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af	Acre-feet
Art.	Article
CATI	Computer-assisted-telephone-interview
CCWCD	Central Colorado Water Conservancy District
cfs	Cubic feet per second
Co.	Company (from court names in chapter 5)
Colo.Const.	Colorado Constitution
CRP	Conservation Reserve Program
C.R.S.	Colorado Revised Statutes
CSFS	Colorado State Forest Service
CSU	Colorado State University
CTO	Colorado Tourism Office
CWCB	Colorado Water Conservation Board
DoLA	Department of Local Affairs
DNR	Department of Natural Resources
DOW	Division of Wildlife
DPA	Department of Personnel and Administration
DPHE)	Colorado Department of Public Health and Environment
DPOR	Division of Parks and Outdoor Recreation
DWCD	Dolores Water Conservancy District
DWR	Division of Water Resources
EDO	Executive Director's Office
e.g.	*exempli gratia* (Latin meaning "for example")
ESA	Endangered Species Act
ET	evapo-transpiration
et al.	*et alia/alli* (Latin meaning "and others")
FEMA	Federal Emergency Management Act
FEMP	Federal Energy Management Program
ICG	Interagency Coordinating Group
Inc.	Incorporated (from court cases in chapter 5)
Irrig.	Irrigation (from court cases in chapter 5)
ITF	Impact Task Force
MSA	Metropolitan Statistical Area
NRCS	National Resources Conservation Service
OEMC	Office of Energy Management and Conservation
RRMI	Resolution Research & Marketing, Inc.
R&RTF	Review and Reporting Task Force

SEO	Office of the State Engineer
U.S.	United States
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
US EPA	United States Environmental Protection Agency
USFS	United States Forest Service
UVWUA	Uncompahgre Valley Water Users Association
v. and vs.	versus
WATF	Water Availability Task Force
WCD	Water Conservancy District
WQCD	Water Quality Control Division

Abandonment: Loss of whole or part of a water right by intent to permanently discontinue use.

Absolute Water Right: A water right that has been placed to beneficial use. See also conditional water right.

Acre-Foot: The amount of water it would take to cover an acre of land to a depth of 1 foot, approximately 325,851 gallons.

Adjudication: A judicial decree dating and defining a water right.

Annual Growth Rate: The increase in a given area's population during a period of one year divided by the area's population at the start of that year. This figure is expressed as a percentage and reflects the number of births and deaths and the number of people moving to and from an area during the year.

Appropriation: The right to take water from a stream and put it to beneficial use. Considered property rights and may be bought, sold, leased, and exchanged. Appropriation establishes a water right by diversion, due diligence, and beneficial use.

Aquifer Storage and Recovery: Underground water storage in a suitable aquifer that is recovered when needed

Assessment Tool/Instrument: The questionnaire used in the Drought & Water Supply Assessment. See also "questionnaire."

Augmentation Plans: A way for junior appropriators to obtain water supplies through terms and conditions approved by a water court that protect senior water rights from the depletions caused by the new diversions. Typically involve storing junior water when in priority and releasing that water when a call comes, purchasing stored waters from federal entities or others to release when a river call comes, or purchasing senior irrigation water rights and changing the use of those rights to off-set the new users injury to the stream.

Beneficial Use: Defined statutorily 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[.]" In Colorado, water must be diverted for a beneficial use, which is the use of a reasonable amount of water necessary to accomplish the purpose of the appropriation without waste.

Carry-over Storage: The amount of water carried over from season to season through both wet and dry cycles in storage facilities.

CATI (computer-aided telephone interviewing): Interviewer-administered telephone surveying using a computer-based questionnaire.

Closed-end Question: Questions that ask the respondent to choose from a limited number of pre-listed answers.

Cloud Seeding: A form of weather modification that involves deliberate treatment of clouds or cloud systems to affect their precipitation processes.

Colorado Drought Mitigation and Response Plan: A plan first developed in 1981 to provide an effective and systematic means for the State to reduce the impacts of water shortages over the short and long term.

Colorado Water Conservation Board (CWCB): A division of the Colorado Department of Natural Resources, the CWCB was created in 1937 for the purpose of aiding in the protection and development of the waters of the state. The Mission Statement of the CWCB is to conserve, develop, protect and manage Colorado's water for present and future generations.

Conditional Water Right: This water right allows an appropriator to secure a priority before water has been applied to beneficial use by showing that the "first step" towards the appropriation has been taken. The "first step" includes the intent to appropriate, plus a sufficient demonstration of that intent. Once the appropriator actually places the water to beneficial use, a final decree may be issued with a priority date relating back to the initiation of the appropriation.

Confidence Interval: The range around a survey result for which there is a high statistical probability that it contains the true population parameter. This is commonly referred to as the margin-of-error.

Confidence Level: The probability that a particular confidence interval will include the true population value.

Conjunctive Use: Combined use of surface and ground water in a coordinated manner.

Cooperative Agreements: Methods for sharing water resources in cases of scarcity, which include legal agreements such as, for example, dry year leasing, transfers, augmentation plans, water conservation easements, water banking and substitute water supply plans.

Cross-tabulation: Examination of the responses to one question relative to responses to one or more other questions.

Department of Local Affairs (DoLA): The Colorado Department of Local Affairs' mission is to strengthen Colorado communities, by improving communities' physical conditions, building partnerships, augmenting local leadership and governing capacities, and improving opportunities for all individuals residing in Colorado communities. Most of the department's assistance to Colorado is provided through technical and financial assistance.

Division Engineer: Head of staff for a water division, supervising a staff of water commissioners, whose primary job is to distribute the waters of the state by monitoring headgates, responding to water calls, issuing orders to reduce or cease diversions, and collecting data on diversions.

Division of Water Resources: A division of the Colorado Department of Natural Resources, the Division of Water Resources administers and enforces all surface and ground water rights throughout the State of Colorado, issues water well permits, approves construction and repair of dams, and enforces interstate compacts. It is also the agency responsible for implementing and enforcing the statutes of the Ground Water Management Act passed by the Legislature as well as implementing applicable rules and policies adopted by the Colorado Ground Water Commission and the State Board of Examiners of Water Well Construction and Pump Installation Contractors.

Drought: Defined as three separate terms, drought is:

> **Meteorological Drought:** "A period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in the affected area." (Huschke, R.E., ed., 1959, Glossary of meteorology: Boston, American Meteorological Society, 638 p.)
>
> **Agricultural Drought:** "A climatic excursion involving a shortage of precipitation sufficient to adversely affect crop production or range production." (Rosenberg, N.J., ed., 1979, Drought in the Great Plains--Research on impacts and strategies: Proceedings of the Workshop on Research in Great Plains Drought Management Strategies, University of Nebraska, Lincoln, March 26-28: Littleton, Colorado, Water Resources Publications, 225 p.)
>
> **Hydrologic Drought:** "A period of below average water content in streams, reservoirs, ground-water aquifers, lakes and soils." (Yevjevich Vujica, Hall, W.A., and Salas, J.D, eds., 1977, Drought research needs, in Proceedings of the Conference on Drought Research Needs, December 12-15, 1977: Colorado State University, Fort Collins, Colorado, 276 p.)

Drought Management Plan: A document that indicates how an entity or set of entities will manage impacts of water shortages over the short or long term. It may contain information on coordinated drought monitoring, impact assessment, response to emergency drought problems, and mitigation of drought impacts.

Drought Mitigation: Actions taken before a drought that reduce the occurrence and severity of water supply shortfalls.

Drought Response: Actions taken during a drought to manage water supplies and water demand appropriately.

Drought Trigger: A typically quantitative threshold at which an entity declares that a drought has been entered. This may be reservoir levels, precipitation levels or other such measurements and are often set to indicate droughts of mild, moderate and severe levels.

Dry-Year Leasing: Negotiation of temporary water transfers for specific hydrologic and climatic conditions.

Evapotransipration: Loss of water from plant transpiration and evaporation from soils and water bodies. Contributes to water losses from water systems.

Frequency: A measure of how often an event occurs; a count of the number of subjects falling in the different categories.

Futile Call Doctrine: Under this doctrine, junior water users are curtailed only if such curtailment makes water available at the time and place of injury to a senior. This allows juniors to continue diverting in times of scarcity, even if a senior is not receiving its whole entitlement, where curtailment of the junior would not allow any additional water to reach the senior.

Growth Rate: The total increase or decrease in a population during a given period divided by the average population in that period.

Impact Task Force (ITF): A set of governmental task forces that are activated to assess and respond to drought impacts under the Drought Mitigation and Response Plan. The task forces focus on the sectors of economic impacts, municipal water, wildfire protection, agricultural industry, tourism, wildlife, energy and health.

Instream Flow Rights: In Colorado, the CWCB is authorized to appropriate or acquire water rights, subject to the priority system, that contribute to minimum stream flows or natural surface water levels or volumes in lakes to preserve the natural environment to a reasonable degree.

Interagency Coordinating Group (ICG): This group is comprised of senior management representatives from lead drought response agencies and ensures the coordination of drought response activities in Colorado. It is intended to review unmet needs identified by task forces and lead agencies and identifies how to meet these needs. It is intended to coordinate with the Executive Branch and State Legislature and determines when to deactivate itself.

Internal Database: Database developed from data within the organization.

Interruptible Supply Agreements: Water rights transferred on a temporary basis for specific needs.

Interviewer or Researcher: The person responsible for recruiting participants for a focus group or the person administering a questionnaire.

Junior Water Right: A water right that follows other rights in priority; see priority.

Leak Detection: A systematic search for water loss in a delivery system or at an end users location. Considered a means of water conservation, repairing leaks found through leak detection controls the loss of water that water agencies have paid to obtain, treat, and pressurize and the loss of water consumers have purchased.

Likert Scale: A scale in which the respondent specifies a level of agreement or disagreement with statements that express a favorable or unfavorable attitude toward the concept under study.

Mapping: The process by which a computer generates thematic maps that combine geography with demographic information and a company's sales data or other proprietary information.

MAPPing: Mathematical Analysis of Perception and Preference.

Margin of Error: The range around a survey result for which there is a high statistical probability that it contains the true population parameter. Also referred to as confidence interval.

Mean: The sum of the values for all observations of a variable divided by the number of observations.

Median: The numerical observation that divides the distribution of observations in half. Sometimes referred to as the second quartile.

Metering: The measurement of water use with a meter to generate data on actual customer use, which is often used for billing purposes. It has been found that billing customers based on actual water use contributes directly to water conservation and aids in detecting leaks throughout a water system. (adapted from http://www.epa.gov/water/you/chap3.html)

Methodology: The research procedures used; the section of the final report in which the researcher outlines the approach used in the research, including the method of recruiting participants, the types of questions used, and so on. Methodology can also mean the approach a moderator uses to conduct focus groups.

Metropolitan Statistical Area (MSA): An urban area determined by the U.S. Office of Management and Budget based on geographic and population characteristics as well as local input from state demographers.

Multiple Choice Questions: Questions that ask a respondent to choose from a list of more than two answers.

Multiple Regression Analysis: Statistical procedure that studies multiple independent variables simultaneously to identify a pattern or patterns.

Objectives: The information to be developed from a study to serve the project's purpose.

Open-ended Question: A question that has no prelisted answers which requires the respondent to answer is his or her own words. Also known as a subjective or verbatim question.

Operating Agreements: Arrangements among water right holders for changes in call priority.

Opinion Data: Information collected in the Drought & Water Supply Assessment of obtaining empirical evaluations of attitudes, behavior or performance. Designed to generate projectable numerical data about a topic that pertains to a water user's quantitative responses to water issues rating a particular matter.

Pearson's Correlation Coefficient: The most common measure of the strength of the association between variables.

Pilot Test: An initial test of a questionnaire conducted with a small number of participants prior to the final modification & commencement of the survey project.

Prior Appropriation Doctrine (or Doctrine of …) : Commonly described as "first in time first in right." Under this doctrine, rights to water are granted upon the appropriation of a certain quantity of water to a beneficial use, within a reasonable amount of time. The date of appropriation determines the priority of the water right, with the earliest appropriation establishing the most senior, or superior, right.

Priority: The ranking of a water right in regards to all other water rights on the stream system. It is determined by the year in which the application was filed for the water right. The date the appropriation was initiated determines the relative priority of water rights for which the applications were filed in the same year. Priority determines who may divert and use water in time of short water supply.

Project Component: The various individual actions or activities that can be performed to mitigate drought impacts.

Public Trust Doctrine: A common law doctrine that holds that it is the legal right of the public to use certain lands and waters and the responsibility of the state to preserve and protect the right of the public to the use of these lands and waters. Colorado does not have a public trust doctrine.

Quantitative Research: Research conducted for the purpose of obtaining empirical evaluations of attitudes, behavior or performance. Designed to generate projectable numerical data about a topic.

Questionnaire: A set of questions designed to generate data necessary for accomplishing the objectives of the research project.

Rank-order Scales (Ranking): Scales in which the respondent compares one item with another or a group of items against each other and ranks them.

Response Bias: Error that results from the tendency of people to answer a question falsely, through deliberate misrepresentation or unconscious falsification.

Review and Reporting Task Force (R&RTF): Comprised of directors from DNR and DoLA and chairpersons of the WATF and the ITFs to review reports from the WATF and ITFs, aggregate assessments and projections, evaluate overall conditions, develop recommendations for drought response and make reports to leadership, the media, the response agencies and others.

Ripple Effect: An indirect or secondary impact.

Risk Management: The process of evaluating risks that have the potential to adversely impact operations or conditions in an effort to either reduce risk to an acceptable level or avoid risk altogether.

Sample: A subset of the population of interest selected for a research study. It is a finite portion that is used to study the characteristics of concern in the population.

Sampling Error: The estimated inaccuracy of the results of a study when a population sample is used to explain behavior of the total population.

Segment: Portion selected on the basis of a special set of characteristics.

Segmentation: The process of dividing a total market into sub-groups (segments) who exhibit differing sensitivities to one or more marketing mix variables.

Senior Water Right: A water right that precedes others in priority; see priority.

Significant Difference: In mathematical terms, difference between tests of two or more variables. The significance difference varies with the confidence level desired.

Skip Pattern: Requirement to pass over questions in response to respondent's answer to a previous question.

State Engineer: The director of the Division of Water Resources (see definition).

State Engineers Office (also Office of the State Engineer): See Division of Water Resources

Sub-state Economic Area: A geographical unit based on economic criteria determined by The Colorado Demography Section, which describe the character and prospects of different parts (counties) of the state. There are three main economic sub-state areas. The three economic sub-state areas are: 1) the metropolitan Front Range, 2) the agricultural Eastern Plains and the San Luis Valley, and 3) areas known as the Western Slope and the Central Mountains.

Substitute Water Supply Planning: Planning for temporary transfers of water during periods of shortage or while looking for permanent sources.

Tests of Significance: Tests for determining whether observed differences in a sample are sufficiently large as to be caused by something other than mere chance.

Trans-basin Diversions: (also trans-mountain diversions and trans-basin water rights): The removal of water from its natural course to another basin such that none of the water returns to its basin of origin upon use.

Validation: The process of ascertaining and recontacting respondents to confirm that interviews were conducted correctly.

Validity: Whether what we tried to measure was actually measured.

Variable: Any characteristic that can be measured on each unit of the population.

Verbatim: A transcript of the actual comments participants made during an interview. See open-ended question.

Water Availability Task Force (WATF): This governmental task force is comprised of Colorado's water supply specialists from state, local and federal governments, as well as experts in climatology and weather forecasting. The WATF monitors snow pack, precipitation, reservoir storage, and stream flow and provides a forum for synthesizing and interpreting water availability information. When the WATF determines that drought conditions are reaching significant levels, it notifies the Governor and recommends activation of the Drought Mitigation and Response Plan.

Water Banking: Pooling of surplus water rights for rental to other water users.

Water Call: The request by an appropriator for water which the person is entitled to under his decree, such a call will force those users with junior decrees to cease or diminish their diversions and pass the requested amount of water to the downstream senior making the call.

Water Conservancy District: A special taxing district, created by a vote of the district's electors, that has authority to plan, develop and operate water supply and potable water projects. There are 47 conservancy districts in Colorado.

Water Conservation: A broad term that can encompass water use efficiency (e.g., low-flush toilets), wise water use (e.g., Xeriscape™), system efficiency (e.g., distribution system leak repair), and supply substitution (e.g., wastewater reclamation). While water use *restrictions* during a drought are often referred to as "water conservation," the objective of long-term water conservation is not to curtail water use. Rather it is to increase the productive use of the water supply in order to satisfy water needs without compromising desired water services.

Water Division: Colorado has seven water divisions determined by drainage patterns of major rivers in Colorado and established in the Water Right Determination and Administration Act of 1969. The Divisions are established as follows: 1) South Platte, 2) Arkansas, 3) Rio Grande, 4) Gunnison, 5) Colorado, 6) Yampa and White, and 7) San Juan and Dolores River Basins.

Water Exchanges: Water taken at a time and place when it would otherwise be out of priority but other water rights that would be injured are satisfied with replacement from another.

Water Reuse: Use of reclaimed water for a beneficial use constitutes water reuse. Direct water reuse involves treating wastewater and piping it directly into a water system without intervening dilution in natural water bodies. Indirect reuse involves an intermediate step between the generation of reclaimed water and reuse, which may be through discharge, retention, and mixing with another water supply.

Water Storage Rights: A right to store water for later application to beneficial use.

Water Supply Master Plan: A comprehensive plan in which a water management entity addresses all technical and political issues related to providing sufficient quantity and quality of water for the entities' clients.

Water Transfers: Reallocation of water from one use to another through sale or lease, which can be a permanent or temporary legal arrangement.

Water User Segment: For purposes of the Drought & Water Supply Assessment, water users were categorized into eight groups or segments: Power, federal agencies, state agencies, municipal entities, agricultural interests, water conservancy districts, industry and other. The segment "other" includes water user groups such as counties, tribes and farm bureaus.

Wildland: Undeveloped lands that are commonly referred to as part of an interface between urban (developed) and wildland (undeveloped) areas. (Definition in progress…)

Useful Resources that Assisted in Creation of Glossary

Central Colorado Water Conservancy District and Groundwater Management Subdistrict at: http://www.ccwcd.org/terms.htm

Colorado Department of Public Health and the Environment at: http://www.cdphe.state.co.us/op/wqcc/StateWaterAgencies.htm

Colorado Division of Water Resources, Water Rights Terminology at: http://water.state.co.us/surfacewater/terms.asp

The Colorado Foundation for Water, *Citizen's Guide to Colorado Water Law*

The Colorado Water Conservation Board at: http://cwcb.state.co.us/

Colorado Trout Unlimited Basic Water Law Terms at: http://www.cotrout.org/water_terms.htm

North American Weather Consultants, Inc. at: http://www.nawcinc.com/wmfaq.html

Public Utility District No. 1 of Whatcom County at: http://www.pudwhatcom.org/web%20options/Option_WM2.3.html

U.S. EPA at: http://www.epa.gov/water/you/chap3.html

USGS Drought Watch at: http://ny.usgs.gov/projects/duration/define.htm

The World Bank Group Glossary at: http://www.unesco.org/education/tlsf/theme_c/mod13/www.worldbank.org/depweb/english/modules/glossary.htm#pgr

Introduction

In days past, water resources management in the Western expanses of the United States was focused, for good or for bad, on the improved utilization of water – on the conservation of water for power, agriculture, industry, and of course, people. The improved utilization of water, or as it was called back then conservation, meant the damming of streams and rivers and the diverting of the most precious resource to locations where the water could be put to its maximum beneficial use, which was typically considered to be irrigation of the nation's rich croplands and cattle ranches and processing of mineral resources. In years past, these were well-accepted conservation practices supported by the federal and local governments, and by the citizenry.

> ***"Water is the true worth of a dry land"***
> ***Wallace Stegner***

A significant natural phenomenon occurred in the 1930's to further drive and influence national sentiments regarding water – the Great Drought. As drought is apt to do, not only did it impact people, families, businesses, and government with respect to short-term resource management, but it also created a paradigm shift, changing the way individuals and organizations thought about water, land, and the connection between the two. Arguably, the greatest impacts of the Great Drought occurred in Texas, Kansas, Oklahoma, Nebraska, Colorado and New Mexico, which coincidentally lie above the largest discrete aquifer in the world, the Ogallala. In the years that followed the Great Drought, it became public policy in these states that the more irrigation, the better, a decision aided by the invention of the centrifugal pump.

Time and weather have again impacted the collective public view of these practices. Irrigators have long known that groundwater resources are finite. Pumping of the Ogallala has contributed to its rapid decline and increased production costs. Development pressures have increased the competition for potable water supply, in some cases drying up agricultural lands through the transfer of water rights, a process that is generally considered both irreversible and potentially damaging to our sustainability as a culture, our heritage and our quality of life. Dams have also been fingered in numerous cases as having caused or contributed to significant environmental damage of submerged wetlands and downstream waterways and riparian corridors. The U.S. Army Corps of Engineers in fact has ongoing authorization from the U.S. Congress to provide local support to those rivers and streams that have been adversely impacted by Army Corps dams across the country for ecosystem restoration, a program that has been used to support river improvements in Nebraska, Colorado, California, Arizona and numerous other Western states.

Water is still in the center of controversy as populations increase in the West; however the nature of the controversy has decidedly changed as has the notion and in some people's minds the definition of what is meant by the term water conservation. Citizens today view the most precious resource as the lifeblood of not only agriculture and the communities that agriculture supports, but as a type of birthright for growing municipalities, as well as for environmental and recreational purposes. As discussed in legal circles, these are all beneficial uses of water. But are all beneficial uses equal in the eyes of the state water administrators and courts, and should they be equally weighted at times of water scarcity? There are no easy answers, and as history has shown, the answers can change over time.

Clearly no one use or user has the sole license or right to use all the water in a basin. Within the State of Colorado, water use is directly related to when, how and for what purpose the water right was claimed. It is a property right and is directly related to a demonstratable beneficial use. This understanding, defined by the laws of prior appropriation ("first in time, first in right"), is clouded in times of water scarcity, if for no other reason than the demonstration by property owners and water administrators that they can be flexible and cooperative when their neighbors with less senior water rights find themselves in need. In fact, recent changes in state laws and policies that allow for cooperative agreements to be developed and implemented between water users in times of water scarcity have codified some of the flexibility water users need and desire. Although property ownership and the rights of that ownership are maintained, as well they should be, the acceptance and use of cooperative agreements has shown that property owners are willing to share their resources even though they are not required to by law in times of drought.

In addition, the most recent drought has demonstrated the variable nature of water needs and water uses in Colorado. Municipal water use changed in response to the drought. Roughly 50% of municipal use is dedicated to lawn irrigation, and this was reduced by 30 to 50% in some locations. Agricultural businesses, which were the hardest hit by the drought, saw numerous farmers and ranchers choose not to use their water, but instead lease their water to thirsty municipalities, because they did not have sufficient water to produce their crops or feed for their livestock. Recreational rafting businesses found river flows so low that float trips could not be sustained or demand of their services was sharply reduced. Any way that you look at it, the drought impacted, and will continue to impact, the way that Coloradoans look at water, water supply and water use in the future.

Office of the State Engineer, Recognized Beneficial Uses

Augmentation
Commercial
Domestic
Evaporative
Export from State
Federal Reserved
Fire
Fisheries
Geothermal
Household Use Only
Industrial
Irrigation
Minimal Flow
Municipal
Other
Power Generation
Recharge
Recreation
Snow Making
Stock
Storage
Wildlife

Introduction

State water planners and managers have reason to improve their understanding of drought and drought impacts on the Colorado water user community, given changing public perceptions, competing uses for water, and the impacts of the current drought. For these reasons the Colorado Water Conservation Board (CWCB) undertook this project. The project was developed to plan, develop and implement an assessment, the Drought & Water Supply Assessment, to engage Colorado water users to:

- Determine how prepared Colorado has been for drought, and
- Identify limitations, and related measures, to better prepare us for future droughts.

The CWCB will utilize this information to reinforce its statewide advocacy focus and role on water issues. Through technical, policy and financial support, the CWCB can aide local water users in planning for and mitigating the affects and impacts of drought. As facilitators of water issues at the state and regional level, the CWCB is also in position to help the water community answer the difficult water rights, water use and water supply questions that will drive future water management and planning in all business sectors and aspects of life.

This report documents the key elements of the Drought & Water Supply Assessment project in two sections, divided into 16 chapters. The first section, which contains eight chapters, presents pertinent background information related to the following topics:

- What is drought and what are its impacts?
- How does a drought impact individual perception of water planning and management?
- How has the state responded to the current drought?
- What are the expected changes in state population and demographics in the coming years?
- What is the legal framework within which drought can be managed?
- What are the existing characteristics of storage in Colorado?
- What tools exist to manage and mitigate drought?
- What structural and non-structural projects may be used to mitigate drought?

The second section of the report presents the planning and implementation tasks performed to develop and administer the assessment, as well as the results of the assessment. The assessment results are grouped into the following categories, presented in individual chapters for ease of reader access:

- Current limitations on water supply
- Current water supply, drought and water conservation planning efforts in place
- Impacts of current drought
- Concerns regarding future water supply
- Structural and non-structural project needs for drought mitigation
- Use of cooperative agreements for drought mitigation and water supply planning
- Potential state policy issues for drought mitigation and water supply planning

A note on the survey scope and applicability

The Drought & Water Supply Assessment was implemented to ascertain the opinions of Colorado's large and small water users that store or divert water for delivery to other water users (e.g., reservoir and ditch companies, state water conservancy districts) and water users that "use" the water directly (e.g., farmers and ranchers, special districts, municipalities, industries). The assessment did not attempt to collect opinions from all Colorado voters, or a subset of representative voters. Therefore, the assessment is invaluable with respect to representing the views and opinions of Colorado's water providers and users (called water users throughout the report).

Chapter 1
Historical Perspectives on Colorado Drought

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What is Drought?

Measuring the Severity of Drought: A Difficult Task

The History and Future of Colorado Drought

Water Availability: Where Does the Precipitation Come From?

Drought Cycles: What Goes Around, Comes Around

Impacts of Drought: What Might the Future Hold?

References

Abstract
Chapter 1 is an introductory chapter and foundation for the rest of the report. It provides the reader with a scientific, yet accessible, understanding of drought. This chapter starts by describing drought and providing a functional definition, discussing the degrees of drought severity and how drought is quantified and its severity measured. The climate patterns associated with drought are also reviewed and analyzed. Next, an historical summary of drought in Colorado is presented, describing our knowledge of the past 300 years (with a special section on tree-ring studies), the past approximately 100 years of existing data, and the droughts of the 1930s, 1950s and 1970s. As part of the historical summary, data accuracy, confidence and length of record are reviewed. Information contained in this chapter is presented at a state and major river basin level. The chapter contains a discussion of the recent drought in Colorado (2000-2003), in context with the historical and scientific information presented. The chapter also incorporates a brief review of current drought literature and resources.

