budget needed for irrigation, the majority of the water diverted for irrigation typically is for crop consumptive use and return flows. The actual amount of total water lost to non-beneficial consumptive use is site-specific but has been estimated at about 10 percent of the crop consumptive use. Figure 3-2 is a schematic of an irrigation system and illustrates the fate of water diverted from the river for irrigation.

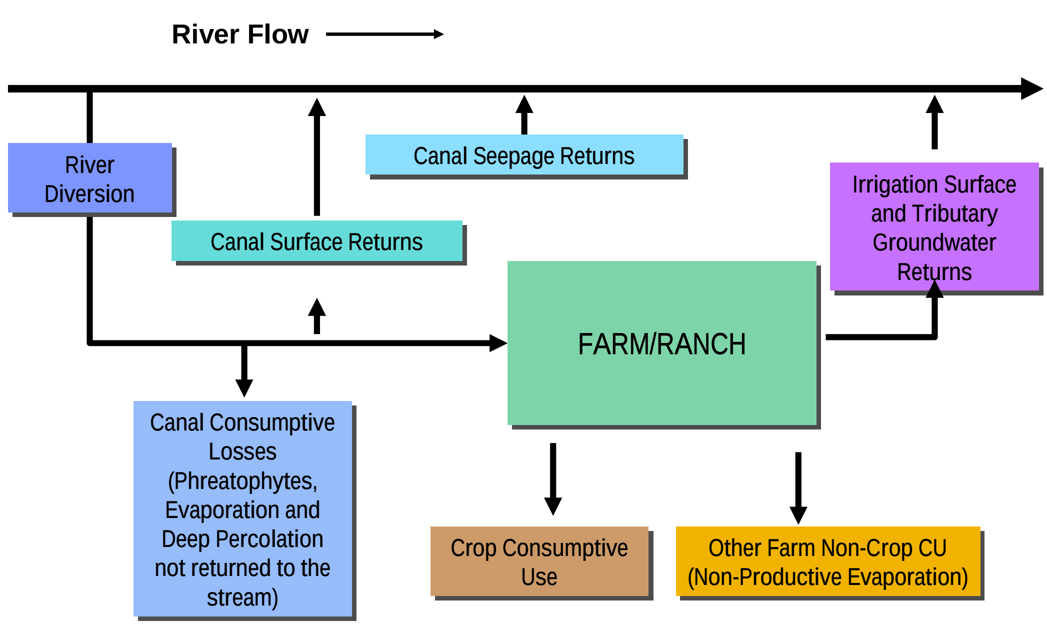


Figure 3-2
Irrigation System Schematic Including Return Flows

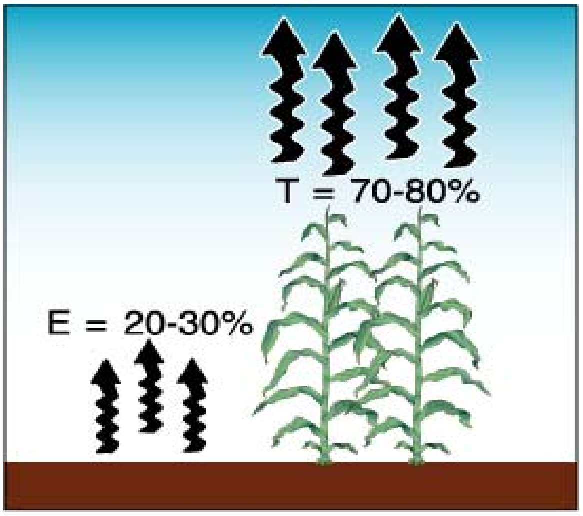


Figure 3-3
Relative Components of Crop Evapotranspiration (ET)

The amount of ET and the relative percent of consumptive use evaporation vs. transpiration (E vs. T) are dependent upon the following factors:

- Crop type
- Percent of canopy cover (stage of development and plant population)
- Irrigation system and frequency of application
- Residue cover (e.g., mulch/tillage system)
- Soil moisture status

ET is a driver for crop growth and yield. In general, 70 to 80 percent of the total consumptive use is via transpiration from the plant canopy (Figure 3-3.) There is a direct relationship between the amount of ET and crop biomass because plant stomata must be open for a crop plant to assimilate carbon. When plant stomata are open, water vapor is lost to the atmosphere. In this way, 99 percent of the water that is taken up by the plant is returned to the atmosphere in the form of water vapor.