Introduction

Drought is an insidious hazard of nature. Unlike tornadoes, hurricanes, floods and fires, it sneaks up on the unsuspecting as a series of sunny, hot summer days or a period of mild, breezy weather during winter. Drought builds slowly on itself until it has a major impact on human existence. Water supplies dry up, wells run dry and crops wither. If drought is very severe, cities and states may turn on one another to secure adequate water.

A good place to start in the planning of future Colorado water supplies is in the understanding of what is drought, in general, and what is drought in Colorado: its history and its cycles. The Drought of 2000-2003 in Colorado has provided a rude awakening to drought's impacts on modern life. A mandate to respond has been sounded. Decisive but meaningful action requires an appreciation and understanding of nature's power.

"If not us, who? If not now, when?"
John F. Kennedy

What is Drought?

Drought has many different meanings. According to the *Glossary of Meteorology, 2nd edition* (American Meteorological Society 2000), drought is defined as "a period of abnormally dry weather sufficiently long enough to cause a serious hydrological imbalance."

While this may sound like a simple textbook characterization, the definition continues with the following qualification:

> Drought is a relative term; therefore any discussion in terms of precipitation deficit must refer to the particular precipitation-related activity that is under discussion. For example, there may be a shortage of precipitation during the growing season resulting in crop damage (agricultural drought), or during the winter runoff and percolation season affecting water supplies (hydrological drought).

Documents provided by the National Drought Mitigation Center (NDMC 2003) provide further insight into this multifaceted phenomenon.

> Drought is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event. It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another. Drought is a temporary aberration; it differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate.

Drought should not be viewed as merely a physical phenomenon or natural event. Its impacts on society result from the interplay between a natural event (less precipitation than expected resulting from natural climatic variability) and the demand people place on water supply. Recent droughts in both developing and developed countries have underscored the vulnerability of all societies to this "natural" hazard.

Clearly, there is no singular expression of the meaning of the term drought. Not only does the meaning vary with the application context, but it is also subject to regional variation.

How is Drought Classified? (Operational Definitions)

The National Drought Mitigation Center (NDMC) classifies meteorological, agricultural and hydrological droughts as "operational definitions of drought". The NDMC (2003) proves to be an invaluable reference, providing four informative operational definitions of drought.

- *Meteorological drought* is usually an expression of precipitation's departure from normal over some period of time. These definitions are usually region-specific, and presumably based on a thorough understanding of regional climatology. Meteorological measurements are the first indicators of drought.

- *Agricultural drought* occurs when there is not enough soil moisture to meet the needs of a particular crop at a particular time. Agricultural drought happens after meteorological drought

> The variety of meteorological definitions from different countries at different times illustrates why it is folly to apply a definition of drought developed in one part of the world to another:
>
> - Great Britain (1936): 15 consecutive days with daily precipitation totals of less than 0.25 mm
> - Libya (1964): annual rainfall less than 180 mm
> - India (1960): actual seasonal rainfall deficient by more than twice the mean deviation
> - Bali (1964): a period of six days without rain

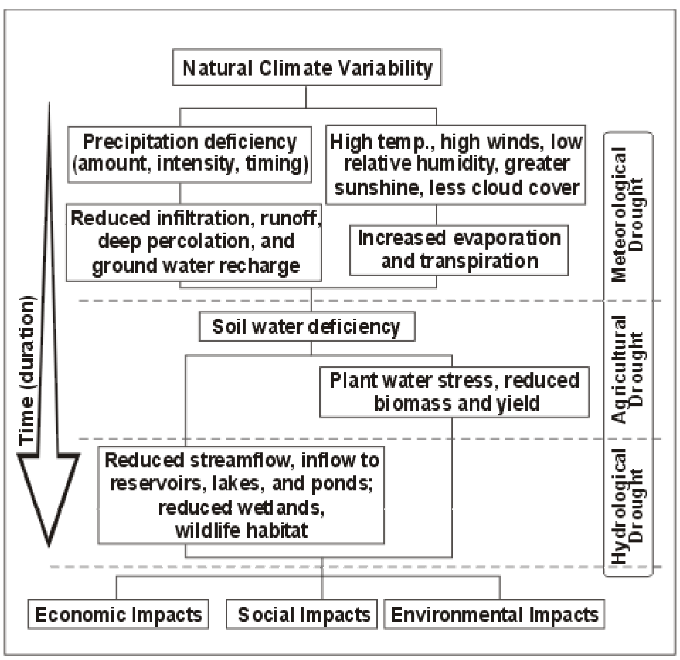
but before hydrological drought. Agriculture is usually the first economic sector to be affected by drought.

- *Hydrological drought* refers to deficiencies in surface and subsurface water supplies. It is measured as streamflow and as lake, reservoir, and groundwater levels. There is a time lag between lack of rain and less water in streams, rivers, lakes, and reservoirs, so hydrological measurements are not the earliest indicators of drought. When precipitation is reduced or deficient over an extended period of time, this shortage will be reflected in declining surface and subsurface water levels.

- *Socioeconomic drought* occurs when physical water shortage starts to affect people, individually and collectively. Or, in more abstract terms, most socioeconomic definitions of drought associate it with the supply and demand of an economic good.

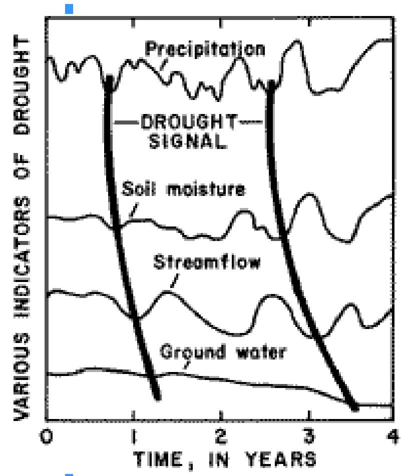
Figure 1-1 illustrates the time lag between meteorological, agricultural, and hydrological drought.

Figure 1-1: Illustration of Operational Drought Definitions (NDMC 2003)



Further, the lag between different components of the hydrology is shown in comparing streamflow and groundwater responses. (Figure 1-2)

Figure 1-2: Time Lag in Hydrologic Drought Response (United States Geologic Survey (USGS) 2003)



Each of the definitions provided above has important contextual implications for the state of Colorado. Taken as a collective whole, these various definitions of drought indicate the variability, complexity, and potential broad-based impacts (e.g., social, economic, etc.) related to the lack of precipitation and the scarcity of water.

Measuring the Severity of Drought: A Difficult Task

In the past 100 years or so, researchers, scientists, and government agencies have established a complex network of instrumentation that is utilized for monitoring climatic variables. The key variables in terms of assessing drought are precipitation, snowpack, and streamflow. McKee *et al.* (2000) state, "these climate observation networks provide important data to analyze current and historic droughts and relate water availability to the observed impacts." Furthermore, years of experience have revealed that the types and levels of drought impacts display a direct relation to the following drought characteristics:

- Magnitude—how large the water deficits are in comparison with historic averages
- Duration—how long the drought lasts
- Severity—combination of the magnitude or "dryness" and the duration of the drought
- Aerial extent—what area is impacted by the drought

Drought Indices

Due to the impossibility of analyzing the voluminous climatic data collected every day in real time, simpler tools are needed to characterize droughts in a manner that can be readily and effectively applied by water supply managers for immediate decision-making and future planning purposes. This necessity has led to the development of a number of drought indices. The NDMC (2003) describes drought indices in a general sense as follows: "Drought indices assimilate thousands of bits of data on rainfall, snowpack, streamflow, and other water supply indicators into a comprehensible big picture. A drought index value is typically a single number, far more useful than raw data for decision making."

A number of computational drought indices, including the Palmer Drought Severity Index (PDSI) and the Standardized Precipitation Index (SPI), have come to prevalence in the scientific community as means for assessing the severity of a drought. Both of these indices are employed by the state of Colorado for drought monitoring and planning purposes. Other common drought indices include the Palmer Crop Moisture Index (CMI) and the Palmer Hydrological Drought Index (PHDI).

The Palmer Drought Indices

Palmer (1965) developed the first quantitative tools that are widely used to assess the severity of drought. Although the specific details of these indices are quite complex, the NDMC (2003) provides simple explanations of each, as presented below. Note that each index correlates to one of the operational types of drought.

> The *Palmer Drought Severity Index,* which relates to meteorological drought, attempts to measure the duration and intensity of long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during the current month is dependent on the current weather patterns plus the cumulative patterns of previous months. Since weather patterns can change rapidly from a long-term drought pattern to a long-term wet pattern, the PDSI can respond fairly rapidly.

Table 1-1: Classifications for PDSI

Value	Meaning
≥ 4.0	Extremely wet
3.0 to 3.99	Very wet
2.0 to 2.99	Moderately wet
1.0 to 1.99	Slightly wet
0.5 to 0.99	Incipient wet spell
0.49 to –0.49	Near normal
-0.5 to –0.99	Incipient dry spell
-1.0 to –1.99	Mild drought
-2.0 to –2.99	Moderate drought
-3.0 to –3.99	Severe drought
≤ -4.0	Extreme drought

> Advantages of the PDSI as an indicator of the severity of meteorological drought, as outlined by Alley (1984) (see Table 1-1), include the following:
>
> 1. It provides decision makers with a measurement of the abnormality of recent weather for a region.
> 2. It provides an opportunity to place current conditions in historical perspective.
> 3. It provides spatial and temporal representations of historical droughts.
>
> The *Palmer Crop Moisture Index,* which relates to agricultural drought, measures short-term drought on a weekly scale and is used to quantify drought's impacts on agriculture during the growing season.
>
> The hydrological impacts of drought (e.g., reservoir levels, groundwater levels, etc.) take longer to develop and it takes longer to recover from them. The *Palmer Hydrological Drought Index* was developed to quantify these hydrological effects. The PHDI responds more slowly to changing conditions than the PDSI.

An additional means for monitoring drought, the Surface Water Supply Index (SWSI), is designed to complement the Palmer indices in the state of Colorado, where mountain snowpack is a key element of water supply. This index is calculated by river basin, based on snowpack, streamflow, precipitation, and reservoir storage (NDMC 2003).

The Standardized Precipitation Index (SPI)

A more recent drought-monitoring tool, the SPI emerged from research conducted by McKee *et al*. (1993). Again, the NCDC (2003) provides a straightforward examination of this index.

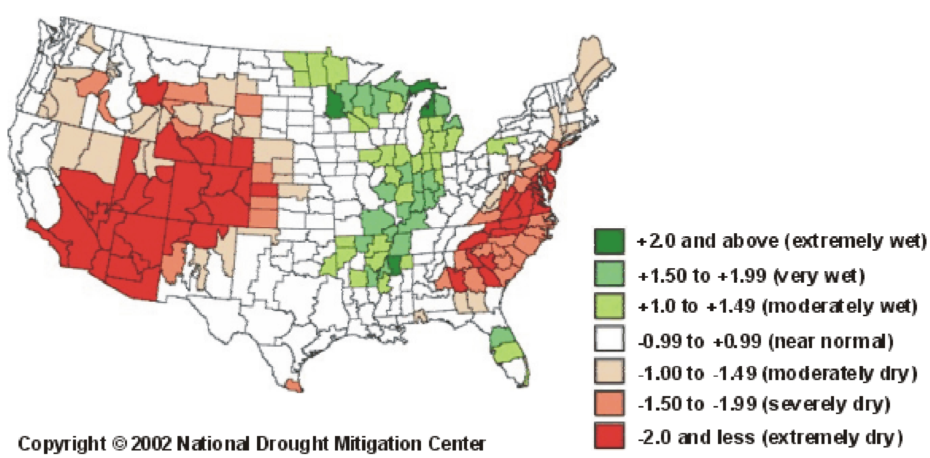
> While Palmer's indices are water balance indices that consider water supply (precipitation), demand (evapotranspiration) and loss (runoff), the *Standardized Precipitation Index* (SPI) is a probability index that considers only precipitation.
>
> The index is negative for drought, and positive for wet conditions (see Table 1-2). As the dry or wet conditions become more severe, the index becomes more negative or positive. The SPI is computed by NCDC for several time scales, ranging from one month to 24 months, to capture the various scales of both short-term and long-term drought.

Table 1-2: Typical SPI Values

Value	Meaning
≥ 2.0	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.0 to –1.49	Moderately dry
-1.5 to –1.99	Severely dry
≤ -2.0	Extremely dry

The SPI has been used operationally to monitor conditions across Colorado since 1994 (McKee *et al*. 1995). The nationwide SPI map presented in Figure 1-3 unmistakably illustrates the severity of the 2000-2003 drought across the entire state of Colorado and much of the southwestern United States.

Figure 1-3: 12-month SPI through End of August 2002 (NDMC 2003)



The History and Future of Colorado Drought

A Look at the Past

The history of drought in Colorado can be traced through the analysis of two important data records. First is the modern, or instrumentation, record consisting of actual measurements of climate variables at various locations throughout the state. This record generally dates from the present back to the late 19th century.

Second is the paleoclimatic record, primarily derived from the analysis of tree rings, and extending backwards through history for several hundred to over a thousand years. This section will begin with a review of the major droughts of the 20th century, followed by a description of paleoclimatic, specifically tree ring, data analyses and a summary of major drought periods throughout the past 2000 years.

Drought is clearly a common occurrence in Colorado, but drought rarely encompasses the entire state at any given time. Key points regarding Colorado drought are as follows:

- The most common droughts are of short duration (6 months or less) with aerial extents that vary with the seasons.
- Multi-year droughts occur infrequently.
- Precipitation data indicate that most weather stations across the state have experienced two or more consecutive years of precipitation less than 80% of average *a few times* during the 20th century.

The most significant droughts of the instrumented period, or since the turn of the past century are listed in Table 1-3. Each drought period is characterized by when it occurred, the worst years of the drought and the portion of the state where the drought was worst.

Table 1-3: Significant Drought Periods of the Modern or Instrumented Era

When	Worst	Major state impact areas
1890-1894	1890 and 1894	Severe drought east of mountains
1898-1904	1902-1904	Very severe drought over southwestern Colorado
1930-1940	**1931-1934, 1939**	**Widespread, severe and long lasting drought in Colorado**
1950-1956	1950, 1954-1956	Statewide, worse than the 1930s in Front Range
1974-1978	1976-1977	Statewide, driest winter in recorded history for Colorado's high country and Western Slope
1980-1981	Winter 1980-1981	Mountains and West Slope; stimulated writing of the "Colorado Drought Response Plan" and the formation of the Water Availability Task Force
2000-2003	**2001-2002**	**Significant multi-year statewide drought, with many areas experiencing most severe conditions in Colorado instrumented history**

Early Turn of the Century Drought
A severe but brief drought occurred in 1890, particularly east of the mountains, followed by a very wet year in 1891. Drought returned in 1893 with severe drought occurring in 1894, again most pronounced over eastern Colorado. This statewide drought preceded a sustained and very severe drought over southwestern Colorado. The worst drought on record occurred in the Durango area during this time.

The Dust Bowl of the 1930's
The major drought of the 20th century in terms of duration and spatial extent is considered to be the 1930s Dust Bowl drought that lasted up to 7 years in some areas of the Great Plains. The Dust Bowl drought, memorialized in John Steinbeck's novel, *The Grapes of Wrath*, was so severe, widespread, and lengthy that it resulted in a mass migration of millions of people from the Great Plains to the western U.S. in search of jobs and better living conditions.

Severe drought developed in 1931 and peaked in 1934 and early 1935, which was interrupted by heavy spring rains in 1935 and more widespread heavy rains in 1938. The decade culminated with one more extremely dry year in 1939 when several stations along the Front Range recorded the driest year in (20th century recorded) history.

...Now the wind grew strong and hard,
it worked at the rain crust in the corn fields.

Little by little the sky was darkened by the mixing dust,
and the wind felt over the earth,
loosened the dust and carried it away.

...from **The Grapes of Wrath**,
written by John Steinbeck.

The Visionary Drought of the 1950's
With the Dust Bowl of the '30's a vivid memory, the statewide drought of the 1950's spurred major development of water storage facilities across the state. The development of the Front Range water supply system may have been a product of the fact that this drought was more severe along

the Front Range than the drought of the 1930's. Its severe impact on the Colorado Front Range and only light to moderate impact on mountain precipitation may have overly influenced water supply planners into using it as a model of sorts since water supply planners developed infrastructure based on drought in the plains and ample mountain snow pack.

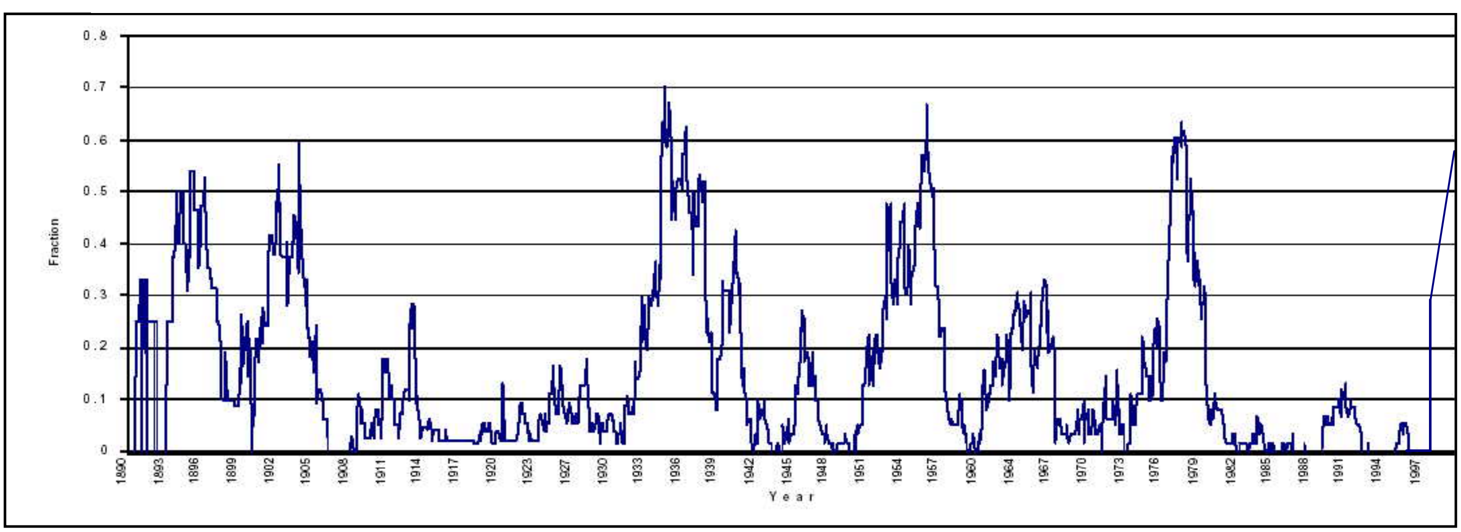
The Severe Mountain Drought of the 1970s

Colorado's last period of sustained multi-year drought in the 20th century occurred from 1974-1981. The record-breaking winter drought of 1976-1977, the driest winter in recorded history for much of Colorado's high country and Western Slope, culminated this drought. Statewide weather modification activities were launched during the winter seasons with hopes of increasing the mountain snow pack. Only limited success was reported before snows briefly returned to the mountains for 1979-1980.

An extreme, but brief, drought period returned for the fall of 1980 into the summer of 1981. This drought most dramatically impacted Colorado's high country and ski industry, and initiated a huge investment in snow making equipment. It also stimulated the writing of the "Colorado Drought Response Plan" and the formation of the Water Availability Task Force, which has been meeting at least once a quarter each year since 1981.

Many of the drought dates presented in the preceding discussion and table are mirrored in the time series plot shown in Figure 1-4. The plot shows the fractional percent of Colorado immersed in at least moderate drought from 1890 to 2002. It is clear that the most prominent droughts in recorded history, those with the longest time-span and largest aerial extent, occurred at the turn of the twentieth century (1890s-early 1900s), the 1930s, the early- to mid-1950s, the mid- to late-1970s and the recent 2000-2003 drought.

Figure 1-4: Fraction of Colorado in Drought Based (McKee et al. 2000) with est. 2000-2003

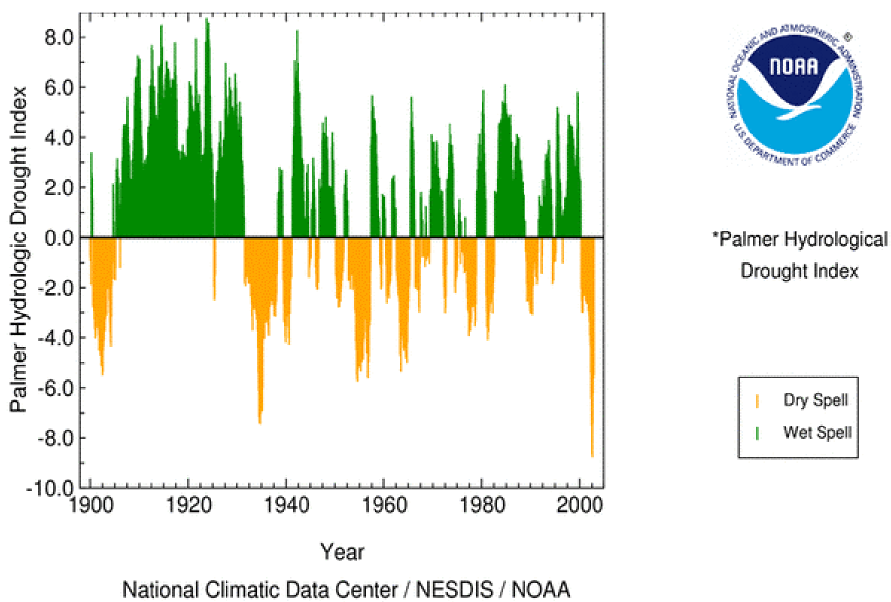


Drought of 2000-2003

The severity of the 2000-2003 drought eclipsed many of the records established during 20th century droughts, including those of the 1930s, 1950s, and late 1970s.

The comparative magnitude of this drought to other Colorado droughts is represented graphically in Figure 1-5. The 2000-2003 drought produced the lowest Palmer Hydrologic Drought Index seen during the modern (instrumental) period of record.

Figure 1-5: Colorado statewide PHDI*, January 1900 - December 2002 (NCDC 2003)



During the drought of 2000-2003, scientists at Hydrosphere and the National Atmospheric and Oceanic Administration (NOAA) collaborated to identify several tree ring records that correlate well with natural flows in Boulder Creek. From these tree ring records, they were able to generate estimates of stream flows in Boulder Creek that extend back as far as 1703.

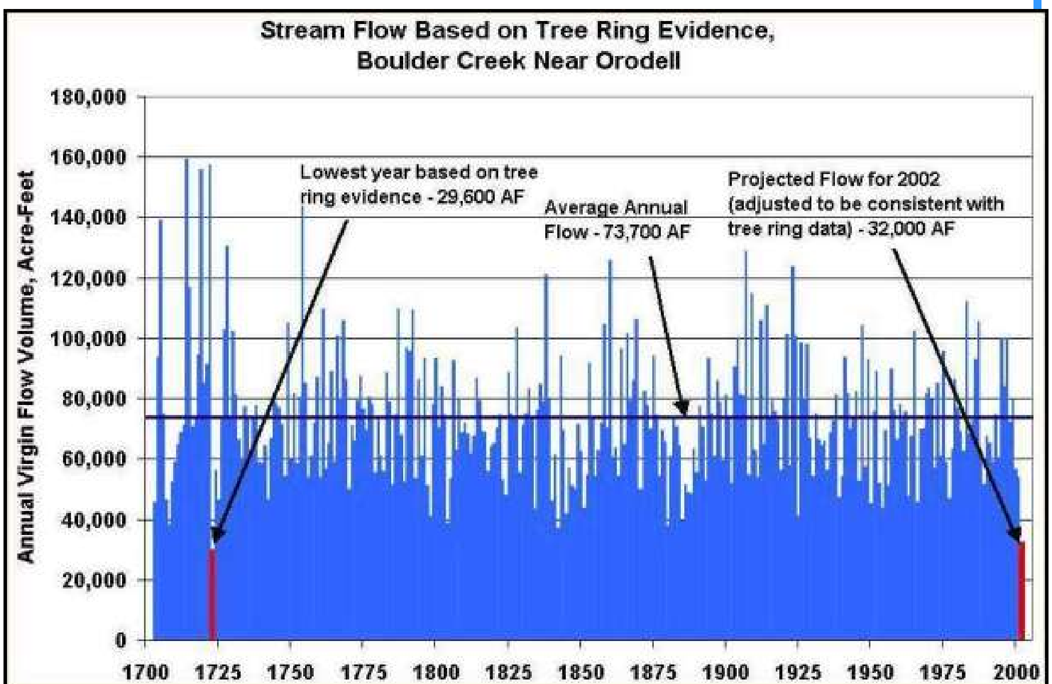
The data depicted in Figure 1-6 show that the 2002 stream flows are the lowest that have occurred since 1725. Not only that, but the data analyzed in tt that droughts lasting more than 15 years have occurred several times within the past 300 years (Hydrosphere 2002).

Hydrosphere qualified the regional significance of the study, saying, "Boulder Creek is fairly representative of most of the northern Front

Range and most of the tributaries into the Colorado-Big Thompson [system] as well" (Associated Press 2002).

More than half the state has been in moderate drought during the droughts of the 1890's, 1930's and the current drought of 2000 – 2003. However, short-term droughts (3-month duration) have previously covered as much as 80% of the state, and longer-duration droughts (2-4 years) have encompassed as much as 70% of the state.

Figure 1-6: Streamflow on Boulder Creek Based on Tree Ring Analysis near Ordell, Colorado that Shows the Comparative Impact of Droughts since 1700.



The question remains how this drought compares to historical droughts of the past 300 to 500 years. Paleo-climatology may provide that insight.

Paleo-Climatology of Colorado Droughts

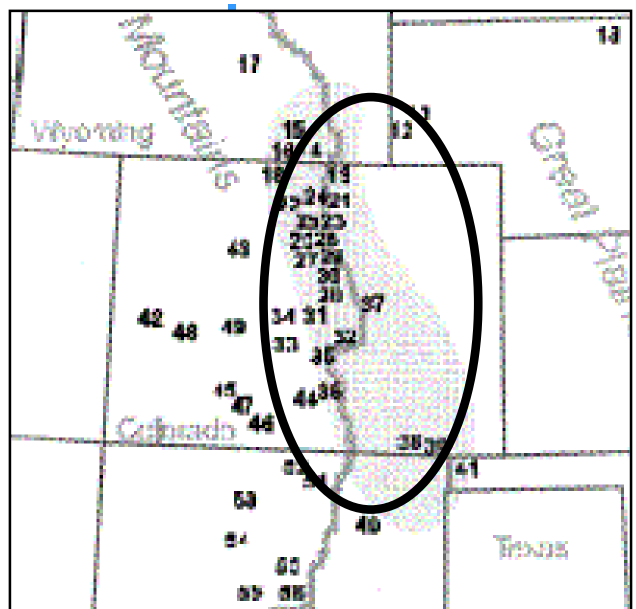
Investigation of droughts that pre-date the instrumentation period falls within the realm of paleo-climatology. Tree rings can be utilized to reconstruct records of past climate, including precipitation, drought, stream flow, and temperature. Trees at mid- to high-latitudes, such as those found in Colorado, grow one ring per year, and the most recent ring is formed inside the bark.