The ratio of evaporation to transpiration changes throughout the year. An illustration of the changes in monthly E vs. T for a corn field is shown in Figure 3-4. In May and June, as the corn is in the early growth stages, a greater percentage of ET is attributable to evaporation, and as the corn increases in biomass and closes the canopy, evaporation as a percent of ET declines due to shading of the ground and the increase in biomass and hence transpiration from the plant.

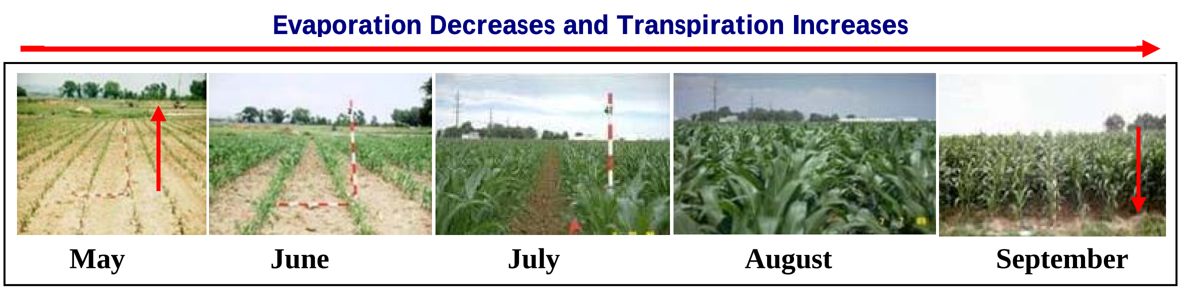


Figure 3-4
Corn Crop and ET Changes during the Growing Season

Section 4
Agricultural Conservation Measures

When evaluating agricultural water conservation improvements, it is important to distinguish between practices that lead to improved application efficiency and those that lead to reduced consumptive use. Water use efficiency is defined as the ratio of water applied compared to water consumed by crop (i.e., ET). Increasing efficiency is likely to reduce losses from deep percolation and runoff (thereby altering historical return flow patterns), but it may or may not materially affect the amount of water consumed by the plant. Much of the water lost to these inefficiencies will return to the river or groundwater system for use by downstream diverters. For this reason, the administrative practice in Colorado is that water saved due to improved efficiency is not available for additional irrigated lands or other expanded uses.

In certain situations, improved irrigation systems such as sprinklers and drip systems may result in improved application uniformity over the entire field. Consequently, areas that previously were under-irrigated and where crop yields suffered now receive adequate water to meet full crop ET. The net result may be increased crop consumptive use on a whole field basis.

Examples of measures that increase efficiency include:

- Ditch and lateral lining
- Pressurized or non-pressurized pipe
- Conversion of flood irrigation to sprinklers or drip
- Land leveling to increase irrigation uniformity
- Furrow diking and contour farming
- Reduced tillage systems
- Irrigation scheduling and monitoring
- Tail water recovery
- Polyacrylamide (PAM) use in ditches and furrows

The efficiency of various irrigation systems varies. Flood irrigation normally ranges from 30 to 50 percent efficiency. This means that 30 to 50 percent of the water diverted at the farm headgate is consumptively used, while the remainder is returned to the environment via tail water runoff and deep percolation. Estimated efficiencies and costs for various irrigation methods are summarized in Table 4-1.

Table 4-1 Estimated Efficiencies and Costs for Irrigation Methods

Type of Irrigation	Range of Application Efficiency	Average Capital Cost/Acre	Average Annual Cost/Acre
Flood	30-50%	—	—
Furrow	40-60%	$37	$30
Gated Pipe	~60%	$178	$51
Center Pivot Circle	~85%	$433	$64
Center Pivot with Corner	~85%	$568	$80
Subsurface Drip Irrigation	~90%	$1,000	$120

Reducing Consumptive Use

In most cases, upgrading irrigation systems increases water use efficiency but does not necessarily reduce consumptive use. A concept that has been discussed can be termed ***conserved CU water***. This is water that results from the reduction in beneficial ET, which can result when one or more of the following occurs:

1. Irrigated acres are decreased.
2. Crop selection is changed from a summer crop to a cool season crop.
3. Crop selection is changed to one with a shorter growing season.
4. Deficit irrigation is practiced, applying some amount less than full ET over the growing season.
5. Evaporative losses from the field surface are reduced as a result of conservation tillage, mulching, and or drip irrigation.

If irrigated acres are decreased, it is relatively simple to calculate the water conserved from reduced ET. This type of conserved water has been recognized in water court transfers of agricultural water rights and is usually accomplished through the requirement of recording a dry-up covenant on the land that will no longer be irrigated. In this case, the amount of water that is available for other uses is the total consumptive use of the irrigation water that can be shown to be reduced.

Most of the difference in consumptive use between crops can be explained by season of active growth and length of growing season. Crops grown during the cool season, such as winter wheat, are subject to lower atmospheric demand and, thus, lower ET rates. Reducing the length of crop growing days also can reduce irrigation demands.

These differences in season-long consumptive use as a result of growing day length or growing period are presented in Table 4-2 below.

Table 4-2 Growing Season and Consumptive Use for Various Crops, Holyoke, Colorado

Crop	Growing Season (Holyoke, CO) (Average Dates)	(Days)	Seasonal Consumptive Use (inches/season)
Alfalfa	3/20 - 10/10	204	35.2
Sugarbeets	4/25 - 10/10	168	29.9
Corn/grain	5/5 - 10/5	153	25.4
Soybeans	5/25 - 10/5	133	16.4
Spring grains	4/1 - 7/25	115	15.2
Dry beans	6/1 - 9/5	96	18.7

Agricultural Water Conservation Techniques that Reduce Crop Consumptive Use and Nonproductive Consumptive Losses

Current water law allows irrigators flexibility in crop types, irrigation timing, methods, and application rates. If properly managed, crop consumptive use or nonproductive consumptive losses may be reduced by the following practices:

- Lower water use cropping systems
- Acreage fallowing
- Shorter season/cool season crops
- Limited/deficit irrigation
- Removal of pivot end guns and reduce acres
- Ditch piping and lining (reducing evaporation, ET, and seepage)
- Crop residue management and mulching
- Phreatophyte control

Limited/Deficit Irrigation Concepts

Limited or deficit irrigation reduces consumptive use by not meeting full crop ET for some part of the growing season. To implement limited irrigation, a required system of practices may incorporate all or some of the following:

- Irrigation water application is timed for maximum benefit (minimize stress during critical growth stages)

- Crop residue maintained to catch moisture and reduce evaporation
- Fields are often split to include lower water use crops (shorter season, cool season crops)
- Weed control
- Stress tolerant crop varieties

- Reduced crop inputs such as fertilizer
- Efficient application that minimizes surface runoff, deep percolation, and evaporation losses
- Inclusion of forage crops in rotation
- Skip row, lower plant population, reduced crop canopy coverage

Optimum Irrigation Scheduling

Irrigation scheduling has long been advocated as a way to obtain greater water use efficiency by applying the right amount of water at the right time to optimize net returns. This management practice may or may not result in reduced consumptive use but implies that:

- The objective is to maximize crop production with the minimum amount of water
- The objective is optimum economic returns, rather than simply maximizing yields
- Optimum irrigation may also involve deficit irrigation

Reducing crop consumptive use comes with a cost and most often a reduction in crop yield, increased management costs, and increased climate-based risk. Additional insect, disease, and weed problems are other hazards that must be managed under limited irrigation. As irrigators manage reduced water amounts closer to the yield margin, higher levels of management and labor are required to maintain profitability.

Agricultural water conservation measures have been implemented in a number of specific situations in Colorado. Examples include:

- The federally funded salinity management program on the West Slope where water conservation measures, improved irrigation, and canal lining were implemented to reduce deep percolation.
- In 2005 and 2006 some San Luis Valley irrigators voluntarily shut off center pivot end guns to reduce pumping by an estimated 8 percent.
- Some growers over High Plains Aquifer where groundwater levels are declining have adopted cropping patterns that include increasing acreage of cool season crops such as wheat.
- Also on the Eastern Plains, the use of deficit irrigation has been employed where well capacity cannot meet ET (wells with capacity of less than 5 gpm/acre are usually unable to meet full ET requirements during mid-summer).

- In the Arkansas Valley, to address impacts of an agricultural water transfer, drip irrigation and new crops were cost-shared by a large municipality to reduce evaporative losses.

- In the South Platte Basin, center pivot irrigation has been widely adopted in recent years to achieve labor savings, but has also resulted in increased irrigation application uniformity and efficiency and changed return flow patterns.