Trees can grow to be hundreds to thousands years old and can contain annually-resolved records of climate for centuries to millenia.

A wealth of long-lived, moisture-sensitive trees in this state make possible the generation of high-quality stream flow reconstructions that extend 300 to over 500 years into the past. Variations in ring widths that are common from tree to tree reflect droughts and other anomalies in climate (Woodhouse 2003).

As depicted in Figure 1-7, the identified core area (the shaded region) of the 1845-1856 drought encompassed much of southeastern Colorado and the Front Range.

Figure 1-7: Core area of 1845-1856 Drought (Woodhouse *et al.* 2002)



Were a drought of this severity and duration to occur here today or in the future, it would have, Woodhouse warns us, "considerable impacts now that the area now includes a major, rapidly expanding metropolitan area as well as large-scale crop and livestock production." These impacts would have widespread significance for Colorado's society, economy, and ecology.

In their review of Great Plains droughts over the past 2000 years, Woodhouse and Overpeck (1998) summarize, saying "the paleo-climatic data suggest a 1930s-magnitude Dust Bowl drought occurred once or twice a century over the past 300-400 years, and a decadal-length drought once every 500 years."

Elaborating on these conclusions, the authors report the following:

> Historical documents, tree rings, archaeological remains, lake sediment, and geomorphic data make it clear that the droughts of the twentieth century, including those of the 1930s and 1950s, were eclipsed several times by droughts earlier in the last 2000 years, and as recently as the late sixteenth century. In general, some droughts prior to 1600 appear to be characterized by longer duration (i.e., multidecadal) and greater spatial extent than those of the twentieth century (Woodhouse and Overpeck 1998).

Table 1-4: Occurrences of Wet/Dry Decades from 1500-1995 based on Tree-ring Growth Index at Colorado Data Points

Millennia	Wet	Decade	Very Dry	Decade	Total Events
1500's	3	20's, 60's, 90's	2	00's, 70's	5
1600's	3	20's, 40's, 60's	2	30's, 70's	5
1700's	2	10's, 50's	2	10's, 30's	4
1800's	2	20's, 30's	2	50's, 60's	4
1900's	2	10's, 20's	2	30's, 50's	4
Totals	12		10		22

The data in Table 1-4 is based on an analysis of the occurrence of wet and dry decades based on the tree-ring PDSI of four data points in Colorado (Henz and Badini, 2002). The four data points were used to analyze the occurrence historically of droughts in the northeastern, southeastern, southwestern and northwestern areas of the state.

Analyses of the Colorado sites produced depictions of wet and dry decades. However, a number of dry decades that affected only the western or eastern half of the state were evident. It should be noted that at least one dry decade affects the entire state each millennia.

From this historical perspective it appears that the current drought of 2000 – 2003 likely has been exceeded in duration, intensity and coverage by historical droughts of the past.

> ***"the paleoclimatic data suggest a 1930s-magnitude Dust Bowl drought occurred once or twice a century over the past 300-400 years, and a decadal-length drought once every 500 years"..***
>
> ***Woodhouse and Overpeck (1998)***

Water Availability: Where Does the Precipitation Come From?

To better appreciate the forces at work during a period of drought in Colorado, the variability in precipitation across the state from both the perspective of location and time must first be examined. Figure 1-8 depicts the annual precipitation found across the state; observe that annual precipitation and elevation are well correlated. By simply examining this figure and Figure 1-9 immediately below it, one can infer the locations of the highest terrain in Colorado. The topography of Colorado has a major influence on the distribution of precipitation across the state.

Figure 1-8: Colorado Average Annual Precipitation (WRCC 2003)

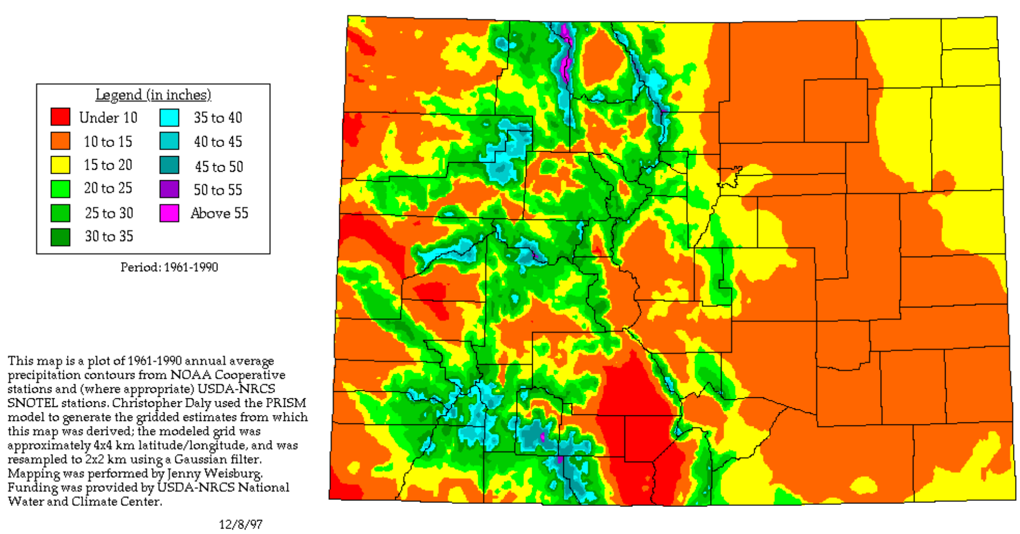
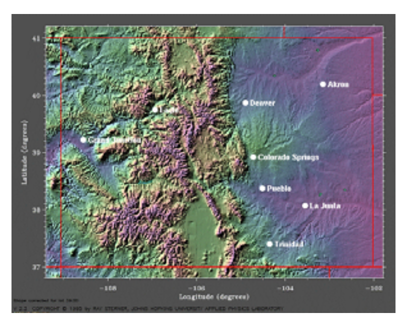
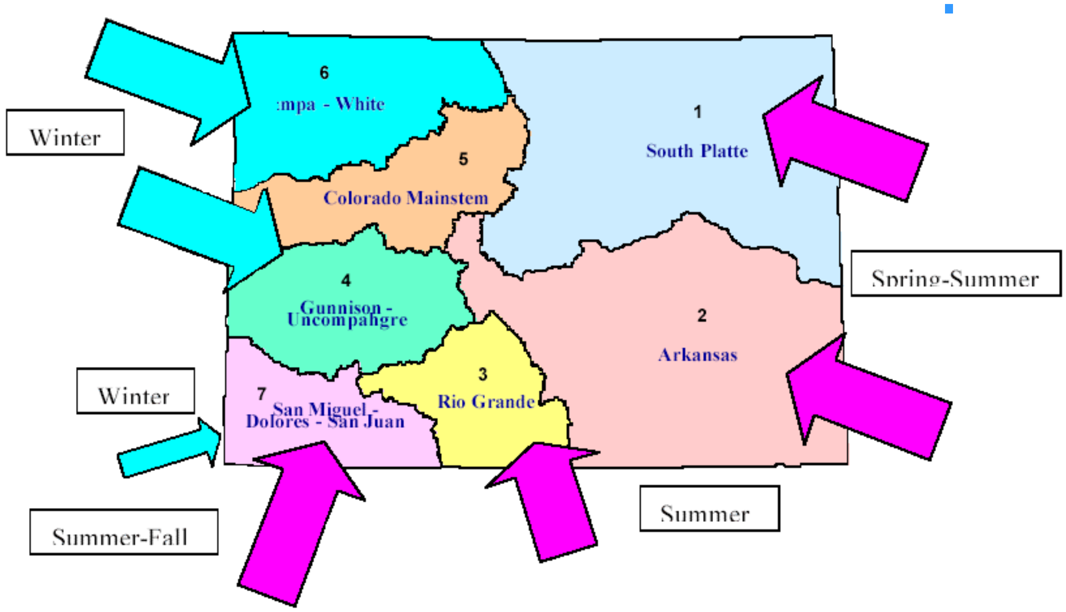


Figure 1-9: Colorado Topography



Wind, Topography and Precipitation
The sources of atmospheric moisture are depicted in Figure 1-10. Clearly the mountainous areas of the state are affected by moisture bearing winter winds from the west to northwest. The southwestern mountains favor wet winds from the southwest from summer into fall and winter. Upslope easterly winds from spring into summer bring green fields to the eastern half of the state and the southern mountains. Thus weather factors that influence the seasonal frequency and moisture content of these winds have a major impact on Colorado's precipitation.

Figure 1-10: Sources of Atmospheric Moisture in Colorado (McKee *et al*. 2000)

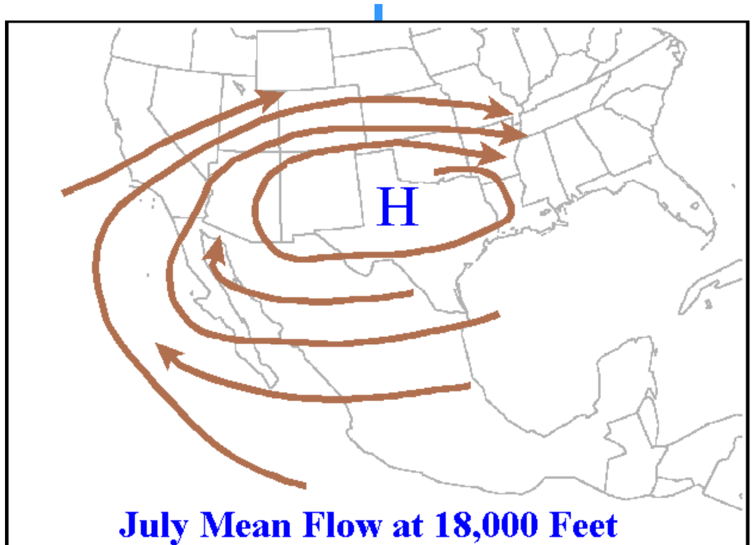


A majority of the seasonal snowpack that accumulates across the higher mountain ranges of Colorado is produced between late fall and early spring. This time period is of particular interest because it is estimated that up to *80% of Colorado's surface streamflow* originates from snowpack that accumulates during this period before melting in the April to July time frame.

During the summer and early fall, the jet stream becomes notably weaker, if not absent, and convective (i.e. thunderstorm) activity becomes the primary source of precipitation. The moisture for this thunderstorm activity derives largely from the pattern commonly referred to as the Southwestern Monsoon. The monsoon area is defined by a general area of high pressure, or ridge, in the mid levels (~7,000-20,000 ft. above sea level) of the atmosphere that develops over southern New Mexico/western Texas (see Figure 1-11). The inflow of monsoon moisture is determined by this flow. The clockwise flow of moisture around this area of high pressure introduces moisture into Colorado from both the Gulf of California and the Gulf of Mexico.

The data in the Figure 1-11 is analogous to an area of high pressure at approximately 18,000 feet above sea level. Droughts that have occurred during the summer and early fall period are typically associated with an unseasonable northward migration of this area of high pressure resulting in two physical impacts.

Figure 1-11: Long-term Average of the 500 MB Height Field for July (from Douglas 1993)



The first impact would effectively funnel the rich sub-tropical moisture to areas further west of Colorado in the direction of California, Arizona, and Utah. The second impact is that a more local presence of this mid-level ridge over the state can result in relatively warmer temperatures at these levels.

Unseasonably warm air (between 10,000 and 20,000 ft above sea level) can act as "a lid on the atmosphere," acting to suppress the strength of convective activity across the region, which reduces the occurrences of summer thunderstorms. The longer-term persistence of this ridge over Colorado can result in below-normal amounts of precipitation on a more widespread basis.

Jet streams, Storm Tracks, El Niños and La Niñas

The production of precipitation across the state is attributed to the general positioning and strength of the jet stream, which typically traverses the state in a west-to-east direction during winter and spring. A majority of the moisture that falls across the state originates from the Pacific Ocean. This moisture is essentially transformed into precipitation by the following mechanisms, either singularly or in combination:

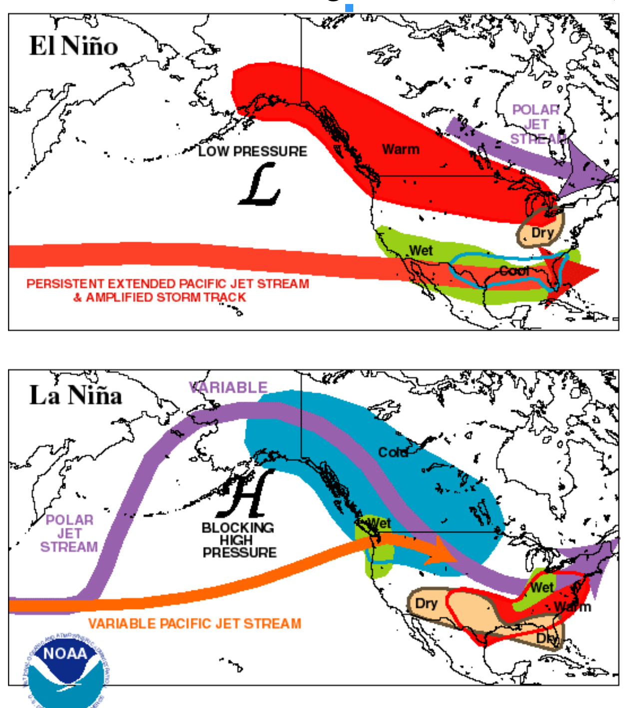
1. Strong lifting by individual storms traveling along the jet stream, and
2. The forcing of air across the mountains barriers, which also provides the lift needed to cool and condense water vapor in the air and produce precipitation.

In early spring, Pacific-based storm systems can effectively draw in low-level moisture from the Gulf of Mexico and generate exceptionally high amounts of precipitation east of the Continental Divide (a fine example of this scenario is the mid-March blizzard of 2003 across the northern Front Range).

To assess the impacts of drought during the late fall to early spring period, one should look at the longer-term positioning of the jet stream at this time of year and the factors that may influence it. The dominant cause of wintertime jet stream variability over western and central North America is the El Niño/Southern Oscillation (ENSO), which is essentially a shifting of relatively warm and cold surface waters and subsequent wind patterns across the equatorial Pacific Ocean. The general effects of El Niño and its counterpart La Niña can be found in Figure 1-12.

In general, El Niños are typically associated with conditions of higher moisture over Colorado while La Niñas have been typically been associated with drier than average conditions over the state during winter. These relationships tend to be more robust in the southern regions of the state. However, it should be noted that the extreme, nearly statewide drought during the winter of 2001-2002 ENSO was not in a conclusive El Niño or La Niña state. Regardless of the state of ENSO or other climatic factors that are currently being examined, either a lack of Pacific moisture, a lack of storms with the jet stream (in strength or numbers), or both can be linked to periods of wintertime drought.

Figure 1-12: Typical January-March Weather Anomalies and Atmospheric Circulation during Moderate to Strong El Niño & La Niña (CPC 2001)



Climate Prediction Center/NCEP/NWS

In La Niña years, the Pacific storm track tends to migrate further to the north and is already in a less-than-ideal position to bring an adequate amount of storms in terms of numbers and intensity for precipitation generation. La Niña years have had a greater tendency to produce drier-than-normal springs across the Front Range.

Note that in Grand Junction and Denver, El Niño years tend to produce more precipitation than in La Niña years. In Grand Junction the impact is more noticeable as a reduction of late summer and fall precipitation during La Niña years with lesser winter and spring impacts noticeable. In Denver both winter and summer precipitation is higher during El Niño periods. The heaviest El Niño precipitation in Denver is evident from late February into early June. The recent Saint Patrick's Day snowstorm of March 17-20, 2003 is an excellent example of an El Niño-assisted major precipitation event.

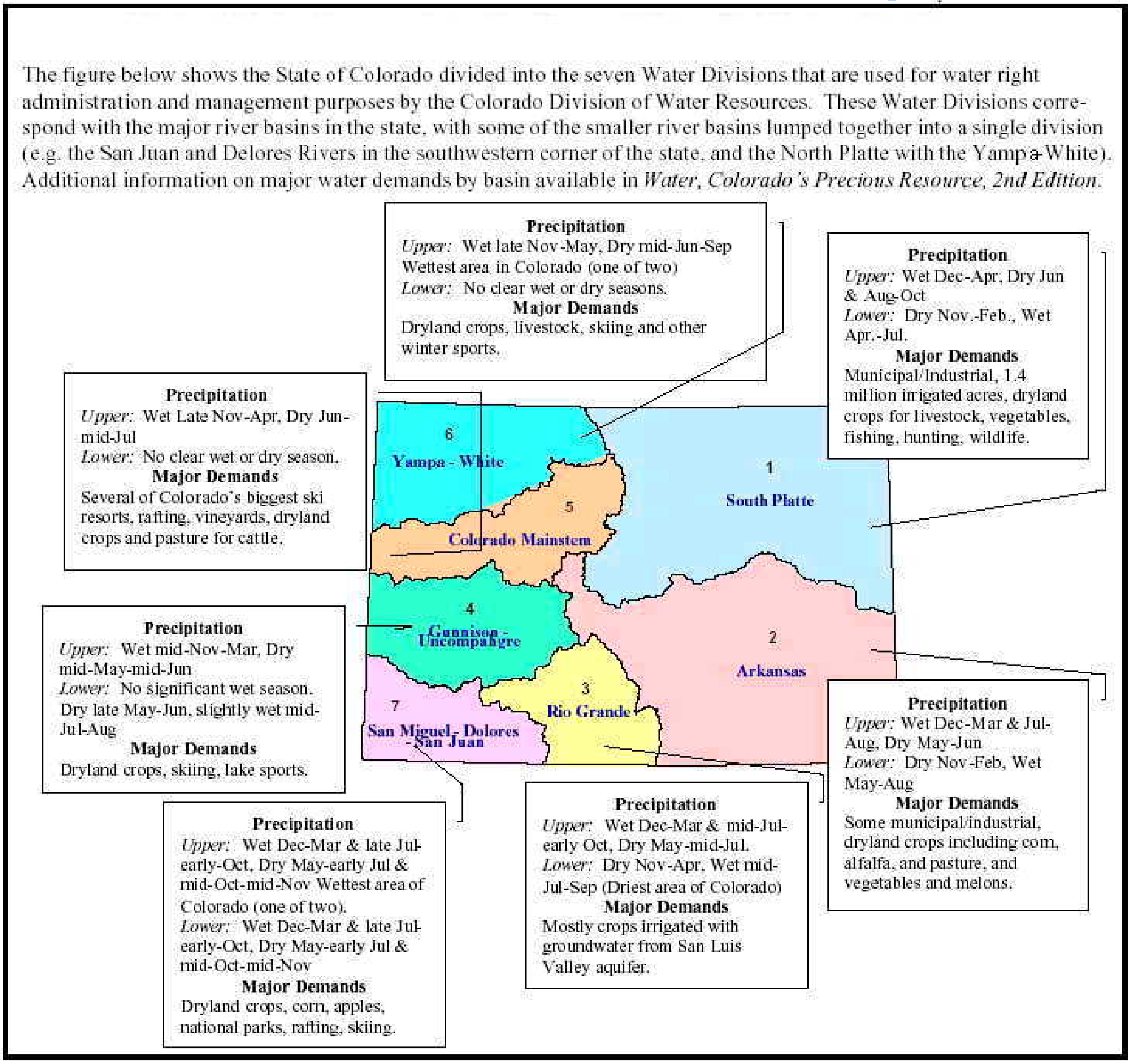
El Niño tend to create wet years statewide.

La Niñas tend to create multi-year dry periods that can accelerate into extended droughts.

Precipitation Variability across Colorado's Major River Basins

Due to the variability in climate and topography that define Colorado's landscapes, it is important to have an understanding of drought at a watershed level. "For many water management and planning

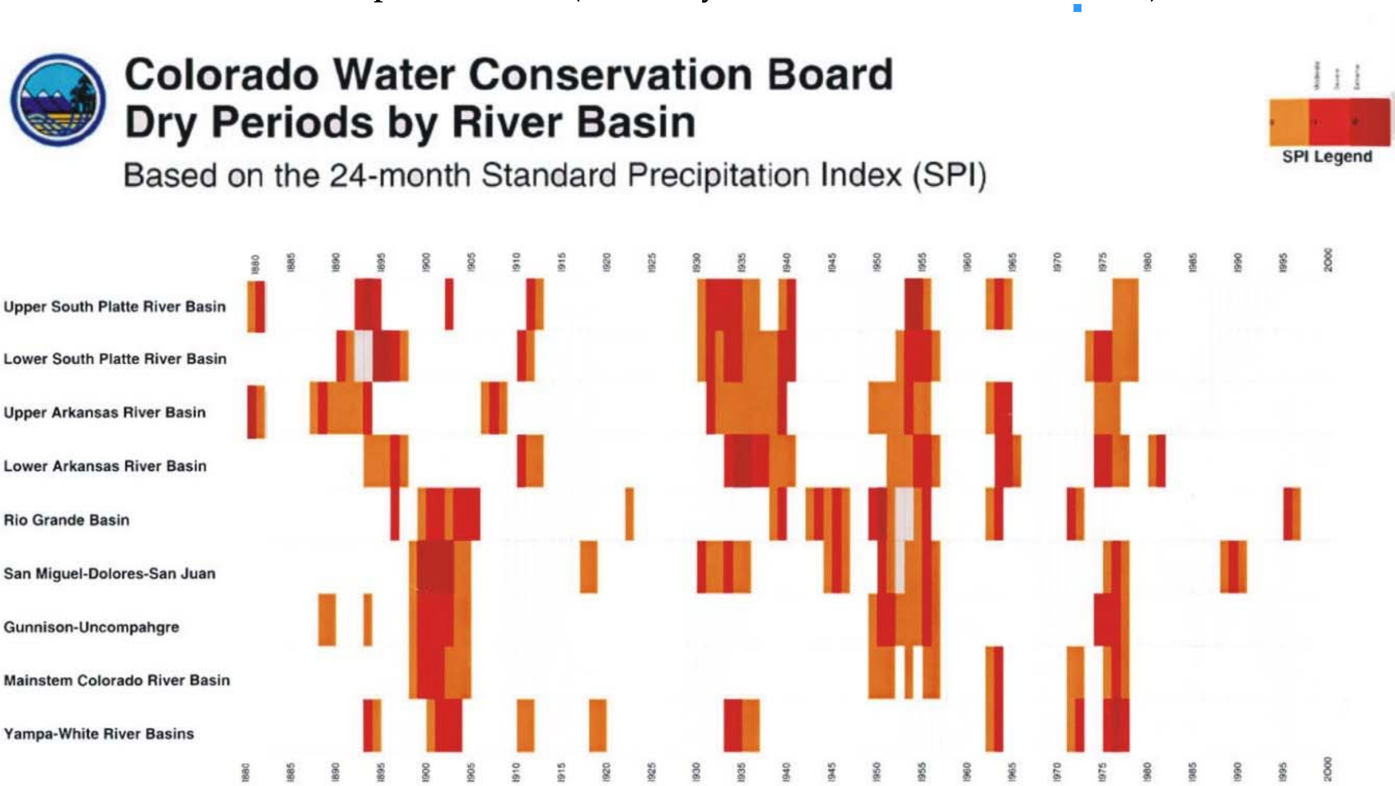
Figure 1-13: Major Water Demands in the Seven Colorado Water Divisions (McKee *et al.* 2000)



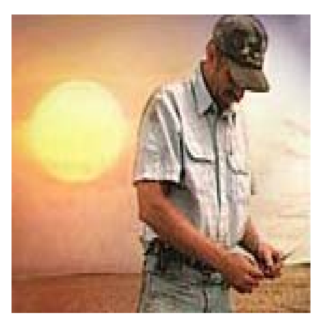
applications," reports McKee *et al.* (2000), "Colorado is divided into seven water divisions. Each of these basins originates in high mountain environments and descends through mountain valleys and eventually drops to much lower elevations. Thus, we can roughly divide each basin into an upper and lower basin based on approximate elevation and mountain proximity." A general picture of typical wet and dry periods in Colorado, as well as the principle demands in each water division, is provided for each of the seven major Colorado River basins (Figure 1-13). Note the great variability in precipitation across different seasons and different regions. An understanding of the various regional demands is important in order to determine the impacts of drought on a particular area of the state.

Figure 1-14 was prepared by the Colorado Water Conservation Board (CWCB) and presents the periods of moderate, severe, and extreme drought by basin since the late 1800s. The figure shows that major droughts rarely impact all of Colorado's major river basins simultaneously. When they do, as noted in the 1890's, the 1930's, the 1950's and the 1970's, the impacts are significant. On the other hand, many regional droughts occur almost every decade that impact only one or two basins for periods of one to two years.

Figure 1-14: Plot of Drought Severity by Year for Major Colorado River Basins based on 24-Month Standard Precipitation Index (created by CWCB, Stanton and Busto, 1997)



Drought is a very frequent visitor to Colorado. Single season droughts with precipitation of 75% or less of average for one to three months in a row occur nearly every year in Colorado. Based on long-term weather station records, it was observed that at least 5% of the state is experiencing drought on 3- to 24-month timescales almost all of the time (McKee *et al*. 2000).



Drought Cycles: What Goes Around, Comes Around

Many drought observers insist that drought cycles exist. Some suggest that the sunspot cycle of 11 years or a "double sun spot cycle" of 22 years controls Colorado's drought patterns. Others claim that a 3- or a 7-year cycle exists in local or regional drought occurrence. An extensive review by the Colorado Climate Center to identify drought cycles was inconclusive.

An example of how new information can be developed through "database mining" can be seen in Table 1-5. Table 1-5 shows a comparison from 1900 to 1999 of decadal occurrences of basin-specific annual precipitation that is 2 inches or more above or below average. The base annual precipitation information was derived from the Western Regional Climate Center database.

Table 1-5: Comparison of the Number of Annual Basin Precipitations +/- 2" of Average/Decade

Basin	00's		10's		20's		30's		40's		50's		60's		70's		80's		90's		Totals		100 year Results
Above/Below	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	
Platte	0	0	3	0	2	0	1	5	1	0	0	2	1	5	0	1	0	0	3	1	11	14	-3
Colorado	1	4	3	0	4	1	0	3	1	0	2	4	0	3	0	2	5	1	3	1	19	19	0
Arkansas	2	0	3	0	4	0	1	3	3	0	1	5	2	4	0	4	0	0	2	0	18	16	2
Rio Grande	0	4	1	0	2	0	0	9	1	1	0	5	1	0	1	4	2	0	6	2	14	25	-11
Total	**3**	**8**	**10**	**0**	**12**	**1**	**2**	**20**	**6**	**1**	**3**	**16**	**4**	**12**	**1**	**11**	**7**	**1**	**14**	**4**	**62**	**74**	**-12**
Difference	**-5**		**10**		**11**		**-18**		**5**		**-13**		**-8**		**-10**		**6**		**10**		**-12**		

A = Years with annual basin precipitation of equal to or greater than 2" above average.