- During the 2002 drought in the South Platte Basin, agricultural users implemented higher levels of irrigation management including reduced set times to minimize runoff and deep percolation in order to meet crop needs under significantly reduced surface water supplies.

- The Grand Valley Water Management Plan was implemented to improve canal hydraulics, which will reduce the need to maintain full canal head to make deliveries to canal users.

- Polyacrylamide (PAM) applications to irrigation canals and ditches on the West Slope and in the Arkansas Valley have shown a 25 percent decrease in seepage losses, while providing sufficient water for the maintenance of riparian plants, e.g., cottonwoods.

Section 5
Legal and Engineering Considerations

In Colorado, a relatively complex set of laws, regulations, and customs pertaining to the use and transfer of water rights has evolved over time. These laws reflect the region's scarcity of water and the fact that streams and rivers were not always located near the intended place of use. Considering this reality, surface water rights depend on use and not on the land where the water is applied. There are a few key principles of Colorado water law that one must understand when considering the conservation of agricultural water use.

- The "No Harm Rule"
- A water right is a property right
- Beneficial use
- The concept of salvaged and saved water

No Harm Rule/No Injury Rule

Under Colorado water law, water rights can be changed in the type, place, or timing of use as long as the change does not adversely affect other vested water rights, whether absolute or conditional. Put another way, appropriators are entitled to the continuation of stream conditions at the time of their appropriation—including return flows from upstream water users. The doctrine of prior appropriation recognizes a right of junior appropriators "in the continuation of stream conditions as they existed at the time of their respective appropriations" (*Farmers High Line Canal & Reservoir Co. v. City of Golden*). The "No Harm Rule" provides protection to water right holders from injury when a water right is changed in Water Court. The reliance on irrigation return flows is common in Colorado; it has been estimated that a drop of water in the South Platte River is used several times prior to leaving the state.

Increasing the efficiency of irrigation water use under a valid water right does not require a formal change of use proceeding. For example, an agricultural user may increase efficiencies by improving water delivery (e.g., lining ditches, pipelines, or polyacrylamides) or by on-farm applications (e.g., sprinklers, drip systems), yet still maintain the overall decreed use of irrigation on the same lands. Water conserved within a given ditch system may in some cases be used within that ditch system. There are potential legal issues with the irrigation company conserving water and then giving or selling that water permanently outside of the system. Although such activities do not require a change of use proceeding in water court, these types of improvements could have detrimental impacts on other water users to the extent that the change alters return flows and/or increases the consumptive use. With no formal change case involved, legal mechanisms to protect downstream water rights and interstate compacts are limited. If irrigation conservation and efficiency measures are to be promoted on a broad scale, then consideration should be given to the substantial effects this might cause, including reduced water available to water right holders and interstate compacts.

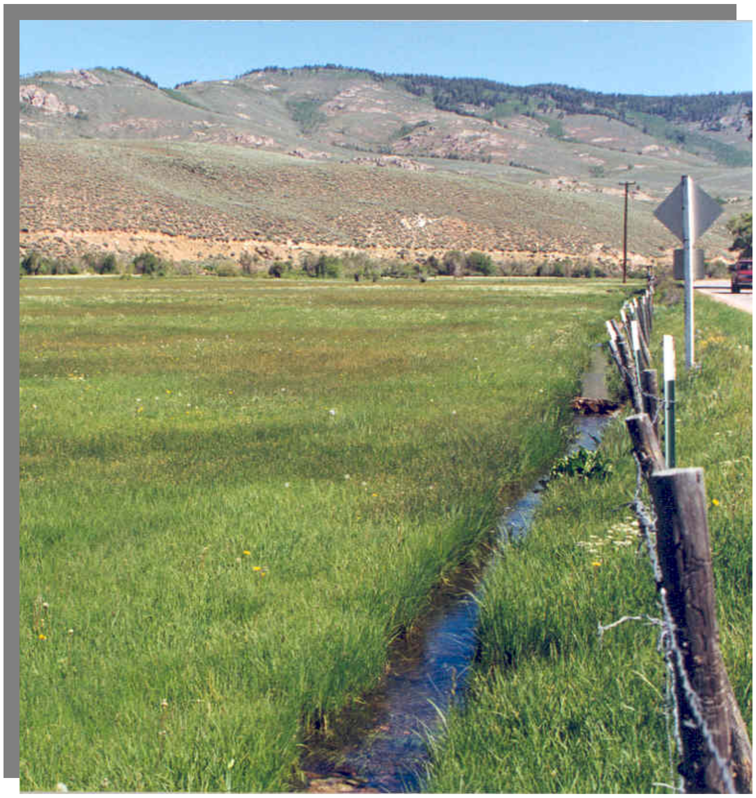
Adjudicating a change of water rights can be time consuming and costly, and formal notification is required by law. Even when no parties object to the change, the process of water court approval takes a minimum of six months, and often much longer due to the heavy case load of water court judges. If parties do oppose a change case, it can take years to get a change decree approved by the court. In addition to paying attorneys' fees, an applicant for a change of water rights generally must hire an engineering consultant to prepare a report explaining the technical aspects of the change and develop an accounting form for administering the change.

While Colorado's legislature has recently enacted legislation that authorizes a water right owner to lease water without formal adjudication of change of water right, these types of leases are only for short-term arrangements and do not address more long-term or permanent changes.

Ensuring the continuation of historical return flow patterns to protect downstream juniors is possibly the largest hurdle to overcome when dealing with agricultural water conservation. To illustrate the complexities involved, the Division Engineer's Office is currently in the process of promulgating rules and regulations for agricultural water users in the Arkansas River Basin to ensure that irrigators converting to higher efficiency systems do not adversely affect return flow patterns and increase consumptive use, thereby affecting the state's ability to meet its compact obligations with Kansas. While Colorado water law allows the conversion of irrigation systems to more efficient ones (i.e., flood to sprinkler systems) without a formal change proceeding in the water courts, the promulgation of rules is a recognition that these actions can have negative effects on return flows and those relying upon them.

In addition to impacting downstream water right holders, implementing agricultural water conservation measures may have other significant effects. For instance, flood irrigation and seepage through earthen ditches and canals provide for significant aquifer recharge. In certain cases, domestic and irrigation wells have been impacted when groundwater recharge from historical irrigation practices was not maintained.

Return flows can also result in improved riparian habitat and provide for base stream flows, which help maintain year-round fisheries that otherwise might not exist. To illustrate, in urban areas, return flows from lawn irrigation and other urban water uses provide base flows for many of the small urban creeks that support riparian habitat and aquatic species. Irrigation ditches also support important riparian vegetation such as cottonwoods and willows. In turn, these plants support fauna that would not be able to exist without them. Lining the canals, ditches, and laterals throughout the state would result in a significant loss of important riparian habitat. Reduced return flows could have an adverse affect on water quality as the dilution flows are reduced; however, depending on soil conditions some water quality improvements could occur if less salts and minerals are leached from soils in the return flow.



In a change case, the measure of the water right is the amount that was historically consumed (not the amount diverted) under the water right. Thus, only the amount of water that the crops consumed (minus effective precipitation) may be transferred for a new consumptive use at the existing or a new location. This limitation ensures that the change will not magnify the historical impact of the water right on the stream system, avoiding injury to other water users. In addition, in a change of water right proceeding, the applicant must take appropriate steps to ensure that historical return flows from the use of the water in amount, timing, and location are maintained. This is required because other water users rely, and are legally entitled to rely, on those return flows to support their appropriation and uses of water.

Water seeping from other ditches and from irrigation of lands is presumed to belong to the river system and is subject to appropriation and administration in order of priority. Flowing water, even diffuse runoff and seepage that is not in a defined channel, is presumed to be tributary to the river system. The 'No Harm Rule' disallows changes that deprive juniors of a senior's return flows which supply their appropriations. Recognition "of the fact that practically every decree on the South Platte River, except possibly only the very early ones, is dependent for its supply, and for years and years has been, upon return, waste and seepage waters." Waters remaining after applying them to a decreed use belong once again to the river system at the moment they are released by the users…and start to flow back to the river. (Comstock v. Ramsey—1913)

Water must be placed to Beneficial Use and is a Property Right

As the doctrine of prior appropriation has been interpreted through case law, two premises of water as a property right have emerged. First, a water right does not include the right to waste the resource. Second, water rights are property rights that can be bought and sold, even apart from the land where they were originally used. The right to use water must be sufficiently flexible to accommodate changes of use and the free transferability of water rights in order to allow the maximum use of water. With regard to the former, Colorado courts have required water users to employ an efficient means of diversion and have limited the amount of water that may be appropriated to the amount necessary for the actual use. The Water Right Determination and Administration Act of 1969 defined beneficial use as:

> *…the use of that amount of water that is reasonable and appropriate under reasonably efficient practices to accomplish without waste the purpose for which the appropriation is lawfully made.*

Courts have applied the principle of beneficial use in holding that a water user has no right to divert more water than can be used beneficially, regardless of the amount decreed, or to expand its use beyond the amount needed for the decreed use.