B = Years with annual basin precipitation of equal or greater value than 2" below average.

In Table 1-5, the droughts of the 1930's, 1950's and the 1970's show up as significant decades of below average precipitation in Colorado's major river basins (as indicated by the negative number in the "Difference" row). Wet periods are indicated by the positive numbers in the "Difference" row. Note that the two wet periods of the past century (the 1980's and 1990's) appear to provide less durational impact than the entire extended dry period of the 1930s through the 1970s.

Impacts of Drought: What Might the Future Hold?

Drought will be a continuing unwelcome aspect of Colorado's climate. Despite all the good science applied to understanding drought, considerable uncertainty exists in trying to anticipate its arrival, duration, severity and departure. The only thing certain is that drought will come again.

Henz and Badini, 2002 attempted to take a bold look into the future of Colorado's climate from 2000 to 2075. Their look ahead, shown in Table 1-6, predicts several periods of state-wide drought in the future. Of particular concern, an extended period of drought appears likely within the next 50 years. This result should not be considered unrealistic given the paleo-climate research results reported earlier.

Table 1-6: Trend Analysis of a Blended Climate Data Set for Average Precipitation in the Major Colorado River Basins from 2000 to 2075

Time	Precipitation/ weather factors outlook
2000-2009	An "average" decade marked by an early drought and wet El Nino
2010-2019	**Significant multi-year drought likely due to extended La Nina**
2020-2029	Drought gives way to a "mildly wet" strongly El Nino decade
2030-2065	**Extended period of drought possible as La Nina is enhanced**
2065-2069	El Nino returns to bring a wet end to the decade
2070-2079	An extended period of above average precipitation returns
	Note: This outlook is experimental

An extended drought may have chased the ancient Anazazi Indians from their dwellings in the Mesa Verde area. If a similar strong and protracted drought were to occur over the next 100 years it would cause major impacts on Colorado residents and their way of life. The drought of 2000-2003 has shown that major impacts on our quality of life and water supplies can be inflicted by short-term drought.

"Those who do not remember the past are doomed to repeat it."

George Santayana (1863 – 1952)
American Philosopher
The Life of Reason, Volume 1, 1905

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Abstract
Recurrent droughts are a real and sometimes critical influence on life in Colorado. Although drought does not have the immediate impact of other extreme weather conditions such as flooding, it nonetheless influences businesses, personal security and freedom, and overall quality of life for everyone in the State. To capture and relate an understanding of the impact of drought on individuals and their perspectives, several people whose work and lives are influenced by water availability were interviewed for this report. The primary focus of the interviews was on how drought has impacted their businesses and their lives, and over what period of time they expect these impacts to persist.

Introduction

The impacts of drought can be partly described in terms of dollars and cents, business losses, and balance sheets. However, drought also has dramatic impacts on individuals, their families, and their quality of life beyond purely economic metrics. To gain an understanding of some of the social impacts of the most recent drought in Colorado, a small group of business persons representing different parts of the state and different economic sectors directly impacted was interviewed. The resulting discussions with these individuals on their perceptions of drought are used to illustrate some short-term and long-term impacts to businesses, families, and communities. Here, we hope to show that there is great variety in how drought directly impacts people, and also that the indirect impacts are widely experienced. Drought is one stress among many, and the resilience of any firm, farm, or family is affected by the whole of its social and financial environment. The policy question we face is how to learn from those experiences, and adapt our mitigation and planning responses to better minimize impacts and the damage done by drought.

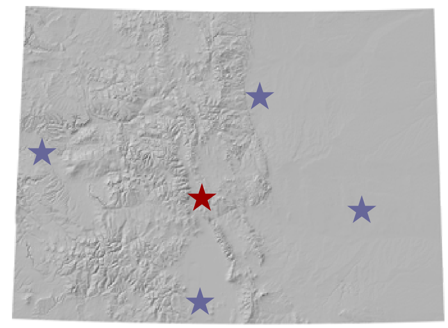
Interview Process

To better characterize the impact of drought in Colorado at an individual level, five individuals were interviewed in June 2003. The interview was an open conversation between an interviewer and the selected individual, beginning with an opening statement that the purpose of the interview was to generate an understanding of how the individual's life and work were impacted by the recent drought and across what time horizon did he or she perceive the effects of drought persisting. To respect the privacy of those interviewed, names are not used in the case studies, though geographic location and business of each interviewee is provided.

Case Studies

Profile 1: Owner and Operator, Rafting Company on the Arkansas River

The owner of a rafting operation on the Arkansas River detailed the ways the drought "definitely affected us on a number of levels." Business did not completely stop on the Arkansas, although he mentioned that "friends on other rivers shut down." His business was down about 20% in 2002 (compared to what he believes was an average of 40% for other rafting companies). Flows were "way below average, but we were still able to operate." Additional costs were accrued in operating under such low flows, especially by running more boats with four rather than seven customers per boat and accounting for wear and tear on boats. Reduced revenue was also realized due to lower visitation numbers because peripheral sales such as wet suit rental and post-trip purchases of t-shirts and photos (customers tend to buy more after a trip if it was exhilarating) were lower. He also had to shut down after Labor Day rather than operate into October as in a non-drought year because of the low level of the river.



Rafting Company, Arkansas River

The drought affected his staff and hiring directly. River guides are paid by trip, so he did not need to cut staff from this end of the business in 2002, though guides experienced significant fatigue and stress to backs and shoulders as they navigated a river with more exposed rocks, worked harder to row and navigate without the current's assistance and had to dislodge more boats run ashore or stuck on rocks. As for office staff, he usually hires about four to five full time staff between two offices. For the 2003 season he has only hired two and may bring on one more. He also had to delay his office manager's start date by over three months. Although he was able to secure a line of credit for the off-season, it was 75% larger than in 2001, which will be a significant debt to repay and is part of the reason for his reduced office staff. In terms of capital, he has halted as much spending as possible on fiscal outlays such as marketing, paddles, rafts and a new van.

> *"Interest in rafting has come back better than anticipated, but I still think we are on a three to five year recovery period before things are humming like they were in 2001."*

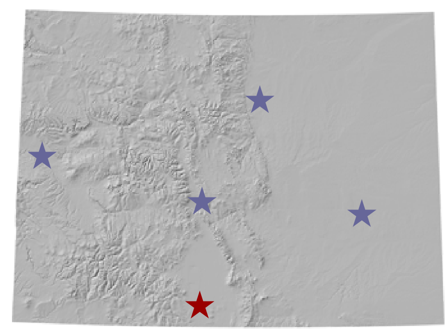
As for how long the impacts may persist, he said that "Interest in rafting has come back better than anticipated, but I still think we are on a three to five year recovery period before things are humming like they were in 2001." It will be necessary to recover from the lower receipts in 2002 as well as the longer-term impacts of curtailed marketing—with revenue down, there was not money to spend on marketing for 2003. He may be facing an even longer-term adjustment prompted in some ways by the drought. He is considering moving from the rafting business to concentrate fully on his fly fishing company. He had been casually considering such a change, but said that the "drought helped me focus. … I have some questions about how viable the [rafting] industry is in the future and don't think I would have been brought into that thinking without the drought." He sees a long-term prognosis for low flows in the Arkansas, which would be difficult for rafting but not as harmful for the fisheries. Hence it appears that this drought has prompted him into reconsidering his business choices.

Profile 2: Farmer and Cow Calf Rancher, San Luis Valley (family ranch since 1883)

We have been "definitely affected in this drought" were the words that started this interview. The drought had and continues to have significant impacts on his business and those throughout the San Luis Valley. Both the extent of impacts and time horizon can be understood through some of the following observations. Since the drought began, he has sold one third of his herd and shipped another third to Missouri with a two year contract, which with the continuing dry conditions may need to be extended another two years. The cattle sold would take several years to replace once wetter conditions return. (Herds often include generations of breeding for a given rancher's preferences and experience, and as such can take many years to create.) The costs to freight cattle to Missouri are $40 per calf each way, so his profit margins drop. "The operation costs on the ranch go on even without the calves." He also commented that "Without a doubt this [drought] has been the hardest thing facing the valley rancher. He won't come out without many years of hard work." Discussing the permanence of impacts, he mentioned that "The next few years will be a critical time for the rancher because he sold the goose that lays golden egg," meaning that ranchers, in selling their cattle, have risked future profits to stay in business today. He added that "People talk about drought as if it was just one year but the real blunt will last a long time. It will vary between five and ten years and some will sell the place out and that's it. . . Lots of real estate and permits are for sale at a sacrifice price. This is going to be, and is, very serious." To wit, financial losses this year reduce the ability of many agricultural businesses to withstand new stresses, and reduce the ability of farmers and ranchers to take advantage of new opportunities, or resist invitations to "cash out," perhaps accelerating the changes in land use in rural areas.

This way of life, which is already at risk, is seriously threatened by drought conditions such as those experienced recently. This rancher added that you "can't measure business entirely by the dollars." He has one son who left the ranch and successfully pursued a different career. Another son and his family are on the ranch, and while his son

"Without a doubt this [drought] has been the hardest thing facing the valley rancher. He won't come out without many years of hard work."

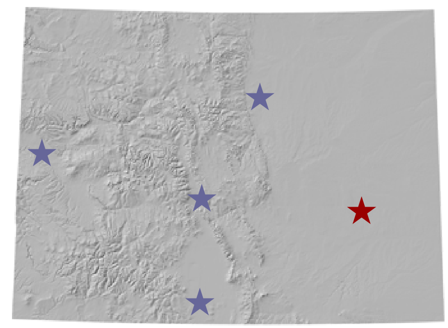


Farmer and Rancher, San Luis Valley

"People talk about drought as if it was just one year but the real blunt will last a long time. It will vary between five and ten years and some will sell the place out and that's it."

may think of leaving, the grandchildren love the ranch life. To him, one of the purposes of ranching is "to train kids to work and be responsible, contributing citizens." The sense of stewardship and commitment to the land is important to many ranchers and farmers. Insomuch as public support exists for preserving farms, ranches and open space, the public interest is affected by the detrimental impacts of drought on agricultural business as well.

Profile 3: Dry Land Farmer, southeastern Colorado (Kiowa County)
"Yes, it's definitely affected our life and lifestyle and not just the farmers." Our conversation started with an emphatic statement that the drought has significantly impacted this farmer's life. Interestingly, though the effects felt on his farm were discussed later in the conversation, the issues he thought deserved primary attention were the ripple (indirect or secondary economic) effects felt by the entire rural community in an agricultural area when farming is affected. "It [drought] has been devastating on the whole community." One very direct example was that while in a non-drought year he puts approximately 800 hours on the five or six tractors they normally run (they always change oil every 200 hours), in 2002 they changed oil only one time on only one tractor. This illustrates not only the reduced production on his farm, but the ripple effect of fewer gallons of fuel purchased and parts that did not need to be replaced by parts suppliers. His spending on fertilizer dropped from an average of $200,000 annually to $40,000 in 2002. That reduced spending directly impacted the local fertilizer cooperative. Another interesting ripple he observed relates to the school system. In Colorado, where schools receive funds in relation to the number of children attending classes, over 20 children from all grades have left in the past two years. With 80 students enrolled in the high school, this means that the school operating budget was significantly cut.



Farmer, Kiowa County

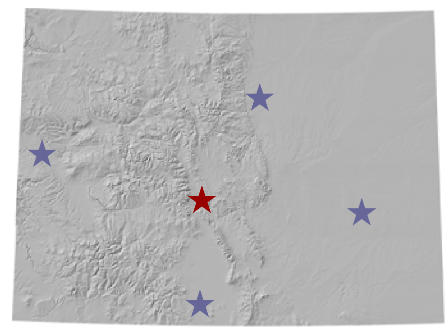
> *"Yes, it's definitely affected our life and lifestyle and not just the farmers."*

In discussing the scope and duration of impact, the Kiowa County farmer's first response was "Boy, it's almost too early to say." At his farm, which normally produces wheat, corn, milo (sorghum) and sunflowers, yields and income have been down drastically for the past three years. He has seen basically no returns on wheat crops in the past three years. Last winter, of approximately 12,000 acres of wheat planted, only 3,000 could be harvested. In the larger community, it is clear that the impact for some families has been life-changing and permanent. For example, one employee was laid off at the local fertilizer company and left Colorado with his family for a new job in Texas.

Drought in eastern Colorado has persisted for three years according to this farmer. The duration of impact of the drought may be determined in 2003. In order to recover from the previous years, he needs to have successful crops, which means "farming like before the drought." This includes planting crops and applying all of the accompanying fertilizers, pesticides, and other crop inputs. In order to raise good crops, he needs "to put money into the land. If something were to happen and we don't [produce a crop], we would be devastated." So the impact of this drought will be a more medium term phenomenon if this year is a wetter one than the last few years. If drought conditions persist, "we would be done and I assume that most everybody else would be too." Therefore, the real impact will to some extent be determined by whether or not the drought continues into the next growing season(s).

Profile 4: Nursery Owner, Denver Metropolitan Area and Member Green Industries Association

Watering restrictions in urban areas were widely publicized throughout the summer of 2002, with some communities moving to complete outdoor lawn-watering bans. In an interview with the owner of a Denver metropolitan area nursery, the effects of the drought on his business were detailed. Direct impacts to his business were felt in a number of ways. First, operating costs increased significantly when their ditch water stopped flowing and they had to use city water for the nursery's plants. Second, he hired fewer people in 2003 than in 2002 expecting to not do as much business as in years prior to the drought. Third, he changed some of his purchasing, buying less over all and changing his plant pallet, to some extent, to include more water-wise plants (those that the media and local water managers were recommending). Finally, as for changed sales or inventory, he mentioned that "We're not selling rocks now instead of bushes, so it [drought] hasn't changed us in that respect." His clientele is looking for largely the same products as before, with a somewhat more water-wise pallet, though it is not clear how long that trend will last. For the first part of 2003, before the wetter weather started, all the above impacts on his business resulted in a 50% decline in sales compared to those realized in 2002 before the severe watering restrictions were enacted.



Nursery Owner, Denver Metro Area

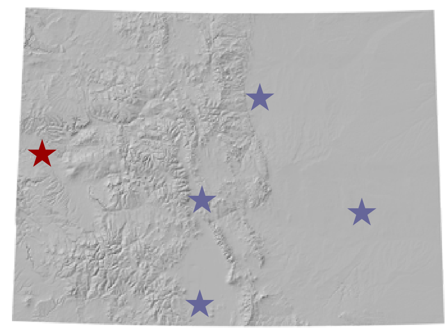
The owner of this nursery, which has been in operation since 1907, said that "Typically the effect of drought has lasted only as long as drought has." While the drought started years prior to 2002, he did not see significant impacts until 2002 because reservoir storage provided water supply prior to that time. Another factor influencing the severity and horizon of drought impacts has been the economy. This business man gives roughly half the credit for lower business to the drought and half to the difficult economy, creating strong cumulative effects. When asked if the drought has made him reconsider his business in general, or maintaining his business in Colorado he said no. The drought "Caused me to worry earlier this

The drought "Caused me to worry earlier this year if I would be able to be in business but not whether I wanted to or not. The weather is always a factor in this business. It is a given that the weather can be a friend or enemy or a little of both; it's just part of the equation."

year if I would be able to be in business but not whether I wanted to or not. The weather is always a factor in this business. It is a given that the weather can be a friend or enemy or a little of both; it's just part of the equation." At the end of the day, he does not see himself going out of business any time soon.

Profile 5: Truck Farmer in the Grand Valley

This farmer of fruits, vegetables, alfalfa and several other crops said that he was "not affected to too great of an extent because we had just about a normal amount of water over the year, though we were cut back a small percentage." He did lose several acres of his early crop of sweet corn because of the very hot conditions in June and the first part of July that stressed crops receiving even a normal supply of water. This loss was at least partially offset by higher alfalfa prices due to the scarcity of both harvested alfalfa and productive rangeland. The Grand Valley ditches have largely senior water rights on the river, so their irrigation systems received sufficient water.



Truck Farmer, Grand Valley

There was some concern that 20,000 acre feet would not be released from Green Mountain Reservoir but a suite of different agencies and water districts were able to find the water in other sources through cooperative agreements. He also noted that orchards in the Grand Valley were kept sufficiently watered. Even when the supply was cut 10 to 20% by the ditch companies in the hottest weather in the valley, they let the fruit growers and commercial entities have what they needed to stay in good condition.

While water was not scarce for Grand Valley farmers with access to irrigation supply, those around them out of the valley floor in Glade Park, Colburn, the south slope of the Grand Mesa and other locations were significantly impacted by the drought. Several of his acquaintances experienced moderate to severe impacts. For example, a family in Glade Park had virtually no feed for their cattle. Of 500 acres of hay that they typically harvest, they could only harvest five in 2002. Another rancher on the south slope of the Grand Mesa only received a very small percentage of his water, perhaps 10 to 20%. "He was out of water by early May last year." One ranching family in the lower valley, ranchers for four generations, had to sell their herd because the summer range they usually used on the Grand Mesa was unavailable and feed was too expensive for use as supplement.

Across western Colorado, this farmer has seen significantly different impacts from the drought. Although he was not greatly affected, others in the area had to acquire significant debt to stay in business, debt which will take many years to repay. Still others left the ranching business entirely. Interestingly, the stress he has felt on his orchards is a result of water quality problems (salinity) which he attributes to high quality water leaving the system at or near the Continental Divide. In other words, while the quantity of water reaching his farm is sufficient, the quality can be and is impacted by upstream impacts of drought (e.g., lack of high quality water from higher in system diluting lower quality sources lower in the system).

Discussion

These case studies illustrate a number of issues regarding the human impact of drought in Colorado. Everyone interviewed was affected by drought in one way or another, and the impacts of drought ripple through all affected communities through the loss of jobs and the related service businesses.

With a focus on commonality of experience, three major themes emerge. These are outlined below:

1. Short-term impacts: Reactions to the drought included reductions in spending and redefining of business practices through changes in planted crops, hiring practices, material and capital purchasing, and services provided. Most short-term impacts are reversible, but they may cumulate with other stresses to cross critical thresholds.

2. Long-term impacts: These impacts are the most alarming, because many of the long-term impacts such as selling businesses, live stock, or the family farm, are or may become irreversible. We heard about people losing jobs or not being hired in the first place, families having to move to find work, and business having to establish larger lines of credit and debt than they would normally. These impacts may last for five to ten years, or may be permanent. Examples of these impacts can be seen in the rafter's interest in selling one business and focusing on another, the green industry's greater involvement with decision-makers about water storage needs, and the ranch and farming communities' increased sales of property and grazing permits.

3. Ripple effect: In all of the cases presented, there were ripple effects from the drought impacts on businesses directly impacting the larger community. In farming communities, sales of gas, fertilizer and pesticides and other inputs that support farming needs were all significantly influenced. It is likely that peripheral service industries such as local slaughter houses, packing plants, and grain elevators were also detrimentally impacted.

   As evidenced by the ranching and farming interviews, the impacts of the drought, as an additional stress on the farm economy, may also affect the demographics for farming, since young persons may find it even more difficult and unattractive to begin farming and ranching. As quality of life changes in the small towns and retail is increasingly centralized in regional centers, social life is also changed. Drought that provides the last metaphorical straw on the camel's back hastens many changes, perhaps especially for small less-capitalized farms often already supported by in-town jobs which themselves may be threatened by decline in the number of farms and farm families. Consolidation of acreage into larger operations may maintain yields, but in a different social setting which may offer reduced opportunities of all kinds, from educational services and breadth to local social life. It is clear therefore that more than just the water users are impacted by the drought and its affects.

An additional impact seen in the "green sector" is the hard-to-estimate impact on seasonal and casual labor in the landscaping and gardening business when sales and plantings are impacted. In this way, the impacts of drought are spread even farther, such as to home-towns that might receive income from laborers who have traveled to work elsewhere. The impact on labor in metropolitan areas is also important here in Colorado; though economic measures are difficult, other impacts include changes in family opportunity and ability to afford education and other investments.

Conclusions

The stories shared by all of the interviewees confirmed that drought has serious and far-reaching impacts at an individual level and across the local community as a whole. Some people have decided on career changes or moves (some out of state) as a result of the drought. Others clearly articulated that they understand that “weather is a factor in this business” and as long as they are able to stay solvent, will continue in their current business. Effective solutions to help reduce or mitigate the negative impacts of drought will be those that address the short and long-term effects of drought and take into some account the ripple of influence drought has on local economies.

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Abstract
This Section will detail significant impacts of the current drought (2000-2003) based on analyses conducted by the State and its impact task force in each of eight different impact areas or sectors – Agriculture, Economic Impacts, Energy, Health, Municipal Water, Tourism, Wildfire, and Wildlife. Information provided by impact task forces for the 2003 Drought Impact and Mitigation Report produced by the Department of Natural Resources, which includes categories such as impacts, planned state and local responses, affected agencies, and costs, will be reviewed and supplemented with additional information collected by the Department of Local Affairs.

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Introduction

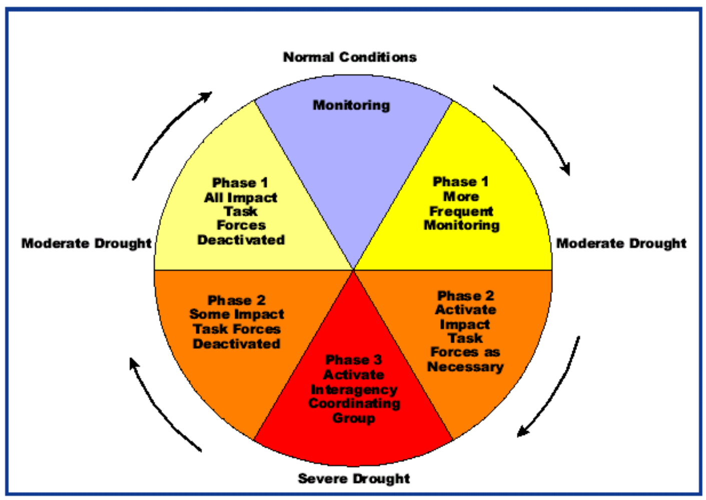
Economic Impacts and Responses

Other Initiatives

Introduction

State drought planning has been developed through the preparation and implementation of the Colorado Drought Mitigation and Response Plan (revised in April 2002). The plan was first developed in 1981, and Colorado was the first in the nation to create a formal mechanism to identify and respond to drought. The purpose of Colorado's plan is to provide an effective and systematic means for the state to reduce the impacts of water shortages over the short and long-term.

The plan consists of four components: monitoring, assessment, mitigation, and response. Monitoring (i.e., Phase 1) is ongoing and accomplished by quarterly meetings of the Water Availability Task Force (WATF). This task force is comprised of Colorado's water supply specialists from state, local and federal governments, as well as experts in climatology and weather forecasting. This task force monitors snowpack, precipitation, reservoir storage, and streamflow and provides a forum for synthesizing and interpreting water availability information. When the WATF determines drought conditions are reaching significant levels, the Governor's staff and cabinet notifies the Governor and recommends activation of the plan.



The Colorado Drought Mitigation and Response Plan operates in three distinct phases depending on the severity of the drought – indicated by the standardized precipitation index, surface water supply index, and the Palmer drought index.

When the plan is activated, the first step (i.e., Phase 2) is impact assessment. Assessment begins with activation of the relevant Impact Task Forces (ITFs). These task forces convene to determine the impacts within specific sectors that affect the environment and the economy. The ITFs are shown at right.

Impact Task Forces

Economic Impacts
Municipal Water
Wildfire Protection
Agricultural
Industry
Tourism
Wildlife
Energy Loss
Health

The Review and Reporting Task Force (RRTF) handles assessment coordination. This task force is comprised of directors from the Departments of Natural Resources (DNR) and Local Affairs (DoLA), and chairpersons of both the WATF and the Impact Task Forces. They review reports from the WATF and ITFs, aggregate assessments and projections, evaluate overall considerations, develop recommendations for drought response, and make timely reports to leadership, the media the response agencies, and others.

The response process (i.e., Phase 3) consists of several lead state agencies, which are selected based on the specific situation, and an Interagency Coordinating Group (ICG). The ICG is compromised of senior management representatives from the lead response agencies. The ICG ensures the coordination of the drought response activities. Additionally, the ICG reviews unmet needs identified by task forces and lead agencies, and identifies and recommends the means to meet those needs. The ICG coordinates with the Executive Branch and State Legislature, and determines when its own deactivation should occur.

In April 2002, for the first time, all eight ITFs were activated, conditions were evaluated, and recommendations were developed for the Governor. The following sections describe the results of the assessments conducted by the ITFs and in some cases indicate the state response based on the assessment.

Economic Impacts and Responses

A thorough examination of the impacts of the drought on Colorado's economy has not been available because there has been little statistical data available to explicitly quantify the impacts. In addition, recent economic impacts have been the result of many factors in addition to the drought. It is difficult to separate the economic impacts from the drought from the overall economic decline in Colorado that occurred as a result of the national recession. As a whole the State had a poor economic performance in 2002, which resulted from a number of factors such as the uncertainty that resulted from the threat of terrorism, and the downturn in the high tech industry.

Table 3-1: State Responsibilities and Specialization for Drought Management

Agency	Specialization	Responsibility							
		Track Impacts Related to Water Shortages	Improve Water Availability Monitoring	Increase Public Awareness and Education	Augment Water Supply	Facilitate Watershed and Local Planning	Reduce Water Demand/ Encourage Water Conservation	Support Programs to Reduce Impact	Provide Other Technical Support
Department of Agriculture	Support to Agriculture and Agribusiness	💧		💧		💧	💧	💧	💧
Department of Local Affairs	Support to Municipal Water Systems	💧		💧	💧	💧	💧		💧
Department of Military Affairs	Resources Support								💧
Department of Natural Resources	Wildlife, Water Administration, Drought and Water Planning	💧	💧	💧	💧	💧	💧	💧	💧
Department of Public Health and Environment	Public Health and Water Quality	💧		💧					💧
Office of Economic Development and International Trade	Tourism	💧		💧					💧
Office of Emergency Management	Life Threatening Situations and Federal Disasters	💧	💧	💧		💧			💧
Office of Energy Management and Conservation	Energy	💧		💧					💧
Office of State Planning/ Budget	Economic Impacts	💧		💧					
State Forest Service	Wildfires	💧		💧					💧

In spite of the challenges that exist with respect to quantifying the economic impacts of the drought, the various sections that follow provide as much information as can reasonably be collected regarding impacts of the most recent drought on the different sectors – be it economic or otherwise.

Agriculture

Colorado's agriculture industry suffered large impacts as a result of the 2002 drought. Annual receipts from agriculture in the state are estimated at approximately $4.7 billion. Crop and livestock losses due to drought were estimated at $150 million for ranchers and $300 million for farmers. In response, the Governor requested a statewide Secretarial Disaster Declaration from USDA. A short-term Secretarial Emergency Disaster Declaration was granted and USDA determined that all 64 counties should be included for relief (for the first time since the 1977 drought). Low interest emergency agricultural loans were made available to qualified applicants in the state.

As a result of reduced forage and water for livestock, the emergency grazing provisions of the Conservation Reserve Program (CRP) lands were implemented through USDA-NRCS. Also, the Colorado Department of Agriculture, Governor's Office, and CSU prepared and provided a list of water haulers to livestock producers. The CSU Extension Service implemented the Hay Hotline to provide supply information to agricultural producers needing supplemental feed.

The tax implications for ranchers forced into herd liquidation prompted the Colorado Department of Agriculture and CSU Extension to develop a workshop to inform agricultural producers about tax implications due to herd liquidation/culling. The workshop also informed producers about assistance/programs available due to drought.

The need to thin or remove moisture competitive trees and brush in watersheds to increase yields for streams and aquifers was also identified as a goal that the USFS, Colorado State Forest Service, and DNR would undertake and would be ongoing as funding permitted. On January 8, 2003, the Governor issued an Executive Order aimed at the eradication of the invasive tamarisk plant, which is responsible for using a great deal of Colorado's water in the many riparian areas where it has become established. The order directed the Department of Natural Resources to develop a plan in one year that will eradicate the plant from all public lands in the state within 10 years.

Finally, the lack of water storage was identified by the Agriculture Impacts Task Force as a need for which legislation should be created to provide more stored water for agricultural purposes on a long-term basis. The need to create legislation which supports temporary transfers of agricultural water to cities in times of drought was also identified. The Colorado Department of Agriculture, Governor's Office, State Legislature, DNR, CWCB, DWR all contributed to this legislation. The passage of HB03-1318 made the creation of water banks statewide possible and is expected to increase the ability for water rights owners to temporarily lease their water to others.

Energy

Potential loss of energy production was an area of concern due to drought and wildfire conditions. The Governor's Office of Energy Management and Conservation (OEMC) conducted a review in coordination with major energy suppliers, which showed that the continuity of Colorado's energy supply seemed assured for 2003. Likewise, the potential loss of energy transmission lines due to wildfires was a similar concern. The OEMC and utilities worked to identify transmission areas of potential risk in the event of wildfires. High-risk transmission areas were identified and mitigation efforts undertaken to reduce risk from wildfire. All of the state's transmission lines were rated "minus 1" which indicated power continuity was assured if any single transmission line was lost.

The Energy Impacts Task Force recommended that spring snowpack and runoff amounts be monitored to determine the extent, if any, of hydroelectric generation reductions. Although hydroelectric generation may be reduced by low runoff, this does not affect pumped storage plants. One of the 100 mega watt units and the Mt. Elbert pumped storage plant was scheduled to be offline in April for necessary scheduled repairs. In addition, it was recommended that communication links between appropriate agencies and utilities continue and updates to contingency plans be developed. Extensive efforts on the part of the utilities and appropriate agencies have improved communication since 2002. Contingency plans have been updated.

Health

Many public water systems throughout the state were stressed by the 2002 drought. Approximately 20 systems (mostly in southeast Colorado) contacted the Colorado Water Quality Control Division (WQCD) for technical or financial assistance. The WQCD approved new sources of water supply to ensure public safety, and identified potential problems in key stream segments and lakes based on flow/water quality information. As appropriate, "bottled water" advisories were developed for impacted systems. Costs for bottled water and water hauling were borne by utilities and their customers.

With the help of the US Geological Survey, a technology-based early warning system was developed, and assessments were made of low-flow related fish kills regarding potential broader impacts. Standard fish kill procedures were utilized to isolate drought-related impacts from potential spill/release impacts. Public awareness was increased of potential public health and environmental issues associated with extreme low flows and water body contact. For drought, the WQCD developed and disseminated a problem/response matrix to assist systems in recognizing and resolving problems. For fire, the WQCD conducted a series of workshops to help impacted systems address treatment and operating issues due to fire impacts.

The WQCD worked with local public water systems to develop appropriate signage or other forms of public information. Potential problems caused by upstream wastewater treatment plants impacting downstream drinking water treatment plants due to drought-related low flows were identified. The CDPHE is planning to utilize procedures developed during 2002 season again in 2003. The WQCD developed guidance and conducted training workshops on the impacts of drought and fire runoff on water supplies and systems.

Municipal Water

Many of the water systems that experienced severe problems in 2002 had been aware of their limited water supplies and had been working with state agencies in prior years. The summer and fall of 2000 had involved significant drought impacts for many systems in the state, and in 2002 many were forced to implement measures they had planned in prior years. The WQCD and DOLA developed and updated a list of public water systems that experienced operational problems and summarized contact information for technical and financial assistance on drought problems. The Department of Public Health and Environment established a Drought Recovery Grant Program which included federal grant monies provided by United States Environmental Protection Agency (US EPA).

Funding from various state programs was made available to meet local needs, and Table 3-2 below shows the funding that was provided through state programs.

Table 3-2: State of Colorado Fire and Drought Assistance

Recipient	Project Description	Amount/Type	State Agency
Aguilar, Town of	Water study	$20,000 loan	DOLA
Akron, Town of	Drill 2 wells and build a raw water transmission line.	$349,799 loan	CWCB
Alma, Town of	Drill two additional water wells	$210,000 grant $13,500 grant	DOLA DPHE
Beulah and Pine Drive Water Districts	Engineering study, storage tank, transmission line for system interconnect, pump station.	$100,000 grant & $60,000 loan	DOLA
Bayfield, Town of	Water treatment improvements	$470,000 grant & $233,000 loan $50,000 grant	DOLA DPHE
Big Elk Meadows Water Association	Water storage	$15,600 grant	DPHE
Central Weld County Water District	Build Dry Creek Reservoir	$3,937,500 loan	CWCB
Coal Creek, Town of	Purchase water rights	$67,500 loan	CWCB
Crestone, Town of	Drill a new fire well	$20,000 grant	DOLA
Durango, City of	Water treatment improvements	$300,000 grant & $200,000 loan	DOLA
East Dillon Water and Sanitation District	Purchase water rights	$2,550,000 loan	CWCB
Edgemont Ranch Metro District	Water storage	$5,000 grant	DPHE
Fredrick, Town of	Rehabilitate Milavec Lake	$1,000,000 loan	CWCB
Freeman Creek Pipeline Association	Treatment plant and water intake replacement	$25,000 grant	DPHE
Kremmling, Town of	Develop an alternate water source	$300,000 grant $1,000,000 loan	DOLA CWCB
Little Thompson Water District	Build Dry Creek Reservoir	$3,937,500 loan	CWCB
Monument, Town of	Rehabilitate Monument Dam	$2,443,000 loan	CWCB
Paonia, Town of	Purchase water rights	$1,000,000 loan	CWCB
Parker Water and Sanitation District	Reuter Hess Reservoir	$15,000,000 loan	CWCB
Pinewood Springs Water District	Engineering study, filtration system improvements	$16,800 loan	DPHE
Poudre Tech Metro District	Reservoir Construction	$2,180,000 loan	CWCB
Red Rock Valley Water District	Drill an additional water well	$70,000 grant $2,500 grant	DOLA DPHE
Sugar City, Town of	Water study	$10,000 grant	DOLA
Weld County (Chambers subdivision)	Connecting subdivision to City of Brighton's water and wastewater systems	$300,000 grant & $100,000 loan	DOLA
Windsor, Town of	Rehabilitate Kern Reservoir	$3,620,000 loan	CWCB

CWCB: Colorado Water Conservation Board
DPHE: Colorado Department of Public Health and Environment
DOLA: Department of Local Affairs

Two tables of potential funding sources for emergency and long-term drought mitigation and fire impacts was developed and disseminated (reproduced here as Table 3-3 and Table 3-4). The CWCB and DoLA provided education and assistance on water conservation planning so that measures would be understood and implemented at the local level. Incentives were considered for public water systems with less reliable supplies to connect to or consolidate with those that had more reliable supplies.

Table 3-3: Drought and Fire Recovery Loan Funds Available in Colorado

Program	Loan Funds Available	Uses/Requirements	Agency and Contact
CWCB Emergency Infrastructure Loan Program	- Subject to a $2 million cumulative annual limit in the emergency account - Loans for up to 75% of project costs. - Rates from 2.75% to 6%	- Raw water projects of an emergency nature - Available to any organization (municipalities, agriculture, ditch companies, homeowners assn, special districts, etc) - Must receive CWCB Board approval	Colorado Water Conservation Board, John Van Sciver 303-866-3449
CWCB Small Project Loan Program	- Up to $1 million loans for small raw water projects - Loans for up to 75% of project costs. - Rates from 2.75% to 6%	- Raw water projects. - Available to any organization (municipalities, agriculture, ditch companies, homeowners assn, special districts, etc) - Must receive CWCB Board approval	Colorado Water Conservation Board, John Van Sciver 303-866-3449; email john.vansciver@state.co.us.
CWCB Construction Fund	- No limit - Loans typically range from $50,000 to $5,000,000	- Raw water projects (dams, pipelines, ditches, wells, new projects or restorations) - Available to any organization (municipalities, agriculture, ditch companies, homeowners assn, special districts, etc) - Must receive CWCB Board and Legislative approval	Colorado Water Conservation Board, John Van Sciver 303-866-3449; email john.vansciver@state.co.us.
Water Pollution Control Revolving Fund (WPCRF)	- Fire-related NPS projects can be given priority status. - Direct loans under $1,000,000 available with Board approval. - $10K grants available for planning (fire-related OK).	- Low-interest loans for public waste water treatment system needs and watershed nonpoint source (NPS) control projects. - Available to governmental agencies. - Emergency projects can be identified at any time throughout the year. - Loan funds require board review, study grants available immediately.	Colorado Water Quality Control Division. Debbie Stenson 303-692-3554
Drinking Water Revolving Fund (DWRF)	- Fire-related projects can be given priority status. - Direct loans under $1,000,000 available with Board approval. - $10K grants available for planning (fire-related OK).	- Low-interest loans for drinking water treatment system needs. - Available to governmental agencies. - Emergency projects can be identified at any time throughout the year. - Loan funds require board review, study grants available immediately.	Colorado Water Quality Control Division. Debbie Stenson 303-692-3554
USDA Rural Development 502 Direct Housing Loan Program	-Loans limited by individual county mortgage limits - Most counties have loan limit of $108,317	Available for wells and water connections - Applicants must be very low income, owner/occupant, unable to obtain conventional credit, and in rural communities and areas.	14 Rural Development offices in Colorado Initial contact Denise Coit (720) 544-2920 for referral to local office

Table 3-4: Drought and Fire Recovery Grant Funds Available in Colorado

Program	Grant Funds Available	Uses/Requirements	Agency and Contact
Natural Resources Conservations Service -Emergency Watershed Protection Program	- Funding available through the Simplified Acquisition Procedures (SAP) ranges from $25K to $100K. -Funded through contracts between project sponsors and the NRCS. There are no grants. The NRCS pays 75% of the costs.	Installing/repairing conservation measures to control flooding and prevent soil erosion. Generally, more than one individual should benefit from the project. Public or private landowners or others who have a legal interest or responsibility for the values threatened by the watershed emergency.	NRCS – The NRCS State Program Manager is Frank Riggle, phone: 720-544-3570. Initial contacts should be made with NRCS county offices when an emergency exists. The county office contacts can be found by going to www.co.nrcs.usda.gov.
Nonpoint Source Pollution (NPS) Grants	-Typical awards range from $30K to $150K.	- Applicants can include governmental and non-governmental organizations. - Applications generally evaluated through a stakeholder process, but this can be waived. - 40% non-federal match is required. - Funds available immediately for fire-damaged watersheds impacting drinking water supplies.	Colorado Water Quality Control Division. Laurie Fisher, Non-Point Source Coordinator, 303-692-3570
Supplemental Environmental Project (SEP) Grants	- Typical awards range from $10K to $25K.	- Available to governmental agencies and non-profit water systems. - Funds available for fire-damaged watersheds and infrastructure.	Colorado Department of Public Health and Environment. Debbie Stenson, 303-692-3554
PPG Grants (EPA funds)	-Typical awards range from $10K to $25K.	- Available to governmental agencies. - Funds available for fire-damaged watersheds and infrastructure, and drought-related needs.	Colorado Department of Public Health and Environment, Debbie Stenson, 303-692-3554
Agricultural Emergency Drought Response Fund	$1million fund for loans and grants	- For emergency drought-related water augmentation purposes. - Limited to agricultural organizations	Colorado Water Conservation Board & Colorado Division of Water Resources & Colorado Department of Agriculture. John Van Sciver 303-866-3449
EDA Economic Adjustment Program	Economic adjustment grants can range from $25,000 up to $2,000,000 depending on the circumstances.	- Job losses from natural disasters - State and local governments and non-profit organizations	U.S. Economic Development Administration – John Zender 303-844-4902
Energy Impact Assistance Fund	- Maximum grant $300,000 (guideline) - Loans available for sewer and treated water projects	- Public facility and infrastructure needs - Eligible recipients include municipalities, counties, and special districts. Loan terms up to 20 years, and interest rates of at least 5%	8 Colorado Department of Local Affairs field offices in Colorado – Initial contact Barry Cress at 303-866-2352 for referral to field office
Community Development Block Grants	Maximum award $250,000 (guideline)	- Public facility and infrastructure needs - Eligible recipients include CDBG "non-entitlement" municipality or county; districts and private systems are eligible sub-recipients. Applicants must provide local cash participation, qualify with low/moderate incomes, pay Davis-Bacon wages, and comply with NEPA.	8 Colorado Department of Local Affairs field offices in Colorado – Initial contact Barry Cress at 303-866-2352 for referral to field office
USDA Rural Development Home Improvement and Repair Loans and Grants (504 Program)	-$20,000 maximum loan - $7,500 maximum grant (must be elderly owner occupant age 62+)	For home rehabilitation, including wells and water connections - Applicants must be very low income, owner/occupant, unable to obtain conventional credit, and in rural communities and areas.	14 Rural Development offices in Colorado Initial contact Denise Coit (720) 544-2920 for referral to local office

The issue of insufficient water system revenue due to reduced water sales was identified and DOLA warned system managers of this possibility in two sets of workshops conducted over the summer of 2002. Suggestions and technical assistance on ways to generate additional revenue from current and alternative sources to offset losses from drought were provided. Many water systems imposed drought surcharges, and assessed penalties for prohibited water use.

Wildfire damage to critical watersheds that supply drinking water was a significant problem for certain systems, and funding for several impacted systems was provided. The WQCD provided $500,000 to Denver Water, and $220,000 to the Florida Water Conservancy District (La Plata County) from the non-point source (319) grant program. To limit fire ignition potential, the Municipal Water Supply Task Force recommended that restrictions on fireworks on local, state, and federal lands be considered when applicable. Also, the pre-positioning of water supply, transportation, and fire fighting resources for quick response was recommended.

Tourism

Tourism is one of the state's leading industries, with more than 200,000 Colorado workers, or 8% of the state workforce, employed by the industry in the year 2000. For that year, it was estimated that state and local governments received approximately $550 million in tax revenue from tourism. In 2001 it was estimated that visitors spent approximately $7 billion in the state, which equated to $19 million per day. Even a minimum decline of 10% in tourism would mean a decrease of approximately $700 million in tourist dollars spent. Moreover, the economies of a number of regions in the state are extremely dependent upon tourism. As a result of the economic losses to recreation and tourism industries, the Colorado Tourism Office (CTO) worked to enhance public outreach and education to provide accurate and informative information about Colorado's drought, and keep the public optimistic about tourism's viability during drought and heightened fire danger. The CTO also drafted crisis communication plans for both drought and wildfire, and began sending informative e-mails to the tourism industry. The first e-mail contained information on "10 Rules of Crisis Communications." Also, CTO encouraged local communities that are dependent on state or national parks for tourism to plan for potential economic impacts with the development of local community mitigation and response plans.

Rafting

Below average snowpack and depleted reservoirs threatened the rafting season. The CTO and industry associations worked to direct visitors to rivers that are raftable, and activites that were more appropriate given the low flows such as kayaking or float fishing, and encouraged rafting to be included into current reports about snowfall/great skiing. Also, river flows were encouraged to be maintained wherever possible.

Ski Industry

To address concerns that fires and national television exposure could discourage summer visitation to mountain resorts, the CTO and Colorado Ski County USA worked to educate the public on what actions are being taken to conserve water and what activities are available at Colorado's resorts.

Fishing and Hunting

Fishing license sales decreased approximately 15% from 2001 levels. It is estimated that approximately one million statewide recreation days may have been lost in 2002. The loss of license sales resulted in $1.8 million in decreased income to the Division of Wildlife (DOW). The CTO and DOW worked to remind the public that they can enjoy fishing in Colorado even if water is low and that fishing opportunities are often available in a variety of areas, such as tailwater areas, in times of drought.

Golf

Loss of golf course related revenues at the state and local levels occurred due to decreased Colorado resident and non-resident participation. Revenue losses were expected to continue beyond the drought until adversely impacted golf courses respond and reseed drought-impacted areas. The Colorado golf associations funded and developed an educational campaign to inform the public about the water conservation measures used by golf courses and the environmental, ecological, recreational, and social benefits of Colorado's golf course industry. Two economic impact studies were undertaken to quantify 2002 drought impacts to the golf industry.

Colorado State Parks

The drought resulted in 23% reduction in reservations and a 3% decline in visitation. The CTO and the Division of Parks and Outdoor Recreation (DPOR) worked to remind the public that they can enjoy Colorado parks even if water is low or fire restrictions are in place. For 2003, spring boating at reservoirs and early reservations were encouraged. Boat ramps at 14 state parks were closed by mid-September. The DPOR lengthened four boat ramps at some parks to accommodate low water levels.

Wildfire

The 2002 fire season was heightened by extended drought conditions that caused well below average fuel moistures in wildland fuels. The impact experienced was increased potential for fire starts and more intense fire behavior. It was reported that a record number of 4,612 wildland fires occurred that burned a total of 619,030 acres.

Evacuations occurred in 142 subdivisions and 12 communities displacing 81,435 people. Ten lives were lost in Colorado due to the wildfires.

While the economic loss to insurance companies may not be large when compared with other natural disasters, the impact to state and local governments can be great. Indeed, the 2000 wildfires in Colorado cost state and local governments $6.5 million. The federal government reimbursed the state for $3.2 million because of a Federal Emergency Management Act declaration. The 2002 forest fire season was the worst that Colorado has ever seen. Colorado had 3,409 wildfires that were not on federal land. The total suppression costs to federal, state, and local governments in 2002 are estimated to be over $150 million. Colorado's share of these costs, based on the percentage of non-federal land to federal land burned, is estimated to be between $30 million to $40 million. After reimbursement from FEMA, these fires are estimated to cost the state $11.6 million. Finally, it is estimated that the insurance losses from the forest fires in 2002 totaled approximately $70 million.

The Governor supported wildfire suppression funding in the amount of $15 million through executive order. If the same level of fire activity is experienced in 2003 as occurred in 2002 it is expected that costs to the state will be similar to 2002 levels. The Governor also provided through executive order funding that provided two additional single engine air tankers (SEAT) used for initial attack on wildfires and funding to acquire 10 wildland urban interface fire engines to complement local and federal resources.

To provide for the increased potential for wildfires in wildland interface areas, the Colorado State Forest Service (CSFS) provided state-supported technical and cost-sharing assistance to counties for the development and implementation of expanded county Fire Management Plans. The CSFS also provided for wildland-urban interface management needs and for a fuels mitigation cost-sharing program, and coordinated and funded the development and implementation of a statewide, county-by-county wildfire risk assessment. State-level support for expanded state participation in zone dispatch center and in the extended attack phase of wildfire suppression. The CSFS, the state telecommunications division, and various federal agencies worked to identify statewide protocols for radio communication across local, state, and federal jurisdictions.

The CSFS and federal land management agencies have worked to coordinate interagency implementation and allocation of funds related to the National Fire Plan, the Ten Year Comprehensive Strategy, and similar efforts, such as the President's Healthy Forest

Initiative, as well as provide state leadership in developing and delivering coordinated interagency wildland fire messages to homeowners, landowners, land management agencies, the general public and others.

Wildlife
In 2002, the State of Colorado saw some significant impacts, primarily to the aquatic environment. The major aquatic-related wildlife impacts experienced in the Upper South Platte Basin in 2002 included the loss of Antero Reservoir's "crown jewel fishery" mostly due to draining of the reservoir. The draining of Tarryall Reservoir for dam repairs, the draining of almost one-half of Spinney Mountain Reservoir, and loss of 40,000 acre-feet of water from Elevenmile Reservoir also resulted in significant aquatic-related impacts. The lower South Platte River reservoirs experienced the loss of fishery resources due to draining of most of the major reservoirs in the lower South Platte system. In the San Luis Valley, the Home, Smith, Mountain Home, Million and La Jara reservoirs were all drained dry with a total loss of fish. On the Dolores River, the fishery from below McPhee Reservoir to the state line suffered significant losses. The Florida River was rendered sterile from Lemon Dam downstream because of wildfire-related mudflows. Bear Creek experienced a significant fish kill as did smaller tributaries below Evergreen due to low flows and water quality issues in this heavily recreated creek. Wildfires in the South Platte, Animas, La Plata, Los Pinos, and Mitchell Creek Watersheds, and their aftermath, have resulted in serious loss of quality habitat in these watersheds. The probability of continued erosion and sedimentation creates ongoing concerns for these areas even should the drought subside.

The major actions undertaken to lessen drought impact on wildlife in 2002 can be grouped in three main categories as shown in Table 3-5 below.

Other Initiatives
In 2003, several major state initiatives were undertaken. On February 14th, the Governor urged state legislators to enact a set of legislative priorities divided into the three major areas of immediate actions, conservation efforts, and addressing long-term supplies. A major outcome of the 2003 state legislative session was a statewide ballot initiative to allow the state, through CWCB, to incur up to $2 billion in debt to finance major water supply projects. The senate bill that provided this initiative also allowed the Colorado Water Resources and Power Development Authority to provide loans of up to $500 million for water projects.

Table 3-5: Major Actions to Lessen Drought Impact on Wildlife

	Major Actions
One	**Cooperative Actions among Water Users, Community Groups and State Agencies** Some of the major joint actions taken included the partnership between water users, power providers, and state agencies in providing additional flows to benefit the seriously strained fishery in the Yampa River through Steamboat Springs. In addition, anglers worked together to encourage fishing early or late reducing stress on the heat-strained fishery. On the White River, community leaders and water users came together to provide relief to the distressed fishery. Stream flows were augmented by release of CDOW water from Lake Avery. On the Conejos River, extremely low stream flows were augmented by release of water from Platoro Reservoir. The CDOW agreed to reimburse the Conejos Water Conservancy District for the released water. On the Rio Grande River, stream flows were augmented by reduced diversions. The CDOW curtailed an approximate 10-cfs diversion to San Luis Lakes to keep water in the mainstem of the Rio Grande. On the Roaring Fork River, cities, state agencies, and community organizations worked to provide additional water to the strained trout fishery. Senator Andy McElhany and Representative Gregg Rippy introduced legislation (HB03-1320) that was passed to allow temporary loans or donations of water rights for instream flows.
Two	**Fisheries Management Actions** State agencies, along with private organizations and community volunteers, worked throughout the summer to improve aquatic habitat and to manage drought impacts. Genetically important native trout species were salvaged and either transferred to isolation units or barren lakes (i.e. native greenbacks were salvaged from Como Creek and Apache Creek and native Rio Grande cutthroat were salvaged from Placer Creek, Indian Creek and Forbes-Trinchera Ranch). Fishing restrictions and regulations were imposed on several stream sections as needed to protect fisheries. Fish salvage operations were also conducted where appropriate (i.e. Antero Reservoir, Jackson Reservoir, Kiser Slough Reservoir, and Roaring Judy kokonee salmon spawning operation). In addition, the CDOW redistributed and reduced stocking of fish throughout the state.
Three	**Major Administrative Actions** Activities undertaken in 2002 to mitigate drought impacts to wildlife included: ▪ The CWCB initiated a statewide review of decrees and called for enforcement of decrees to protect the State's instream flow water rights. ▪ The CWCB placed formal, written calls for water on several streams to ensure instream flow water rights were receiving water to which they were legally entitled. ▪ The Colorado Wildlife Commission approved more than 14,000 new antlerless rifle elk licenses and 2,500 new antlerless archery elk licenses for the 2002 big game season in an effort to reduce herd size in anticipation of the lack of winter forage due to the ongoing drought. The CDOW's Habitat Partnership Program increased the use of distribution management hunts on private land. These hunts are designed to redistribute concentration of big game to reduce or eliminate damage to private landowners. These two aggressive administrative actions to increase elk licenses resulted in a new state record elk harvest in 2002 of just over 61,000 elk harvested.

The Colorado Water Conservation Board remains involved in a number of initiatives aimed at alleviating the drought conditions. These efforts include:

- Statewide Water Supply Initiative (SWSI) – An effort that involves the gathering and sharing of information in a statewide forum to develop a common understanding of existing water supplies and future supply needs and possible means of meeting those needs.
- Colorado River Return Reconnaissance Study – An engineering evaluation of the physical, logistical, environmental, financial and institutional aspects of a large-scale delivery system from the Colorado River near the Utah border to the basins of the South Platte, Arkansas and Colorado basins.

Regarding state facilities and assets, the Department of Personnel and Administration (DPA) which provides asset management services to the state's capitol complex grounds and buildings, as well as the state's fleet of vehicles, has achieved some important successes. In 2003, the number of vehicle washes was reduced by over 50% by having the motor pool limit car washing to no more than two per month per vehicle. Also in 2003, the DPA's capitol complex, responsible for maintenance of 14 buildings and 7.5 acres of land installed new sprinkler clocks to enhance the system's ability to conserve water. In addition, the installation of smaller nozzles and additional sprinklers in certain zones has reduced overspray and reduced run times. The number of flowers planted at the capitol complex was also reduced by 66% and mulch was used to enhance water retention in flower beds. Finally, DPA is having an audit conducted of water and plumbing systems which might result in water savings of 25 – 50% through the use of low flow fixtures.

Population Change in Colorado's River Basins: A Brief History from 1950 to 2000 and Forecasts from 2000 to 2030

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Contents:

A Brief History and Forecast of Population Growth in the State's Economic Areas

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Discussion

Abstract
This Section will summarize and present data on population change in Colorado from 1950 to 2000 and on expected change from 2000 to 2030 by river basin. The section will first describe the economic regions of the state and how they relate to river basins. It will next show how past economic and population changes of the economic regions have manifested themselves by river basin. Because of the aging of the baby-boomers of the State and of the Western U. S., new patterns of growth are expected to occur within the state. These too will be translated onto the respective river basins to provide a sense of future growth based on state geography.