With respect to flexible use of water rights and the right to buy and sell water rights apart from the land where it was historically applied, Colorado law recognizes water absolute and conditional direct flow and storage rights, groundwater rights augmentation plans, changes of water rights, appropriative rights of exchange, and instream flow rights, all of which allow water users to make the most of a scarce resource. These tools and the ability for water rights to be bought and sold on a willing buyer/seller basis allow water to be transferred from uses of lower economic value to uses of higher economic value. In addition to making efficient beneficial use of water, interstate compacts and equitable apportionment decrees limit the amount of water Colorado can use.

Salvaged and Saved Water

Within the context of the above discussion, two concepts have emerged from case law: salvaged water and saved water.

- Salvaged Water is generally viewed as water that results from reducing nonproductive consumptive use of water, such as by the cutting or removal of phreatophytes.
- Saved Water is generally viewed as water that results from more efficient diversion and application methods.

Much of the debate over water conservation indicates that imprecise use of terminology creates confusion and often obscures the real policy considerations. A better evaluation of the role of saved or salvaged water will be fostered by the use of consistent language and an understanding of irrigation water use.

In 1974, the Colorado Supreme Court in *Southeastern Colo. Water Conservancy Dist. V. Shelton Farms* (1974) ruled that water salvaged by the removal of phreatophytes ("water-loving" plants such as tamarisk and cottonwoods) belongs to the river system and is subject to administration in order of priority. Water salvaged by reducing evaporation or cutting vegetation does not belong to the person responsible for the salvage and cannot result in a new water right, free of the river's call. The Court in *Shelton Farms* stated that while landowners are prohibited from claiming water rights by cutting down phreatophytes, there is a need for the Legislature to address the issue. Phreatophyte management is an important issue in Colorado, and incentives should be created for landowners to actively eradicate these invasive species. If phreatophytes were eliminated on a wide-scale basis, Colorado could see significant amounts of water made available for appropriation.

With regard to salvaged water, at least two statutory clarifications to the salvaged water concept allow reservoirs and gravel pits to take credit against their evaporative losses for vegetation that was eradicated by inundation of the water surface.

Over the last two decades, there have been attempts to create legislation that would provide the right to sell, transfer, and/or reuse water resulting from salvaged, saved, or conserved concepts. This has contributed to the confusion over the terms "salvaged" and "saved" water. An attempt was made to address the issue of "saved" water in 1991 when HB 91-1110 was introduced as a bill allowing the sale, transfer, or reuse of "saved water" as long as it caused no injury to any downstream water right holders. This bill was not adopted.

In a 1992 Report to the Legislature, the Colorado Water Conservation Board presented an analysis of salvaged water issues in Colorado. Anne Castle and Bill Caile of Holland and Hart authored a memo on Salvaged Water that was presented to the South Platte Task Force on July 12, 2007. These two documents present greater detail on the issue of salvaged and saved water.

Conserved Consumptive Use Water

Saved and salvaged water, as currently construed in Colorado, do not include the concept of water potentially conserved through the reduction of crop consumptive use. The transfer of this water, while theoretically possible under Colorado water law, has not yet been tested in water court or codified by the legislature. ***Conserved CU Water***, as described in this paper, describes water that is part of the consumptive use of a water right that is permanently removed from an irrigated cropping system (or other beneficial use).

Implications

What are the legal implications for agricultural users that want to implement on-farm water conservation measures? Colorado water law permits the use of conservation measures. Depending on how these measures are implemented, they could result in increased consumptive use, reduced return flows, and/or increased irrigated acreage (if those acres were part of the original water rights decree) and therefore reduce return flows, potentially impacting other water rights or compacts. These issues place added responsibility on the State Engineer to ensure that other water rights are not injured and that the basin is in compliance with interstate compacts. Conversely, the irrigator can accomplish his historical consumptive use with less total stream diversions via implementation of conservation measures. The only water that is transferable is the historical consumptive use and as described previously, this often entails a lengthy and costly process through the water courts.