A Brief History and Forecast of Population Growth in the State's Economic Areas

In 1950, Colorado's population was 1.3 million. By the year 2000, it more than tripled, reaching 4.3 million. In 1950, the metropolitan Front Range consisted of two-thirds or 67% of the total population, with significant portions located in each of the other sub-state areas. Between 1950 and 1970, as the state added 0.9 million people, virtually all of that growth went to the metropolitan Front Range. The Western Slope population increased somewhat during that period, but the other three sub-state areas—the Eastern Plains, the Central Mountains, and the San Luis Valley (see Figure 4-1 and Table 4-1)—actually declined during this period. By 1970, the Front Range comprised 80% of the state's population.

After 1970, as the state's skiing and outdoor recreation resort industry experienced rapid growth, the Western Slope began growing very rapidly as well. By 2000, its 1970 population of 191,000 increased 140% to 460,000. Similarly during this period, the metropolitan Front Range doubled in size, from 1,328,000 in 1970 to 2,582,000 in 2000. In the Central Mountains, growth occurred strongly in the 1970s and then again in the 1990s, partly because of the development and expansion of prisons in Fremont and Chaffee counties and partly because of the attractiveness of these scenic areas for tourism activities. However, the populations of the Eastern Plains and the San Luis Valley continued to decline, only reversing this trend in the 1990s as economic successes elsewhere in the state spilled over into these regions.

By 2030, the state is expected to continue to grow at an average rate of 1.7%, which is above the national average of 1%, but below the very fast rate of the 1990s—2.7% (see Table 4-2). A state population of over 7.1 million is expected by 2030, which is nearly a 67% increase over the state's 2000 population of 4.3 million. Growth will again be fueled by hi-tech industrial development, national defense activities and regional services in the metropolitan Front Range. In addition, tourism will continue to expand both in the Front Range and in the Central Mountains and Western Slope as baby-boomers not only from Colorado but from the entire Western United States, including California and Texas, spend more time in the Rocky Mountain west, in many cases in their second home.

Figure 4-1: Map of Colorado's Statistical Sub-state Areas

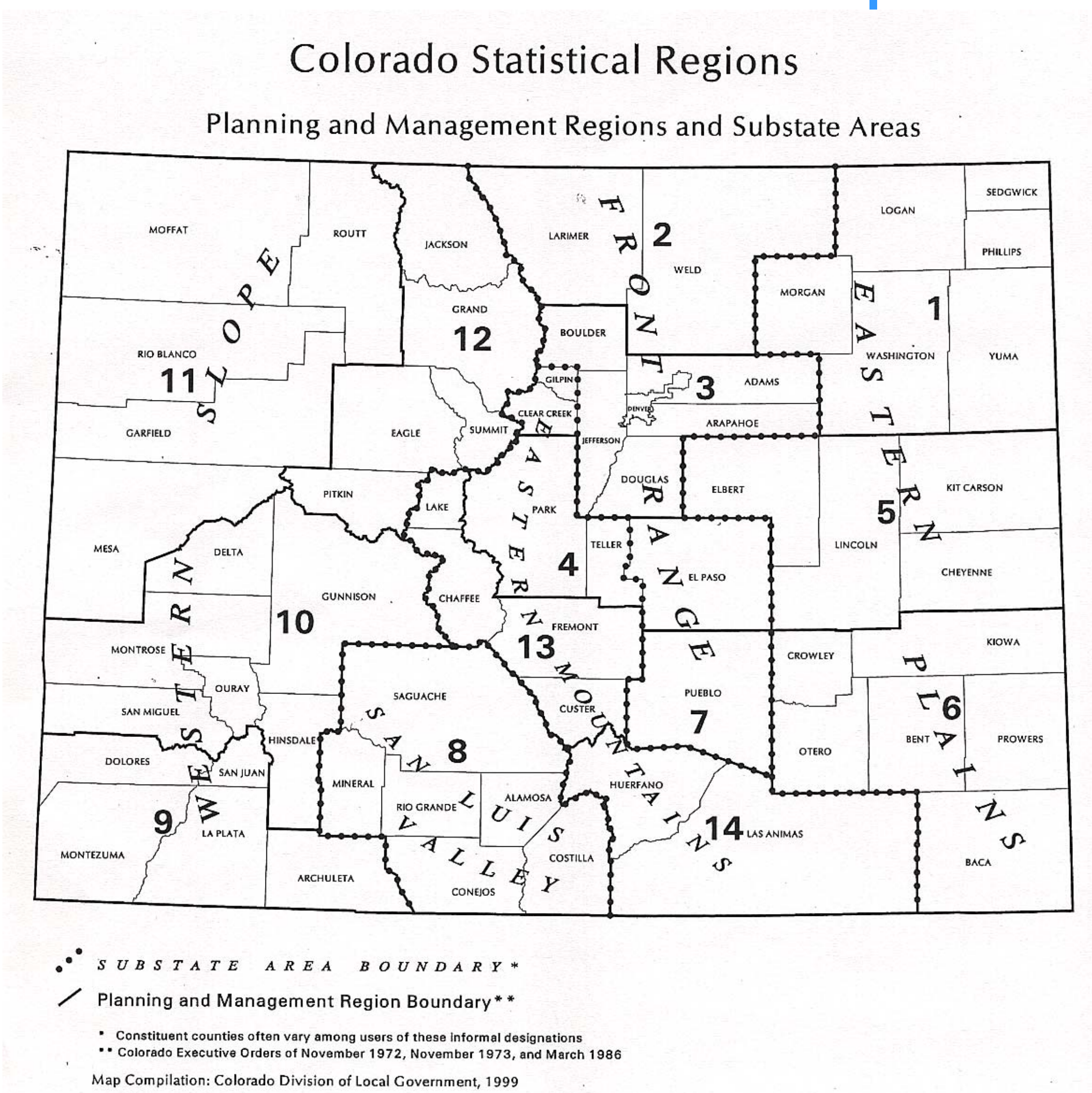


Table 4-1: Overlap between Sub-state Economic Areas and Water Divisions

Sub-State Economic Area	Water Division/Major River Basin
Front Range	Division 1, South Platte and Republican River Basins Division 2, Arkansas River Basin
Eastern Plains	Division 1, South Platte and Republican River Basin Division 2, Arkansas River Basin
Central Mountains (Eastern Mountains on Figure 4-1)	Division 2, Arkansas River Basin
San Luis Valley	Division 3, Rio Grande River Basin
Western Slope	Division 4, Gunnison River Basin Division 5, Colorado River Basin Division 6, Yampa, White, and North Platte River Basins Division 7, San Juan and Dolores River Basins

However, another major aspect of continued growth in the state will be the retirement of the state's and the west's baby-boomers. Assuming many of these retirees will stay in or come to Colorado, this demographic phenomenon will add a new dimension to Colorado's population—a significantly large elderly group. Also assuming that new middle-aged and younger people will replace them in the workforce, this additional dimension of Colorado's population will mean more people both in the Front Range and in the scenic areas of the state: the Western Slope and the Central Mountains but not excluding those of the Eastern Plains and San Luis Valley as well.

Table 4-2: Population from 1950 to 2030 by State Water Division

	1950	1960	1970	1980	1990	2000	2010	2020	2030
Division 1	821,522	1,152,158	1,508,314	2,000,569	2,280,470	2,988,027	3,579,800	4,200,900	4,961,900
Division 2	299,494	384,755	472,113	560,919	641,499	807,621	947,100	1,089,400	1,242,400
Division 3	45,963	38,704	37,466	37,914	40,207	46,190	51,600	57,000	62,400
Division 4 Gunnison	40,667	41,174	42,978	58,599	58,438	79,754	98,600	120,400	147,500
Division 5	61,831	75,420	89,650	144,025	178,555	252,567	327,700	412,400	517,300
Division 6	21,581	19,869	19,770	34,655	33,022	40,437	47,200	54,800	64,300
Division 7	34,031	41,867	39,305	53,052	62,203	86,665	108,600	134,000	164,600
State Total	**1,325,089**	**1,753,947**	**2,209,596**	**2,889,733**	**3,294,394**	**4,301,261**	**5,160,600**	**6,068,900**	**7,160,400**

A History and Forecast of Population Growth in the State's River Basins

Division 1: The South Platte and Republican River Basins

Historic Population Change

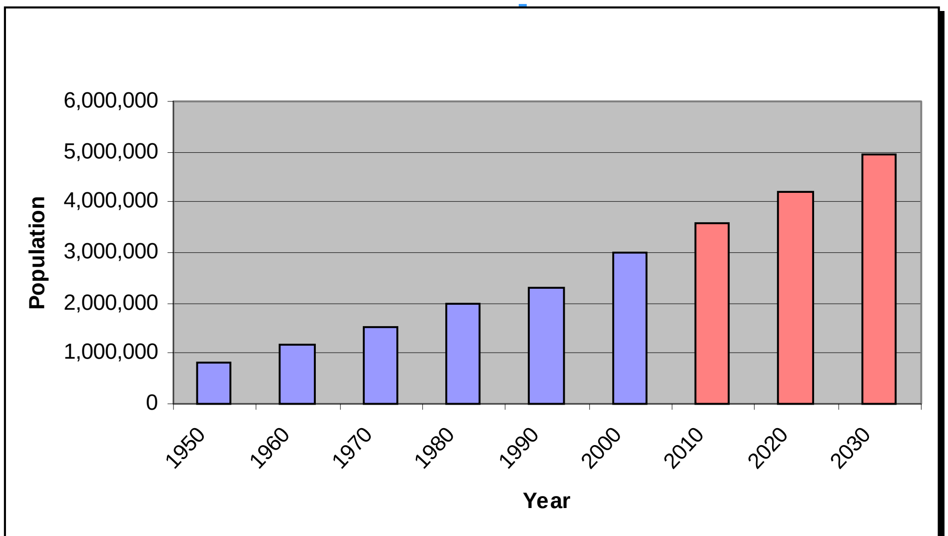
The Front Range population growth from 1950 to 2000 affected both the South Platte and the Arkansas River Basins. In the South Platte River Basin, the Denver-Boulder metropolitan statistical area (MSA) (as determined by the US Office of Management and Budget in June 1993) population quadrupled, going from 600,000 to 2.4 million. Similarly, the North Front Range (with the Fort Collins and Greeley MSAs) more than quadrupled, going from 100,000 to 432,000.

Meanwhile, the Northeast and East Central agricultural regions of the Eastern Plains declined slightly by 1990 from a population of 86,000 in 1950 until suburban growth in the northwestern part of Elbert County in the 1990s boosted the area to 105,900. In sum, the population in the South Platte River Basin grew 264% between 1950 and 2000 (see Figure 4-2).

Projected Population Change

In the next thirty years, by 2030, the population within the South Platte basin is expected to grow another 65%. The fastest growing part of the basin will be the North Front Range, which will double during this period. In addition, the Denver-Boulder region will add another 1,300,000 to reach 3,700,000. Park and Teller counties, combined with Gilpin and Clear Creek counties will add another 100,000 (see Table 4-3 and Figure 4-2).

Figure 4-2: Historic and Projected Population, Division 1



On the Eastern Plains regions of East Central Colorado and North East Colorado, growth will be modest and will occur mainly in Elbert and Morgan counties, which are located closest to the Front Range. Elbert County is expected to triple its population by 2030, while Morgan County will add 20,000 to a year 2000 population of 27,000.

Table 4-3: Projected Population Change in Division 1

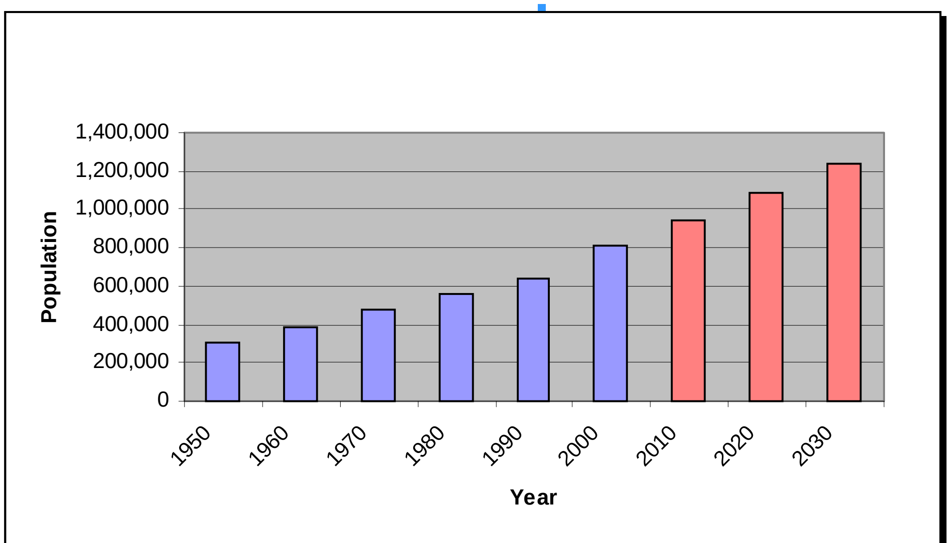
				Annual Growth Rate	
Division 1	**2000**	**2010**	**2030**	**'00-'10**	**'10-'30**
North Front Range	436,700	557,000	902,400	2.5%	2.4%
Denver-Boulder Region	2,415,000	2,830,300	3,723,000	1.6%	1.4%
Gilpin, Clear Creek	14,100	16,500	24,800	1.6%	2.0%
Park & Teller	35,800	50,700	123,400	3.5%	4.5%
East Central Colorado	36,600	45,300	81,500	2.2%	3.0%
North East Colorado	70,100	79,700	107,000	1.3%	1.5%
TOTAL	**3,008,500**	**3,579,800**	**4,961,900**	**1.8%**	**1.6%**

Division 2: The Arkansas River Basin
Historic Population Change

In the fifty-year period from 1950 to 2000, the population of the Arkansas River Basin increased 170%. Most of this increase occurred in the Colorado Springs MSA, which grew almost seven times, from a population of 74,500 in 1950 to a large metropolitan area of over half a million people by the year 2000. The Pueblo metropolitan area grew as well, though more modestly, from 90,000 to 150,000 during the period. Up stream, in the Central Mountains, the population more than doubled, partly because of the burgeoning prison industry in Fremont County, and partly from tourism in the upper parts of the river basin.

Downstream in the southeastern agricultural portion of the Eastern Plains, the population actually declined, from 65,000 in 1950 to 52,400 in 2000 (see Figure 4-3).

Figure 4-3: Historic and Projected Population, Division 2



Projected Population Change

In the thirty years from 2000 to 2030, the population is expected to increase 52%, going from 812,000 to 1,242,000. Most of this growth will occur in the Colorado Springs and Pueblo metropolitan areas of the South Front Range. However, the Upper Arkansas Area is expected to increase 77% adding another 57,100 to its population of 74,200. The South Central counties of Huerfano and Las Animas will grow slightly and the South East (Plains) Region will add only 4,500 people (see Table 4-4 and Figure 4-3).

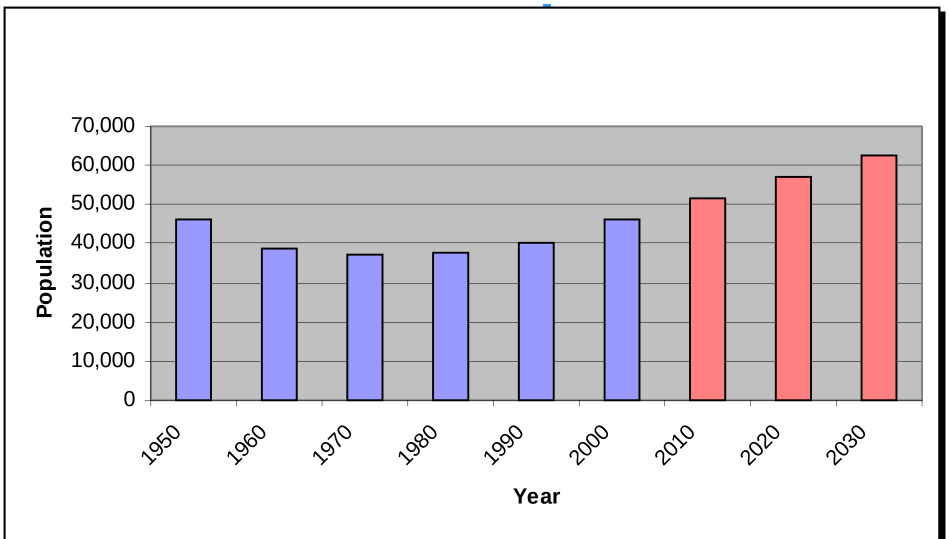
Table 4-4: Projected Population Change in Division 2

				Annual Growth Rate	
Division 2	**2000**	**2010**	**2030**	**'00-'10**	**'10-'30**
Upper Arkansas	74,200	86,700	131,300	1.6%	2.1%
South Central Colorado	23,100	27,600	37,000	1.8%	1.5%
South Front Range	662,600	779,800	1,016,400	1.6%	1.3%
South Eastern Plains	52,300	53,000	57,700	0.1%	0.4%
TOTAL	**812,200**	**947,100**	**1,242,400**	**1.5%**	**1.4%**

Division 3: The Rio Grande River Basin
Historic Population Change

The population of the San Luis Valley of the Rio Grande River Basin has increased only slightly in the fifty years between 1950 and 2000. The population actually declined between 1950 and 1970 to a census low of 37,500 in 1970, increased only slowly in 1990, and then began to grow again at a rate of 1.4% through the 1990s. The largest county and the regional center, Alamosa County grew the most over the fifty-year period. Rio Grande, the next largest county with both an agricultural and tourism economy, declined in population from 1950 to 1980, then recovered most of that loss by 2000 (see Figure 4-4).

Figure 4-4: Historic and Projected Population, Division 3



Projected Population Change

The population of the Rio Grande River Basin is expected to grow more steadily, at approximately 1% per year over the next thirty years. The region expects to maintain its agricultural base, but more importantly expand its opportunities for tourists and retirees. Alamosa County, at the center of the region is expected to grow the most. However, all other counties of the region should benefit from new opportunities leading to a population increase of 37% (see Table 4-5 and Figure 4-4).

Table 4-5: Projected Population Change in Division 3

Division 3	2000	2010	2030	Annual Growth Rate '00-'10	Annual Growth Rate '10-'30
Mineral County	800	1,000	1,200	1.7%	1.0%
Rio Grande County	12,434	13,400	15,900	0.8%	0.8%
Saguache County	5,954	7,100	8,700	1.8%	1.0%
Alamosa County	15,139	17,300	23,100	1.3%	1.5%
Conejos County	8,400	8,800	9,900	0.4%	0.6%
Costilla	3,675	4,000	4,600	0.9%	0.7%
Total	**46,435**	**51,600**	**62,400**	**1.1%**	**1.0%**

Division 4: The Gunnison River Basin
Historic Population Change

The Gunnison River Basin consists of the five counties of the west central part of the Colorado Western Slope: Delta, Montrose, Ouray, Gunnison, and Hinsdale counties. During the fifty-year period from 1950 to 2000 its population increased 84% with most of the growth occurring in the 1970s and the 1990s. Delta and Montrose Counties are the largest and the fastest growing; combined they grew nearly doubled in the past fifty-year period (see Figure 4-5).

Projected Population Change

The population of the Gunnison River Basin is expected to continue to grow in the next thirty years to 2030 from 80,200 to 147,500. Its major drivers will be tourism and retirees. All five counties are of exceptional beauty with many scenic public lands. As the baby-boomers approach retirement age, the area's population growth will remain steady, above 2%, and will be fairly independent of national economic downturns (see Table 4-6 and Figure 4-5).

Figure 4-5: Historic and Projected Population, Division 4

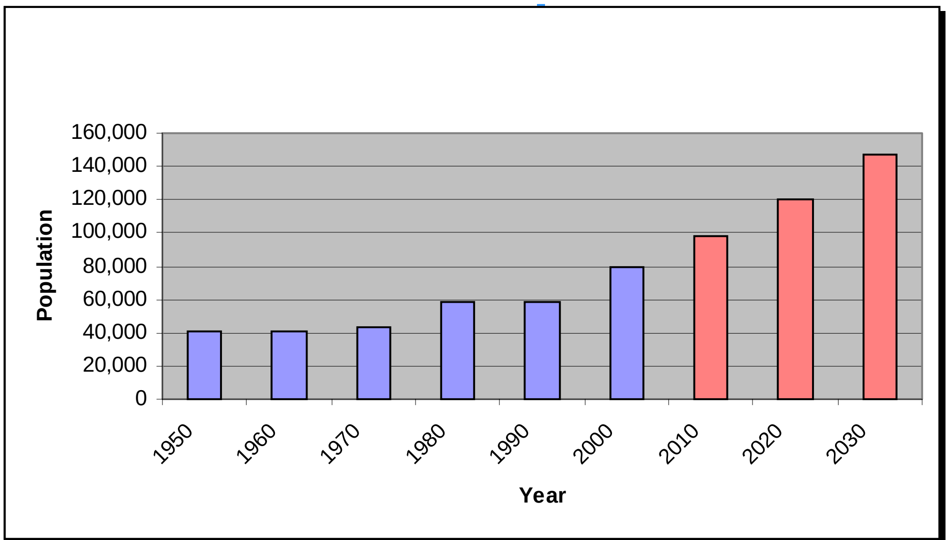


Table 4-6: Projected Population Change in Division 4

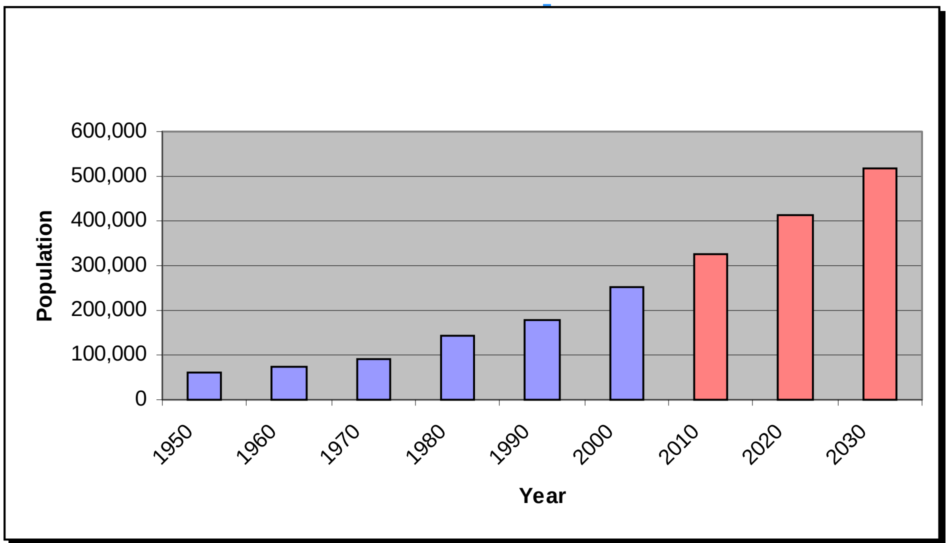
Division 4	2000	2010	2030	Annual Growth Rate '00-'10	Annual Growth Rate '10-'30
Delta County	28,000	34,400	50,900	2.1%	2.0%
Montrose County	33,700	42,900	66,600	2.4%	2.2%
Ouray County	3,800	4,700	7,000	2.3%	1.9%
Gunnison County	14,000	15,600	21,800	1.1%	1.7%
Hinsdale County	800	900	1,100	1.4%	1.8%
TOTAL	**80,200**	**98,600**	**147,500**	**2.1%**	**2.0%**

Division 5: The Colorado River Basin

Historic Population Change

The population in the Colorado River Basin quadrupled from 1950 to 2000. The basin consists of five resort counties and the Grand Junction metropolitan area (Mesa County). The resort counties increased five times between their 1950 population of 23,000 to 136,300 in 2000. The Grand Junction metropolitan statistical area population tripled its 39,000 1950 population to reach 116,300 by the 2000 census (see Figure 4-6).

Figure 4-6: Historic and Projected Population, Division 5



Projected Population Change

The Colorado River Basin is expected to double again by 2030 from gains both in tourism and in its retirement population. Grand, Summit, Eagle, Pitkin, and the eastern end of Garfield Counties will continue to thrive from tourism and, in particular, activities related to second homes. Again, many of these occupants will make these homes a temporary, if not permanent, place of retirement.

Mesa County is already a major retirement center with retirees accounting for nearly half of its economic base. This industry will continue to expand further as baby-boomers in the Western United States consider the areas mild climate and access to public lands. Western Garfield County, with the world's largest supply of oil shale, holds a small though significant potential of exploding all population forecasts for the area (see Table 4-7 and Figure 4-6).

Table 4-7: Projected Population Change in Division 5

				Annual Growth Rate	
Division 5	**2000**	**2010**	**2030**	**'00-'10**	**'10-'30**
Grand County	12,900	16,800	29,700	2.7%	2.9%
Summit County	25,700	32,500	50,600	2.4%	2.2%
Eagle County	43,400	57,100	90,000	2.8%	2.3%
Pitkin County	15,900	18,700	27,600	1.6%	2.0%
Garfield County	44,300	58,700	99,000	2.9%	2.6%
Mesa County (Grand Junction)	117,700	144,100	220,400	2.0%	2.1%
TOTAL	**259,800**	**327,700**	**517,300**	**2.3%**	**2.3%**

Division 6: The Yampa, White and North Platte Basins
Historic Population Change

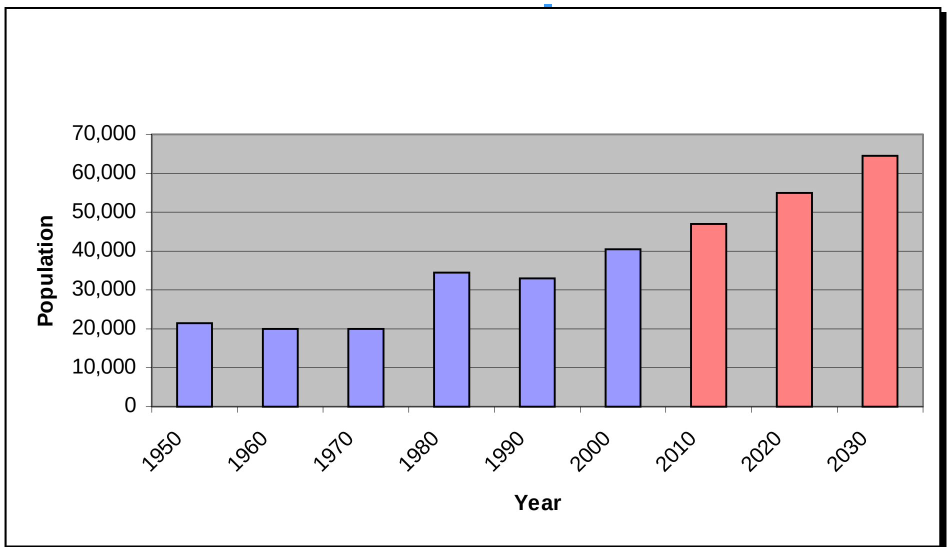
In Jackson County (the entirety of the North Platte River Basin in Colorado), the population in 2000 was only 1,577, having declined from 1,976 in 1950.

In the Yampa and White River Basins, the 1950 population of 18,000 of the three counties in Division 6 more than doubled to 39,000 by 2000. Most of this growth occurred in the 1970s because of the development of the recreational resort industry in Steamboat Springs (Routt County) and the energy industry in neighboring Moffat County. Further growth of tourism, especially related to second homes in the 1990s in Routt County contributed to the additional population growth in these basins during this fifty-year period (see Figure 4-7).

Projected Population Change

The Yampa and White River Basins are expected to grow another 60% mainly due to the continued growth of second homes and the work force they require and because a number of their occupants may stay, making the basin a part of their retirement. Routt County will receive most of these new residents adding 15,000 of the area's overall increase of 23,000.

Figure 4-7: Historic and Projected Population, Division 6



Jackson County is expected to grow back to over 2000 by 2030 at a slow rate of just under 1% (see Table 4-8 and Figure 4-7).

Table 4-8: Projected Population Change in Division 6

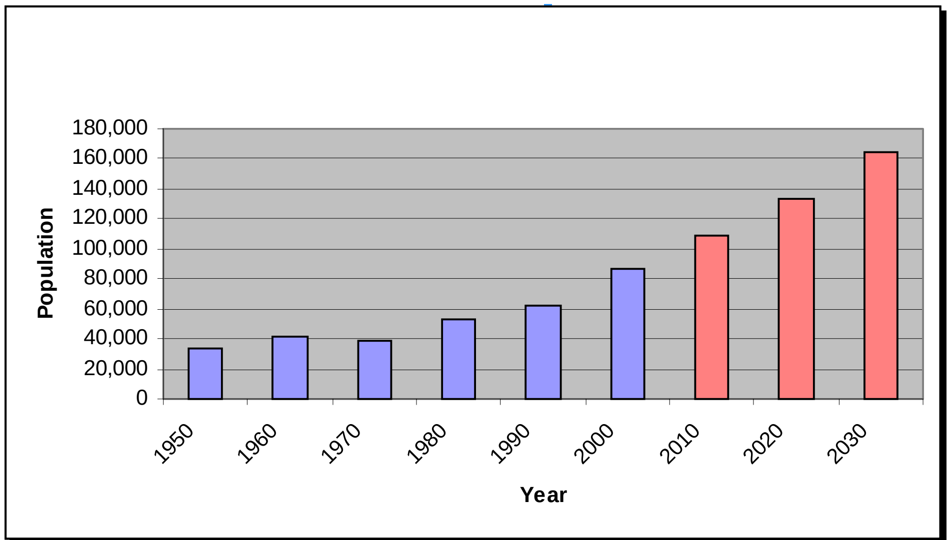
Division 6	2000	2010	2030	Annual Growth Rate '00-'10	Annual Growth Rate '10-'30
Routt County	21,100	24,200	35,600	1.9%	1.9%
Moffat County	13,200	14,700	17,600	1.1%	0.9%
Rio Blanco County	6,000	6,800	9,100	1.3%	1.5%
Jackson County	1,577	1,600	2000	0.1%	1.0%
TOTAL	**39,300**	**45,600**	**62,300**	**1.5%**	**1.6%**

Division 7: The Dolores and San Juan Basins

Historic Population Change

The Dolores and San Juan River Basin consist mainly of six counties in southwest Colorado: the larger of which are La Plata (Durango), Montezuma (Cortez), and Archuleta (Pagosa Springs). Other counties include San Miguel (Telluride), Dolores, and San Juan (Silverton). The population for the six counties increased 155% increase over the fifty year period from 1950 to 2000 with the largest growth occurring in La Plata and Montezuma counties (see Figure 4-8). San Miguel County's growth occurred in spurts in the 1970s and the 1990s due the development of tourism around Telluride.

Figure 4-8: Historic and Projected Population, Division 7



Projected Population Change

The population of the Dolores and San Juan River Basin is expected to nearly double in the next thirty years. The driving forces will be tourism in La Plata and San Miguel counties and growth in the retirement populations in those two counties as well as Archuleta and Montezuma counties. Archuleta County, with a current population of 10,000 is expected to more than double by 2030, mostly from retirement related populations (including necessary workforce populations) (see Figure 4-8 and Table 4-9).

Table 4-9: Projected Population Change in Division 7

Division 7	2000	2010	2030	Annual Growth Rate '00-'10	Annual Growth Rate '10-'30
San Miguel County	6,700	8,900	13,700	3.0%	2.2%
San Juan County	600	600	800	1.0%	1.4%
Dolores County	1,800	2,100	2,800	1.4%	1.3%
Montezuma County	23,900	28,100	40,000	1.7%	1.8%
La Plata County	44,600	54,400	80,400	2.0%	2.0%
Archuleta County	10,000	14,400	26,700	3.7%	3.1%
TOTAL	**87,500**	**108,600**	**164,400**	**2.2%**	**2.1%**

Discussion

The figures and explanations of population change in Colorado presented in this chapter clearly show that Colorado has a growing population. Several themes emerge that are important to water planning scenarios:

1. Population is growing and will continue to grow in all seven major river basins; however, that growth is higher in certain basins. Among the fastest growing basins are the San Juan River, South Platte/Republican River and the Colorado River basins. In particular, the fastest growing areas into 2030 are projected to be East Central Colorado, and Park, Teller, Garfield, Grand, and Archuleta Counties, which are all projected to have over 2.5% growth over the period from 2000 to 2003. This growth rate translates into more than a doubling of population in these areas

over the planning period. In order of projected growth, Table 4-10 shows how the divisions fall.

2. Growth will be fueled by a combination of factors such as growth in jobs, a population shifting into retirement and the growing importance of tourism-related jobs in the scenic areas of the state.

Table 4-10: Ranking of Divisions by Annual Growth Rate and 2030 Projected Population

Ranking by Annual Growth Rate		Ranking by Projected Population in 2030	
Division 5	2.3%	Division 1	4,961,900
Division 7	2.1%	Division 2	1,242,400
Division 4	2.0%	Division 5	517,300
Division 1	1.6%	Division 7	164,400
Division 6	1.6%	Division 4	147,500
Division 2	1.4%	Division 3	62,400
Division 3	1.0%	Division 6	62,300

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Abstract
This chapter focuses on statutory and other legal tools available in Colorado for coping with drought. The chapter begins with a narrative discussion of how the focus of Colorado water law on the protection of private property rights shapes opportunities for dealing with drought. Following is a listing of legal tools applicable to water supply and drought management in Colorado under federal, state, and local laws. Examples of materials covered in the chapter include local restrictions on residential irrigation; state statutory tools, such as augmentation plans and instream flows; and federally authorized programs for financial and technical assistance relating to drought. The chapter also discusses examples of voluntary measures taken by major water users in Colorado developed in cooperative efforts within the framework of Colorado water law to ameliorate the effects of drought on other water users and on the environment.

Contents:

The Focus of Colorado Water Law on the Protection of Private Property Rights Shapes Opportunities for Dealing with Drought

The Principles of Prior Appropriation as Tools for Drought Management

Statutory Tools for Drought Management

Federal, State and Local Legal Tools for Drought Management

Federal Tools for Drought Management in Colorado

State Statutory Tools for Drought Management

Local Drought Measures

I. The Focus of Colorado Water Law on the Protection of Private Property Rights Shapes Opportunities for Dealing with Drought

Like most arid western states, the allocation of water in Colorado is governed by the doctrine of "prior appropriation," commonly described as "first in time first in right."[1] Under this doctrine, rights to water are granted upon the appropriation of a certain quantity of water to a beneficial use, within a reasonable amount of time.[2] The date of appropriation determines the priority of the water right, with the earliest appropriation establishing the most senior, or superior, right.[3]

Thus, the right to the beneficial use of water in Colorado is based on a diversion for beneficial use through prior appropriation, rather than by grant from the State. [4]

[1] *See Irwin v. Phillips*, 5 Cal. 140 (1885).

[2] *See* Colo.Const. Art. XVI, § 6 ("The right to divert the unappropriated waters of any natural stream to beneficial uses shall never be denied"); *see also* C.R.S. § 37-92-103(3(a) ("Appropriation" means the application of a specified portion of the waters of the state to a beneficial use pursuant to the procedures prescribed by law"); and *Board of County comm'rs v. Upper Gunnison River Water Conservancy Dist.*, 838 P.2d 840 (Colo. 1992) ("To be effective, an appropriation must divert a definite quantity of water with the intent of applying such water to beneficial use").

[3] *See* Colo.Const,. Art.XVI, § 6 ("Priority of appropriation shall give the better right as between those using the water for the same purpose"); *Farmers' High Line Canal & Reservoir Co. v. Southworth*, 21 P. 1028 (1889) ("Priority of right to water by priority of appropriation is older than the constitution itself, and has existed from the date of the earliest appropriations of water in the boundaries of Colorado").

[4] The other major approach to water rights allocation in the United States is known as the "riparian" system, which is prevalent in the water rich states of the eastern United States. Under this system, water is allocated based on land ownership. Most riparian states now have permit statutes, under which an administrative official determines the quantity of water that may be diverted, and the terms and conditions for its use, based on criteria adopted by the legislature to protect public interests in the resource.

The right to appropriate and use water is a valuable property right that arises solely by the act of placing unappropriated water to beneficial use. [5] This right is protected under Colorado law and is rooted in Colorado's Constitution, which establishes that public uses of water in Colorado are subject to the right to appropriate a water right for private use:

> The water of every natural stream, not heretofore appropriated, within the state of Colorado, is hereby declared to be the property of the public, and the same is dedicated to the use of the people of the state, subject to appropriation as hereinafter provided. Colo.Const. Art. XVI, § 5.
>
> The right to divert the unappropriated waters of any natural stream to beneficial uses shall never be denied. Colo.Const. Art.XVI, § 6.

Like other property rights, vested water rights may not be taken without payment of just compensation, and may be bought and sold separately from land on which they are used.[6]

Colorado does not have a "public trust doctrine," like some states, nor is "the public interest" a factor considered in adjudicating a water right.[7] However, while the legislature in Colorado cannot prohibit the appropriation or diversion of unappropriated water for beneficial use based on public policy concerns, it can regulate the manner of effecting an appropriation.[8] Important tools for the management of water resources have been developed through case law and statutory enactments governing the diversion and use of water.[9]

As the doctrine of prior appropriation has been interpreted through case law, two major principles have emerged based on the constitutional requirement of "beneficial use" and the conception of

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[5] *See Sherwood Irrigation Co. v. Vandewark*, 331 P.2d 810 (1958) ("Water is a valuable property right, subject to sale and conveyance"); *see also* Justice Gregory Hobbs, "Colorado Water Law: An Historical Overview," 1 U.Denv. Water L. Rev. 1 at 2 ("Western prior appropriation water law is a property rights-based allocation and administration system, which promotes multiple use of a finite resource.").

[6] *See Strickler v. City of Colorado Springs*, 26 P. 313, 316 (Colo. 1891) ("A priority to the use of water for irrigation or domestic purposes is a property right and as such is fully protected by the constitutional guaranties relating to property in general").

[7] *See* Hobbs, 1 U.Denv.Water.L.Rev 1 at 23, *supra*, *citing People v. Emmert*, 597 P.2d 1025, 1027-28 (Colo. 1979) and *Aspen Wilderness Workshop v. Hines Highlands Ltd. Partnership*, 929 P.2d 952, 972 (Colo. 1996).

[8] *City and County of Denver v. Bergland*, 517 F.Supp. 155 (D.Colo. 1981), *aff'd in part and rev'd on other grounds*, 695 F.2d 465 (10th Cir. 1982) ("The right to appropriate and divert water is not absolute.");*see also Fox v. Division Eng. For Water Div. 5*, 810 P.2d 644 (Colo. 1991).

[9] The Water Right Determination and Administration Act of 1969 (the "1969 Act"), §§ 37-92-101 to 37-92-602, provides the statutory framework for implementing the constitutional right to divert water for beneficial use.

water as a property right. These include: First, that water must be used efficiently and that a water right does not include the right to waste the resource; and second, that 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 in times of scarcity. 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. Regarding flexible use of water rights, Colorado law recognizes water storage rights, conditional water rights, augmentation plans, changes of water rights and instream flow rights, all of which allow water users to make the most of a scarce resource.

In summary, the absence of a permit system or a public interest test in Colorado requires the State to stay within the bounds of the priority system, and to respect private property rights, in managing the resource for public purposes in times of drought. However, the prior appropriation system, itself, provides opportunities for management of the resource. The following discussion focuses, first, on: (1) the elements of the prior appropriation doctrine which promote efficient use of a scarce resource, and which, themselves, are tools for drought management; and (2) statutory tools adopted by Colorado's legislature to manage water resources within the parameters of the prior appropriation system. Second, there is included a summary of federal, state and local legal tools available for drought management in Colorado.

A. The Principles of Prior Appropriation as Tools for Drought Management

1. The Priority System

The priority system of water allocation is designed to cope with water scarcity.[10] Under the doctrine of prior appropriation, if water is insufficient to meet the needs of all water users, senior water users can require full or partial curtailment of diversions by junior water users, such that users with later priorities receive less than their allotted amount of water, or none at all.[11] Essentially, this doctrine protects senior appropriators from injury by junior appropriators.[12]

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[10] *See* James N. Corbridge Jr. and Teresa Rice, Vranesh's Colorado Water Law (Revised ed. 1999) at 2 ("The primary advantage of the appropriation system is the development of methods for the orderly distribution of water in water-short regions by establishing procedures for both the quantification and prioritization of water rights").
[11] *See* C.R.S. § 37-92-301(3) (requiring the state engineer to distribute water in accordance with the priority system).
[12] *Application of Hines Highlands Partnership*, 929 P.2d 718 (Colo. 1996).

Thus, the more senior the water right, the more valuable it is, particularly in times of drought. As mentioned above, water rights may be bought and sold and changed to a new type, place and manner of use, pursuant to the statutory provisions for a "change of water right," discussed below. Therefore, one tool for management of drought in Colorado simply involves taking advantage of the market for water rights to obtain rights with a senior priority.[13] As discussed below, Colorado statutory law allows the State to do this by purchasing water rights and changing them for use as instream flows. Likewise, municipalities and other water users can protect themselves against water shortages in times of scarcity by acquiring water storage rights and by purchasing senior agricultural water rights and converting them to municipal, commercial or industrial uses.

2. *Beneficial Use*

The single most important restriction on the appropriation of water in Colorado, in terms of the State's ability to limit the amount of water diverted and used, is the constitutional requirement that water be placed to a "beneficial use."[14] "Beneficial use" is defined in the Water Right Determination and Administration Act of 1969, Section 37-92-101 et seq. (hereafter 1969 Act) as follows:

> Beneficial use is 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[.][15]

The purpose of the beneficial use requirement is to prevent waste, hoarding and speculation by appropriators and to encourage the quick and efficient use of the resource.[16]

The beneficial use requirement acts as a limit on the amount of water that may be appropriated for private use throughout the life of the water right. In order to establish a valid appropriation for an absolute water right, a water user must demonstrate that a certain amount of water has been applied to a beneficial use for the proposed purpose. [17] The amount decreed is limited to the amount placed to beneficial use.

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[13] According to an article in the Denver Post on June 30, 2003, current prices for water in the Front Range range from $11,000 to $13,000 for an acre-foot. *See* Denver Post, "Farmers' Market: Lease Water to Cities," by Coleman Cornelius.

[14] *See* Vranesh, *supra*, at 43, citing *Thomas v. Guiraud*, 6 Colo. 530 (Colo. 1883) (referring to the beneficial use requirement as the "true test of an appropriation of water").

[15] C.R.S.§ 37-92-103(4) (2002).

[16] *See* Vranesh, *supra*, *citing*, *Combs v. Agricultural Ditch Co.*, 152, 28 P. 966, 968 (Colo. 1892).

[17] *See* C.R.S. § 37-92-103(a) (this section sets forth Colorado's "anti-speculation doctrine," requiring that an applicant for an absolute or conditional water right show that the proposed appropriation is not based upon the "speculative sale or transfer of the appropriative rights[,]" and that the applicant has "a specific plan and intent to divert, store or otherwise capture, possess, and control a specific quantity of water for specific beneficial uses").

In order to obtain a conditional water right, which has not yet been placed to beneficial use, a water user must establish that it "can and will" place a certain amount of water to beneficial use within a reasonable amount of time.[18] Thus, a water user may not appropriate more water than it actually needs for its intended use.

Courts have further applied the principle of beneficial use in holding that a water user has no right as against junior appropriators to divert more water than can be used beneficially,[19] regardless of the amount decreed, or to expand its use beyond the amount needed for the decreed use.[20] Thus, the true measure of a water right is the amount that can be placed to beneficial use, which may be less than the amount decreed, if the user's actual need for water changes over time.

As a practical matter, a water user that diverts more water than it can place to beneficial use may be curtailed by the Division Engineer.[21] In addition, if water under a vested water right is not placed to beneficial use for an extended period of time, and an intent to abandon the water right is demonstrated, a vested water right may be lost to abandonment through non-use.[22]

Thus, application of the principal of beneficial use allows the State to limit the quantity of water initially allocated under individual water rights, and to ensure through administration, that the amount of water used under a water right over time remains limited to the amount actually needed. Ensuring that water is used efficiently, without waste, enables the State to conserve water for other uses and users. Conservation is clearly an important tool for managing water scarcity in times of drought.

3. *Maximum Utilization*

Colorado courts have held that water should be allocated and administered in a way that promotes the "maximum utilization" of the resource.[23] This principle was formulated in reliance on Article XVI, Section 6 of the Colorado Constitution, providing that "[t]he right to divert the unappropriated waters of any natural stream to beneficial uses shall never be denied."[24] Maximum utilization has

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[18] *See* C.R.S. § 37-92-305(9)(b).
[19] *See*, *Comstock v. Ramsay*, 133 P. 1107, 1110-11 (Colo. 1913).
[20] *See Weibert v. Rothe Bros. Inc*, 618 P.2d 1367, 1373 (Colo. 1980).
[21] *See* § 37-92-502(2)(a) "Each division engineer shall order the total or partial discontinuance of any diversion in his division to the extent that the water being diverted is not necessary for application to a beneficial use[.]"
[22] *See City & County of Denver v. Middle Park Water Conservancy District*, 925 P.2d 283, 286 (Colo. 1996).
[23] *See Fellhauer v. People*, 447 P.2d 986, 994 (Colo. 1968).
[24] *See id.* at 994 ("It is implicit in these constitutional provisions that, along with Vested rights, there shall be Maximum utilization of the water of this state") (capitalization in original); *see also* C.R.S. § 37-92-102(1)(a) (Under the "basic tenets of Colorado water law," the legislature has codified the doctrine of maximum utilization, declaring that "it is the policy of this state to

been applied by the courts in two ways: (1) to require an efficient means of diversion with the purpose of making more water available to other water users; and (2) in support of the adoption of statutory tools allowing flexible administration in times of scarcity, including, for example, augmentation plans, exchanges, storage rights and the "futile call doctrine."

Applying the principle of maximum utilization, Colorado courts have limited appropriators to use of a reasonably efficient means of diversion. In *City of Colorado Springs v. Bender*,[25] for example, the Colorado Supreme Court held that senior well owners were not entitled to enjoin pumping by a junior well owner where the senior's well was unreasonably shallow and where changes to the seniors' wells, within the "economic reach" of the seniors, would allow them to achieve their appropriation without curtailment of the junior user.[26] In *Alamosa-La Jara Water Users Protection Association v. Gould*,[27] the Court held that the state engineer could determine through regulations what constitutes a "reasonable means of diversion," and could require senior water users to adopt such reasonable means in furtherance of the goal of achieving "maximum utilization" of water.

The doctrine of maximum utilization has also been applied by the courts in support of the use of augmentation plans.[28] Augmentation plans, described in more detail below, are statutory creations which allow out-of-priority diversions by juniors, while protecting seniors from injury through the provision of substitute supplies to other water users. The Colorado Supreme Court has recognized the importance of plans for augmentation where water is scarce, stating, "the fact that the rivers involved are over-appropriated, rather than being an argument against the plans for augmentation, is the very reason for the valid exercise of ingenuity of persons seeking to maximize the use of water . . . ."[29]

Like augmentation plans, the "futile call doctrine" also allows junior water users to divert when they are out-of-priority under certain circumstances. Under this doctrine, a junior water user will be curtailed only if such curtailment makes water available at the time

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integrate the appropriation, use, and administration of underground water tributary to a stream with the use of surface water in such a way as to maximize the beneficial use of all of the waters of this state") (emphasis added).

[25] 366 P.2d 552 (1961).

[26] *Bender*, 366 P.2d at 555, 556 ("the plaintiffs cannot reasonably 'command the whole' source of supply merely to facilitate the taking by them of the fraction of the entire flow to which their senior appropriation entitles them").

[27] 674 P.2d 914 (Colo. 1983).

[28] *See* C.R.S., § 37-92-501.5, requiring the State Engineer to "exercise the broadest latitude possible in the administration of waters under their jurisdiction to encourage and develop augmentation plans and voluntary exchanges of water . . . in order to allow continuance of existing uses and to assure maximum beneficial utilization of the waters of this state."

[29] *Kelly Ranch v. Southeastern Colo. Water Conservancy Dist.*, 550 P.2d 297, 304 (Colo. 1976).

and place of injury to a senior.[30] This allows juniors to continue diverting in times of scarcity, even if a senior is not receiving its whole entitlement, where curtailment of the junior would not allow any additional water to reach the senior.

Likewise, storage projects also promote the maximum utilization of water. In *A-B Cattle Co. v. United States*,[31] the Colorado Supreme Court relied on the principle of maximum utilization to uphold a replacement plan necessitated by the construction of the Frying-Pan Arkansas storage project, recognizing that storage projects promote maximum utilization in times of scarcity. In this case, the Court held that a water user did not have the right to continue receiving water with a high silt content, which had the effect of sealing the user's ditch to prevent leakage, where the silty water was replaced with clear water as a result of the construction of the dam. As stated by the Court: "In using its leaky ditches the Bessemer Co. has not attempted to make maximum utilization of the water. . . . [P]laintiffs do not have the right to use silt content to help seal leaky ditches. To view it otherwise would run contra to a basic principal of western irrigation that conservation and maximum usage demand the storage of water in time of plenty for the use in times of drought."[32]

The principle of maximum utilization is a double-edged sword in terms of its usefulness as a tool for drought management. On one hand, the State can rely on maximum utilization in administering water rights in order to require water users to use a reasonable means of diversion, and in support of statutory mechanisms allowing water users to divert water under plans for augmentation or from storage, when water would otherwise not be available in times of drought. On the other hand, the focus in Colorado on maximum utilization of the resource, without qualification by any requirement that water be conserved for public uses, limits the ability of the State to manage the resource to protect the environment or the public interest in times of drought.[33]

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[30] *See* C.R.S., §§ 37-92-102(2)(d) ("No reduction of any lawful diversion because of the operation of the priority system shall be permitted unless such reduction would increase the amount of water available and required by water rights having senior priorities"); and 37-92-502(a) ("Each division engineer shall order the total or partial discontinuance of any diversion in his division . . . to the extent that the water being diverted is required by persons entitled to use water under water rights having senior priorities, but no such discontinuance shall be ordered unless the diversion is causing or will cause material injury to such water rights having senior priorities").

[31] 589 P.2d 57 (Colo 1978).

[32] *Id.* at 61.

[33] The Colorado Supreme Court has tempered its application of the principle of maximum utilization where the proposed manner of obtaining additional water would have obvious environmental costs, referring in such cases to the requirement for "optimum use" and requiring "proper regard for all significant factors, including environmental and economic concerns[.]" *See e.g. Southeastern Colo. Water Conservancy Dist. v. Shelton Farms, Inc.*, 529 P.2d 1321, 1327 (Colo. 1974) (the court held that cutting down cottonwood trees would not produce water that could be used free from the priority system); *R.J.A., Inc. v. Water Users Ass'n, 690 P.2d 823 (Colo. 1984)* (additional consumptive use could not be obtained by draining a peat bog or wetlands); *State*

B. *Statutory Tools for Drought Management*

1. *Instream Flows*

Under the 1969 Act, the Colorado Water Conservation Board ("CWCB") is authorized to appropriate water for "minimum stream flows or for natural surface water levels or volumes for natural lakes to preserve the natural environment to a reasonable degree."[34] Appropriations for instream flows may only be made by the CWCB, not by private individuals, and must be made within the priority system, consistent with the restrictions in Sections 5 and 6 of Colorado's Constitution. The CWCB can also acquire water rights for instream flows "by grant purchase, donation, bequest, devise, lease, exchange, or other contractual agreement."[35]

In recent years, Colorado's legislature has expanded the resources available to the CWCB for instream flow purposes. In 2002, the legislature increased the sources of funding that the CWCB may use to acquire water for instream flows, to include "any funds available to it, other than the construction fund created in section 37-60-121, for acquisition of water rights and their conversion to instream flow rights.[36] In 2003, the legislature amended § 37-83-105, C.R.S., which provides for temporary loans or exchanges of water between water users in times of drought without requiring adjudication of a change of water rights, to allow the CWCB to receive water through loans from water users for instream flow purposes on a temporary basis, not to exceed 120 days, in any basin where the Governor has declared a drought or other emergency. [37] Such loans are subject to a determination by the State Engineer of non-injury to other water users.

The ability of the State to acquire water within the priority system for instream flow purposes is essential to its ability to protect wildlife and the environment in a prior appropriation state during times of drought. Since Colorado water law does not allow the State to consider environmental factors in allocating or administering water, the only way for the State to ensure protection of stream flows for public purposes is by acquiring water rights, itself, within the priority system. By acquiring a water right with an enforceable priority, the State can place environmental concerns on equal footing with agricultural, commercial, municipal and other uses of water. This means that in times of scarcity, the State's instream flows will be

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Eng'r v. Castle Meadows, Inc., 856 P.2d 496, 510 (Colo. 1993) (augmentation water could not be obtained by paving impermeable land surfaces).

[34] C.R.S. § 37-92-102(3).

[35] *Id.*

[36] *See id.*

[37] House Bill 03-1320.

protected in a manner consistent with their priorities – to the extent the priorities are junior to other water rights, the CWCB's instream flows will be curtailed to make water available to other senior water users, and to the extent the CWCB's priorities are senior, the CWCB may request the Division Engineer to curtail more junior users to protect its instream flows.

2. *Conditional Water Rights*

A conditional water right is defined in the 1969 Act as "a right to perfect a water right with a certain priority upon the completion with reasonable diligence of the appropriation upon which such water right is based."[38] A conditional water right allows an appropriator to secure a priority before water has been applied to beneficial use, based on a showing that the "first step" towards the appropriation has been taken. The "first step" includes the intent to appropriate, plus a demonstration of that intent through "physical acts sufficient to constitute notice to third parties."[39] Once the appropriator actually places the water to beneficial use, a final decree may be issued with a priority date relating back to the initiation of the appropriation through the "first step."