Section 6
Site-Specific Opportunities and Limitations

The opportunities and limitations related to agricultural water conservation measures vary significantly from basin to basin. In order to calculate volumes and locations of potentially available water, a basin-specific analysis will be necessary, a task that is beyond the scope of this paper. A few examples of the basin-specific limitations and potential opportunities are noted below. More detailed information on interstate compact requirements can be found in Section 4 of the SWSI report.

South Platte

- In the South Platte, the compact with Nebraska requires the delivery of water to one ditch in Nebraska under certain conditions during the irrigation season. There are no requirements for delivery during the non-irrigation season.

- The Three States Agreement between Colorado, Nebraska, and Wyoming and the Department of Interior has certain periodic flow targets and requirements regarding future depletions.

- The conversion to center pivot sprinklers in Water Districts 1, 2, 3, and 64 may result in a reduction of return flows and impacts on alluvial groundwater, which historically were supplied from flood irrigation.

- There is a potential for water conservation measures in Water District 64, especially downstream near the state line, if these were implemented in a way that would not impact any Colorado water rights or endangered species flows.

Arkansas

- The Arkansas River Compact requires the maintenance of historical streamflow conditions as of the date of the compact.

- The Colorado State Engineer has taken the position that agricultural efficiency improvements in the Arkansas may not occur if they reduce the usable amount of usable state line flows as specified in the Arkansas River Compact.

- Existing irrigation practices have resulted in return flows that have raised the water table, resulting in non-beneficial evaporation from the soil surface and increasing the salinity of both ground water and surface water. Any measures addressing these concerns must be in conformance with the Compact.

- Irrigation of certain lands results in significant impacts to downstream water quality from leaching of metals and salts. In addition, the return flows from irrigation of these lands impacts agricultural production on other lands diverting downstream.

- There are opportunities in the basin to improve water quality and crop yield from agricultural conservation measures if water rights and compact concerns are adequately addressed.

Rio Grande

- The Conejos River and the Rio Grande are subject to the Rio Grande Compact and have separate delivery obligations to the Compact. Terms and conditions of the Compact provide that as flows increase the Conejos River, the Rio Grande must deliver an increased percentage of the total flows respectively for Compact purposes. Return flows from irrigation of certain lands in the basin return to the river above the Lobatos gage and help meet compact delivery requirements. Implementation of conservation measures in this area could reduce return flows that are used to meet compact obligations.

- Many agricultural lands in the Closed Basin of the Rio Grande have been converted from irrigation of spring grain with an average of 18 inches CU to full season alfalfa at an average of 30 inches CU. This contributed to the decline in water levels in the unconfined aquifer of the Closed Basin as supplies decreased and consumptive use increased.

- The proposed groundwater management subdistricts are examining measures to reduce consumptive use in certain areas pumping groundwater.

Gunnison

- The Upper Gunnison Basin has some irrigated areas with very low irrigation application efficiencies. Some of this irrigation water application may be needed to build up the water table to allow for sub-irrigation. The quantity of irrigation water that is lost to consumptive use from the raised water table and free standing water on fields has not been evaluated.

- The low irrigation efficiencies in the Upper Gunnison result in return flows that help sustain late season streamflows.

- Along the Uncompahgre River system, return flows are reused several times within its system, but there is still a significant return flow leaving the system with a degradation of water quality. There is a potential for water quality improvement if the irrigation of the Mancos shale soils on the east side were more efficient and return flows minimized. This would have to be done in a manner to protect the water rights of the Uncompahgre water users and prevent buildup of salts in the soil.

- The Uncompahgre Water Users Association diverting from the Gunnison River also has senior rights and, at times, call out Upper Gunnison basin water rights. Water conservation measures in the Uncompahgre area resulting in less need for water could help upper basin users. The Uncompahgre Water Users Association has stated that any water conserved through these improvements is for the benefit of its users. Possible win-win projects might be possible through water conservation improvements that protect the yield of Uncompahgre water users and even result in an increase in a dry year, even if diverting the same river headgate volume.

- The Redlands Irrigation District calls for and diverts significant quantities of water for hydropower generation to pump water diverted from the Gunnison River to irrigated acres on the Redlands. Conservation measures could potentially reduce the amount of water required to be pumped, also reducing diversions for hydropower generation. This in turn could result in more water available for in-basin water users upstream.

Colorado

- Grand Valley ditches hold senior rights in the basin and control the river at lower flows. Due to inefficiencies in canal control structures, excess water is diverted and then spilled back to the river downstream of the diversion. Below the diversion is the 15 Mile Reach, where there are endangered fish species. Improvements in the canal structures or in farm water conservation measures could result in additional water in the river, which would improve endangered fish habitat and make water available for diversion by upstream water users. Additional water made available for upstream users, however, would result in reduced flows through the Colorado Basin down to the Grand Valley headgates.

- Several successful improvements in canal control structures in the Grand Valley area have occurred in the Government High Line Canal, a Bureau of Reclamation Project. This allows for reduced river diversions without impacting deliveries to irrigators.

- Several ditch systems in the Grand Valley have participated in limited canal improvements that could be expanded. There are no downstream water rights below the diversions, so no Colorado water rights would be injured by reducing return flows.

- The conversion of Ag land to housing developments has changed historical return flow patterns so that there is less water in the river later in the irrigation season. Conservation of irrigation water that results in more water available for consumptive upstream uses could result in less water available downstream and potentially higher salinity levels.

Yampa/White/Green

- Existing river headgate diversions and irrigation methods used by downstream senior agricultural water rights can impact upstream rights by placing a call during lower flows. Increased efficiency in diversion and irrigation methods could result in a reduced need for river diversions, benefiting upstream diverters. However, the current methods may provide flow for the Steamboat Springs junior recreational in-channel diversion water right.

North Platte

- The North Platte Equitable Apportionment Decree limits the amount of irrigated acreage in Colorado. The basin is currently below that limit. There is the potential to irrigate additional acreage or increase yield through water conservation measures.

Southwest (Dolores, San Juan, La Plata, San Miguel River Basins)

- The Southwest Basin is composed of separate and distinct river basins. The rivers in the basin are primarily governed by the Colorado River Compact. Water conservation options are possible without significant concerns regarding the Colorado River Compact; however, the La Plata River flows are impacted by compact delivery obligations to New Mexico. Delivery obligations on the La Plata at the Hesperus gage are tied to upstream flows. Conservation measures can reduce return flows and impact the Compact deliveries. In this basin, there are concerns about impacts of water conservation measures on groundwater levels and domestic wells.

High Plains (Northern and Southern)

- Pumping of groundwater in the High Plains is currently at a rate that substantially exceeds recharge. Energy costs to pump this water are increasing as water levels drop and pumping head increases. Any measures to reduce the amount needed for irrigation will reduce energy costs and extend the life of the aquifer.

The State of Colorado should consider conducting an in depth basin-by-basin analysis of the opportunities for agricultural water conservation measures incorporating the potential benefits and limitations as outlined in this report.

Section 7
Future Considerations

The following points related to the implementation of agricultural water conservation and efficiency measures are presented by the Colorado Agricultural Water Alliance as a starting point for further dialog. It is important to note that any successful implementation of these measures is only one component of meeting Colorado's future water needs. The better use of existing surface and groundwater storage resources and the development of new storage to meet future demands and for drought years will also be required to meet both existing agricultural shortages and future M&I demands.

1. Each agricultural operation and basin is unique and has unique water management considerations. As such, thoughtful consideration should be given to the effects of implementing agricultural water conservation measures, either at the farm scale or basin-wide scale.

2. Incentives for on-farm implementation of conservation measures should be considered and evaluated in the context of compacts and basin hydrology.

3. Incentives for landowner control of phreatophytes, given salvaged water limitations, should be developed.

4. To create incentives for implementing water conservation measures, the cost of water conservation measures should be borne by the beneficiaries of the conserved water. The agricultural user is unlikely and/or unable to bear the costs if the benefits only accrue to improved stream flow, water quality, or the basin as a whole.

5. It should be recognized that if irrigation water conservation measures are implemented, in some areas there will be a periodic need for salinity leaching to maintain productivity.

6. Statutory definitions of saved, salvaged, and conserved water should be provided.

7. Statutory clarification of the legality to transfer conserved CU water should be provided.

8. If legislation is enacted, the state will need to develop administrative means to track and allocate conserved water and ensure compliance.

9. The state should undertake irrigation water conservation demonstration and pilot projects in each basin.

10. The state should undertake a more thorough analysis of the impact of adopting sprinkler and drip irrigation systems in Colorado.

11. The state should conduct an in depth basin-by-basin analysis of the opportunities for agricultural water conservation.

12. The role of agricultural water conservation in meeting future water demands requires additional discussion as to whether it offers opportunities for meeting existing agricultural demands, a drought supply for M&I users, or a base supply for new M&I growth.

Section 8
References

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