As explained by the Colorado Supreme Court in *Public Service Co. v. Blue River Irrig. Co.*,[40] a conditional water right "encourage[s] development of water resources by allowing the applicant to complete financing, engineering, and construction with the certainty that if its development plan succeeds, it will be able to obtain an absolute water right." Conditional water rights are crucial to large-scale development projects, such as trans-mountain diversions and storage projects, because they allow an appropriator to secure a priority to protect its investment when water cannot immediately be placed to beneficial use.[41] Thus, conditional water rights are a tool that may be used by cities or individuals to complete major water projects, including, storage reservoirs, trans-mountain diversion projects, or pipelines, for managing scarcity in times of drought.

3. *Water Storage Rights*

A right to store water for later application to beneficial use is a recognized by the 1969 Act.[42] Storage rights, like other water rights, are assigned a priority and must be exercised without injury to other water rights.[43] Storage rights are obviously a very important mechanism for ensuring that water supplies will be adequate in times of drought.

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[38] C.R.S.§ 37-92-103(6)
[39] *City of Aspen v. Colorado River Water Conservation Dist.*, 696 P.2d 758, 761 (Colo. 1985).
[40] 753 P.2d 737, 739 (Colo. 1988).
[41] *See* Vranesh, *supra* at 99.
[42] C.R.S. § 37-87-101.
[43] *Id*.

Reservoirs provide year-round water to cities when stream levels drop following the snow melt each year.[44] Over the years, there have been numerous reclamation projects undertaken by Colorado irrigation districts and water conservation districts in partnerships with the federal government.[45] Some examples of such projects include the Fryingpan-Arkansas Project, which serves Western Colorado, and the Colorado-Big Thompson Project, which brings water from Western Colorado to the front range to meet the growing needs of cities.

Currently, the CWCB is investigating a major new water diversion/storage project to shore up Colorado's water reserves, known as Colorado River Return Project, also called "The Big Straw Project." This project would involve construction of a large-scale water delivery system to transport water from the Colorado River near the Utah border, eastward to the South Platte, Arkansas and Colorado River basins. A study of the feasibility of this proposal was initiated by the CWCB in 2002, and is due to be completed in November, 2003.

4. Changes of Water Rights

A change of water rights is another tool that allows water users flexibility to maximize potential uses of water. As described in the 1969 Act, a change of water rights includes "a change in the type, place, or time of use, a change in the point of diversion," and changes in the manner or place of storage. A change of water rights will not be allowed unless it is approved by the water court,[46] subject to the "no injury rule," which requires a finding that the change "will not injuriously affect the owner of, or persons entitled to use, water under a vested water right or a decreed conditional water right."[47]

To prevent injury from a change of water rights, water courts restrict the amount of water that may be changed to the amount of historic consumptive use associated with the water right, which may be less than the amount decreed. [48] Thus only the amount of water actually consumed through use or evaporation, which is not returned to the stream as return flows, may be changed to a new place or type of use. This limitation ensures that the change will not enlarge the historic impact on the stream system, avoiding injury to other water users.

Changes of water rights allow for the reallocation of water resources to meet changing demands. For example, in Colorado, the highest demand for water was traditionally for agriculture, in rural areas. As

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[44] *See* Hobbs, I U. Denv. Water L. Rev. 1 at 13, *supra*.
[45] *See id.* (for discussion of 1902 Reclamation Act and reclamation storage projects in Colorado).
[46] *See Northern Colo. Water v. Three Peaks Water*, 859 P.2d 836 (Colo. 1993).
[47] C.R.S. § 37-92-305(3).
[48] *See Santa Fe Trail Ranches Property Owners Ass'n v. Simpson*, 990 P.2d 46 (Colo. 1999).

a result of the population explosion in the front range during the past twenty years, however, the highest demand for water is now in municipal areas. The procedure for a change of water rights allows cities to purchase senior agricultural water rights, formerly used in rural areas, and change them to municipal uses in cities. Likewise, the CWCB can also purchase agricultural water rights and change them for use as instream flows.

The adjudication proceedings required to effect a change of water rights are time consuming and costly. Even when no parties object to the change, the process of water court approval takes a minimum of three months, and often much longer due to the heavy case load of water court judges. If parties do intervene in a change case, it can take years to get a change decree approved by the court. In addition to the attorneys' fees, an applicant for a change of water rights generally must hire and engineering consultant to prepare a report explaining the technical aspects of the change and developing an accounting form to be used by the Division Engineer to administering the change. In order to avoid these costs and to speed the process, Colorado's legislature recently enacted legislation providing for leases of water without requiring a change of water rights to be adjudicated. This legislation is discussed immediately below.

5. *Leases of Water*

During the last legislative session, C.R.S. §§ 37-80.5-101 to 105 were amended to authorize the State Engineer to create water banks within each water division, and to adopt rules governing their operation. The aim of this legislation is to simplify the process for transferring water rights by eliminating the adjudication proceedings required for a permanent change of water rights. The statute provides that the rules shall allow for the "lease, exchange, or loan of stored water within a water division," including a transfers to the CWCB for instream flow purposes, without the need to submit to any adjudication proceedings. Notwithstanding the fact that the lease, exchange or loan is not adjudicated, such arrangements will still be subject to administration by the Division Engineer, within the priority system, without material injury to other water users.

Even prior to the enactment of the above-described legislation, leases of water, particularly by municipalities during dry years, are common in Colorado. In March, 2003, for example the city of Fort Collins entered into two year-long leases with two irrigation companies, under which the city uses agricultural irrigation water rights for municipal uses.[49] The water rights subject to the leases belong to approximately 400 northern Colorado farmers, most of whom did not think enough water would be available this year due to drought

[49] Denver Post, June 30, 2003, "Farmers' Market: Lease Water to Cities," by Coleman Cornelius.

conditions to enable them to farm their crops. Leasing their water allows the farmers to earn some income during a drought year when their crops are not likely to be successful, without permanently changing or selling their water rights. As a result of the drought conditions in recent years, the cost to lease water rights has risen from approximately $25 per acre foot to $300-$500 per acre foot.[50]

6. *Augmentation Plans*

An augmentation plan allows a water user to divert water out-of-priority from its decreed point of diversion, so long as replacement water is provided to the stream from another source, to make up for any deficit to other water users.[51] An augmentation plan, like a change of water rights, must be approved by the water court and is also subject to the "no injury rule." Accordingly, the 1969 Act requires substituted water to be "of a quality and quantity to meet the requirements for which the water of the senior appropriator has normally been used[.]"[52]

As explained by the Colorado Supreme Court in *In re Application of Midway Ranches v. Midway Ranches Property Owners Association, Inc*,[53] "[a]ugmentation plans implement the Colorado doctrine of optimum use and priority administration, which favors management of Colorado's water resource to extend its benefit for multiple beneficial purposes." Augmentation plans provide a statutory mechanism for many different types of water users, big and small, to make water available when they want it, where they want it, by taking advantage of large water storage projects in which they have acquired shares, as well as other sources of augmentation water. In times of scarcity, an augmentation plan allows a water user to continue diverting even under a relatively junior priority, so long as it can purchase replacement water to satisfy the needs of downstream seniors.

7. *Voluntary Measures*

During the summer of 2002, when Colorado's drought was at its worst, many water users undertook voluntary measures to ease the impact of drought on other water users and on the environment by abstaining from enforcing their priorities against juniors. For example, several ditch companies in northwest Colorado allowed water owned by the Colorado Division of Wildlife (DOW), stored in Big Beaver Reservoir, to flow past their head gates so that the water could reach a stream segment with an instream flow water right held by the CWCB, in order to protect fish in that stream segment.[54] The

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[50] *Id.*
[51] C.R.S. § 37-92-305(5).
[52] *Id.*
[53] 938 P.2d 515, 522 (Colo. 1997).
[54] *See http://dnr.state.co.us/news/press.asp?pressid=2037,* "Water Users Allow Water to Bypass Diversion Structures to Benefit Environment," August 15, 2002.

DOW's water rights are decreed for storage and could not be used for instream flow purposes, because only the CWCB may hold an instream flow water right. Ordinarily, the ditch companies, whose water rights are senior to the CWCB's instream flow right on the affected segment, would divert the water released from the reservoir to satisfy their own priorities. Therefore, the ditch companies had no obligation under law to allow the water to flow past them to the affected reach.

Also during the summer of 2002, certain Grand Valley entities, including the Grand Valley Water Users Association, Orchard Mesa Irrigation District and the Grand Valley Irrigation Company reduced their call[55] for water to conserve water stored in upstream reservoirs for the next year. This had the added benefit of helping Denver Water by reducing the water it would owe under certain contractual arrangements to Dillon Reservoir this year by 15,000 acre feet.[56]

In addition, during 2002, several large power companies reduced their demand in order to allow reservoirs to fill, benefiting water users all over Colorado who are dependent on stored water. This past winter and spring, the Shoshone power plant eliminated its call for water to one of its two turbines, cutting power generation in half, in order to allow Granby, Green Mountain, Williams Fork, Dillon and Windy Gap reservoirs to fill. Shoshone was reimbursed, primarily by Denver Water, for its loss of power, but absorbed other costs associated with foregoing power.[57] Between the fall of 2002 and April, 2003, Redlands Power Authority reduced its demand from 750 to 600 c.f.s., benefiting the entire Gunnison River Basin and allowing water to be stored in the Aspinall Unit. Redlands was compensated, primarily by the Colorado River Water Conservation District for revenue lost due to decreased electrical generation.[58]

Nothing under Colorado water law prevents water users from adopting voluntary, or paid, arrangements under which a senior water user temporarily agrees to forego calling out a junior user. In order to have a water right abandoned through non-use, failure to use the water right must endure for a significant amount of time and there must be an intent to abandon the right. According to the Division Engineers for Water Divisions 4 and 5, these types of "neighborly" arrangements were fairly common among water users during 2002, when drought conditions were at their peak.

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[55] The call for water by these entities is collectively referred to as the "Cameo call," named after the Cameo gauging station at the Xcel Energy power plant on the Western Slope.
[56] This information was obtained from Alan Martellaro, Division Engineer, Water Division No. 5.
[57] *Id.*
[58] This information is based on conversations with Frank Kugel, Division Engineer, Water Division No. 4.

II. Federal, State and Local Legal Tools for Drought Management

The following section includes examples of tools that may be utilized in Colorado to cope with drought, including: (1) federal programs designed to assist states to deal with drought; (2) state statutory tools, in addition to the major statutory tools discussed in more detail above; and (3) local municipal approaches to drought management.

A. *Federal Tools for Drought Management in Colorado*

Many federal programs exist to assist states in times of drought. These programs focus primarily on the provision of funds or technical assistance, including information on weather trends and monitoring data, for example. Table 5-1 shows examples of assistance available to states from the federal government, but is not comprehensive.

Table 5-1: Federal Tools for Drought Management in Colorado

1. National Streamgaging Program
"Under this program, the USGS collects the streamflow data needed by Federal, State, and local agencies for planning and operating water-resource projects and regulatory programs." For this program the USGS continuously measures the stage and flow at key points on streams and rivers and also monitors ground-water levels, reservoir contents, and water quality. The data made available is used in responding to drought emergencies, characterizing a drought, finding alternative supplies of water, and allocating water resources.
2. USACE Emergency Water Supply/ Drought Assistance Program
Under this program the U.S. Army Corps of Engineers is "authorized to transport emergency supplies of clean drinking water for human consumption to any designated area as a drought distressed area, and to construct wells in such drought distressed areas." The assistance provided through this program is supplemental to State and local efforts and is applicable in any locality faced with a threat to public health and welfare as a result of drought.
3. Crop Disaster Program
Under this program, farmers are reimbursed for crop production and quality losses (other than sugar cane, sugar beets or tobacco). For crops produced during 2001 and 2002, payments were issued for losses exceeding 35% of expected crop production at: 50% of the established price for crops covered by insurance, 50% of the established price for crops which insurance was not available and 45% of the established price to producers for crops that could have been but were not insured.
4. Noninsured Crop Disaster Assistance Program
This program provides financial assistance to eligible farmers affected by natural disasters, including drought. This federally funded program covers non-insurable crop losses and planting prevented by disasters.
5. Reclamation Reform Action
Section 210(b) of the Reclamation Reform Act and most water service contracts and repayment contracts executed after July 17, 1979, contain provisions requiring contractors to prepare and submit water conservation plans.
6. 2003 Livestock Feed Program
This program provides relief to livestock producers in areas hit hardest by drought by making available surplus stocks of non-fat dry milk. This non-fat dry milk serves as a high quality source of protein to maintain foundation livestock herds during the drought.
7. Federal Energy Management Program ("FEMP")
This program provides technical support to federal facility mangers to help identify opportunities for successful water conservation projects. The purpose of the program is to enable agencies to move easily from identifying a project to implementing it. The FEMP's technical assistance program offers a broad range of services that include project and financing assistance, software tools, and training.
8. National Oceanic and Atmospheric Administration: Drought Information Center
The National Oceanic and Atmospheric Administration has an online drought information center which provides current information on drought and climate conditions. In addition to giving an updated assessment of recent conditions and drought status, the website provides a number of other services including: U.S. soil moisture monitoring, a monthly standardized precipitation index, and a crop moisture index which is updated weekly.

B. *State Statutory Tools for Drought Management*

In addition to the major statutory tools allowing for flexible water use in Colorado, discussed above, there are several other Colorado statutes which address drought management. These statutes are summarized briefly in Table 5-2.

Table 5-2: State Statutory Tools for Drought Management

1. C.R.S. § 24-32-2105.5
Encourages the Water Availability Task Force to continue to monitor drought conditions to recommend legislation addressing drought emergencies.
2. C.R.S. § 37-60-123.5
Appropriates funds to the CWCB for use in making loans and grants to agricultural organizations for emergency drought-related water augmentation purposes.
3. C.R.S. § 37-60-106(1)(c) & (d)
Authorizes the CWCB to formulate plans for "bringing about the greater utilization of the waters of the state" and to "gather data and information" to the same ends.
4. C.R.S. §37-60-124
Establishes the Office of Water Conservation, which oversees a program to generate water efficiency information and which administers grants for municipal water efficiency demonstration projects.
5. C.R.S. § 37-60-115
Authorizes the CWCB to study water resources toward a "unified and harmonious development of all waters for beneficial use in Colorado to the fullest extent possible under the law," including studies regarding inter-basin transfers.
6. C.R.S. § 37-98-102
Creates a water resources review committee to monitor the conservation and development of water resources in Colorado.
7. C.R.S. § 37-92-309
This section, adopted during the last legislative session, gives the State Engineer authority to approve temporary, "interruptible water supply agreements" between water users, providing for the temporary transfer of historic consumptive use credit to another type and/or place of use, without requiring adjudication of a change of water rights. Such agreements are subject to approval by the State Engineer upon a finding of non-injury to other water users and non-interference with inter-state compact requirements, and will only be approved for operation during a calendar year in which a drought or other emergency has been declared by the Governor, and the first full calendar after the declared emergency terminates.
8. C.R.S. § 37-83-104
Allowing water users to release stored water to the stream, or to a ditch, and in exchange, to divert an equal amount of water from a point higher upstream, without adjudicating an exchange. Such exchanges are subject to the "no injury rule," and a water user undertaking such an exchange may be required by the State Engineer to release additional water from storage to make up for delivery losses.
9. C.R.S. § 37-83-105
Allowing persons taking water from the same stream or ditch to exchange or loan water to one another, for a limited time, for the purpose of saving crops, or using water in a more economical manner, without requiring an adjudication of a change of water rights. As discussed above, this section was recently amended to allow temporary loans of water to the CWCB for instream flow purposes.
10. C.R.S. § 37-83-106
Allowing water conservancy and conservation districts to enter into cooperative agreements with other political subdivisions for the lease or exchange of water outside district boundaries.

C. *Local Drought Measures*

In response to drought conditions, many municipalities in Colorado have adopted programs imposing watering restrictions and promising economic incentives to encourage their constituents to conserve water. These programs can be expected to increase in the coming year in response to a resolution adopted during the last legislative session. House Joint Resolution 03-1015 calls upon homeowners' associations, municipalities and counties to review and revise their covenants, codes and ordinances, as needed, to encourage water conservation measures, specifically including the use of soil enhancements and Xeriscaping™. Table 5-3 contains some examples of conservation measures adopted by municipalities in Colorado.

Table 5-3: Local Drought Measures

1. Denver
Denver disseminates drought information and conservation tips on its website and has adopted watering restrictions due to drought conditions, including time limits for irrigation zones, new sod watering restrictions and car washing restrictions. In addition, Denver offers several different economic incentives to promote water conservation, including a rebate of up to $720.00 for residential customers who make water saving improvements to their irrigation systems, or plant drought tolerant trees and shrubs, as well as rebates towards the installation of water efficient toilets and washing machines.
2. Boulder
Boulder distributes drought information and conservation tips on its website and has adopted voluntary watering restrictions, asking its customers to limit watering to every three days. Boulder also offers a number of rebate programs that allow customers to earn money for installing drought-tolerant plants and for using water efficient washing machines.
3. Thornton
Thornton has voluntary watering restrictions in place, whereby residents are encouraged to avoid watering during the middle part of the day and to limit watering to three days a week. Thornton also has a rebate program allowing residents to earn money for installing water saving toilets, washing machines and shower heads. Thornton also has plans to implement an education program for school children concerning water conservancy.
4. Grand Junction
Grand Junction has a number of water conservations programs which include: education, training, use of technological tools that monitor water use and waste, and water saving projects in parks and golf courses. As an example of a water saving project, two of Grand Junction's golf courses use a computerized irrigation system connected to a weather station. This system calculates the evapo-transpiration (ET) daily and can adjust the watering based on how much water is actually needed.
5. Telluride
Telluride is implementing mandatory water conservation measures which include: prohibiting the refilling of pools, hot tubs, or landscape water features, prohibiting the installation of new public or private landscaping, and limiting landscape irrigation to 30 minutes during certain times of the day and every other day dependent upon address.
6. Trinidad
Trinidad has adopted a number of water restrictions including: restricting lawn watering to every other day, limiting water served in restaurants to those customers who expressly request it, and mandating that individuals washing vehicles at home must do so with a bucket and a quick shut-off type nozzle on their hose.
7. Fort Morgan
Fort Morgan has a number of restrictions currently operating including: restrictions on lawn watering to specific days of the week and specific times, prohibitions on filling of fountains or pools, and prohibiting restaurants from serving water unless requested by the customer. In addition to their water restrictions, Fort Morgan has on its website, seven pages of water saving tips, ranging from how to water trees during a drought to recommending the use of low-volume toilets.

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Abstract
Colorado water users rely on water storage to capture spring and monsoon runoff for later beneficial use and seasonal water demands. A review of selected past (1977) and current (2000-2002) drought impacts on storage observed by spring, summer and fall measurements will be presented for all seven major river basins. Carry-over storage will be evaluated versus time for different geographies and water user segments in Colorado.

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Introduction

Available Data and Analysis

Discussion of Results

Conclusions

Introduction

Runoff throughout Colorado is extremely variable from season to season as the winter snowpack melts each spring and from year to year as cycles of droughts and wet periods. Potential uses for stored water in Colorado are shown at right in Table 6-1.

Because the variability of supplies and demands are not in sync, surplus supplies exist at some times and in some locations while shortages inevitably occur at other times and locations. These shortages can be offset by a number of means, such as controlling demand by modifying operations, reducing demands through water conservation, moving the supplies from locations of surplus to locations of shortage, and storing surpluses for later use when shortages occur.

Table 6-1: Potential Uses for Stored Water in Colorado

Irrigation of crops during the summer and fall.
Year-round **domestic and municipal** use that includes a summertime component for lawn irrigation and outdoor use.
Industrial needs such as water for processing and cooling.
Hydropower production.
Environmental needs such as minimum streamflows to maintain habitat.
Recreational needs to provide the flows needed to maintain or enhance uses such as river rafting, kayaking, and fishing.

The focus of this chapter is on the use of storage in Colorado's river basins to balance supply and demand. Colorado water users rely on water storage to capture runoff from spring snowmelt and summer rains for later beneficial use and seasonal water demands. Storage facilities can take various forms, the most typical being the construction of earthen or concrete dams built to impound natural flow or diversions and form a lake or reservoir behind the dam. These can be built on a river or stream or built offstream with water diverted from another location into storage. Anther type of storage includes enclosed aboveground and underground water tanks, typically for supplying a small local use such as a farm or municipal area or neighborhood. Groundwater storage is also utilized, taking advantage of the natural storage characteristics in the underground aquifers in various parts of the State to store excess surface runoff by pumping via injection wells into the ground and later extracting those supplies as emergency or drought supplies. For this evaluation, surface storage (both onstream and offstream) is addressed as these represent the major type of storage used in Colorado to provide protection against drought.

Agricultural users have been utilizing reservoirs and ponds since the 1800's for storing spring runoff and irrigating crops in the summer and fall, when their direct flow water rights are insufficient to supply their needs. Storage facilities for irrigation range from small ponds impounding a few acre-feet of water for a single farmer to large projects such as Julesburg Reservoir and Lake Granby that impound tens of thousands to hundreds of thousands of acre-feet of water to supply irrigation water for hundreds of users.

Storage is used to regulate streamflow and produce hydropower, with small in-stream hydroelectric facilities such as the Idylwide facility on the Big Thompson River to the Shoshone Power Plant on the Colorado River and Blue Mesa Dam and Powerplant on the Gunnison River.

Storage has also been an integral part of municipal supply systems, with relatively small facilities such as Harper Reservoir serving the City of Louisville and large facilities such as Dillon Reservoir serving Denver.

Many storage projects, particularly the larger ones, meet multiple uses. Systems such as the C-BT Project provide water for agricultural, municipal, and hydropower use, as well as meeting needs of environmental and recreational interests. Coordination of operations between projects is also taking place, with programs such as the Colorado River Basin Coordinated Reservoir Operations used to enhance habitat in the 15-mile reach of the Colorado River.

Storage is also used for flood control, to temporarily capture runoff from both snowmelt and storms and control releases to prevent flooding downstream. Operation of storage for flood control generally conflicts with operations for drought protection, as the objective for flood control is to keep the storage facility empty to provide the maximum available capacity to capture flood waters, while the objective for drought protection is to keep the facility full to provide the maximum available supply to meet demands during drought. However, with appropriate operating policies, a storage facility can be operated for both objectives, an example of which is Chatfield Reservoir.

As noted previously, storage is used to capture surplus runoff for later use when demands exceed supply. The water stored at the end of a surplus period for use during a deficit period is referred to as "carryover storage". The amount of water carried over from season to season through wet and dry cycles is referred to as seasonal carryover storage. The amount of water carried over from one year to another is referred to as multi-year carryover.

To evaluate both the utilization of storage during drought cycles and the impact that storage has on water use, a component of the survey included requests for storage level contents of the respondents' systems. The reference years selected for the Drought & Water Supply Assessment were 1977 and 1998-2002, representing two significant recent drought periods years (1977 and 2000-2002) with relatively wet and average periods (1998-1999). Information on carryover storage was requested from each participant during these selected reference periods. The goal was to observe both drought impacts on storage and utilization of storage by spring, summer, and fall measurements for all seven major river basins and across the water use segments surveyed.

Available Data and Analysis

Data for this evaluation were available from the Natural Resources Conservation Service (NRCS), the State Engineer's Office, and the Division Engineer's offices throughout the State. The most comprehensive and complete data coverage over all basins and during our reference years was available from the NRCS and was used to provide the information for this assessment. The exception was 1977 where data were limited – a combination of sources were used to the extent possible.

The NRCS reports a summary of monthly storage contents in key reservoirs throughout Colorado. While not providing a complete picture of storage in each basin, the data can be used to provide a representative picture of the patterns of storage use during wet and dry cycles on a basin-wide and state-wide basis.

The storage data were extracted from the NRCS reports for the six reference years for three key dates as shown at right.

April 1: representing the beginning of the runoff season (note that data for 2003 were also available and are included in this evaluation).

July 1: representing the end of runoff when the reservoirs should be near their fullest.

November 1: representing the end of the irrigation season when the reservoirs should be near their lowest storage volumes and minimum operational storage.

Storage contents are shown graphically on Figures 6-1 through 6-7, corresponding to Water Divisions 1 through 7. Data not available are shown as "Not Reported" on the figures. Average lines are shown on each figure – these represent the monthly averages for only those six reference years (not a long term average) – to provide a relative comparison among the years. Runoff for each year is also classified in each basin. These classifications are defined using the major streamflow gages in each basin that are used by the State Engineers Office in characterizing runoff. Flows over the period of record were averaged for each gage, and those years where annual runoff was less than 85% of average were classified as below average, those where runoff was greater than 115% of average were classified as above average, and those between 85% and 115% of average were classified as average.

Discussion of Results

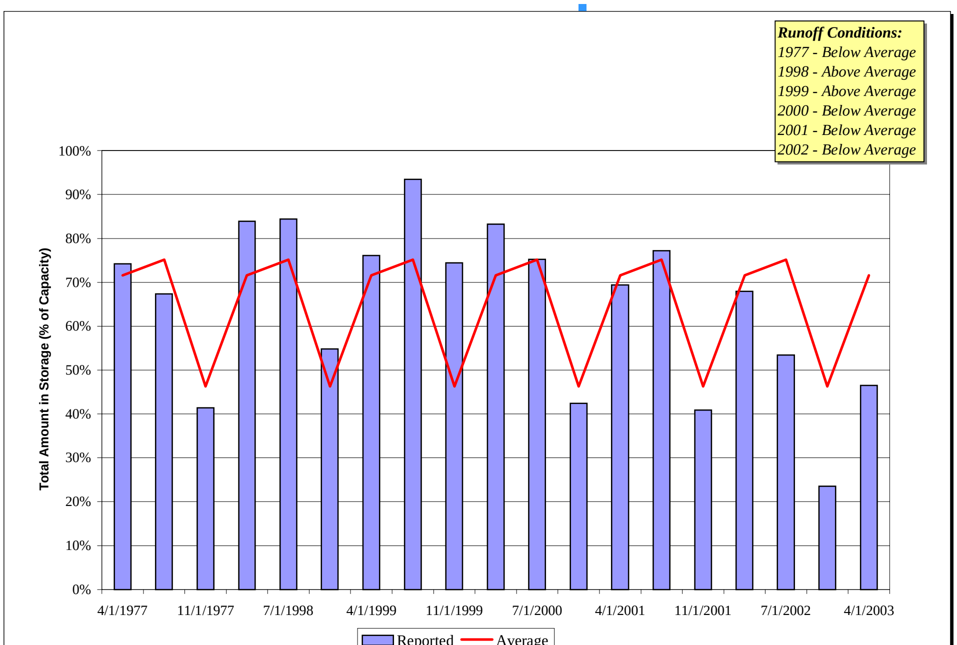
Varying results were obtained from basin to basin. Utilization of storage during wet and dry cycles, as well as the potential for storing additional water was examined. Caution should be exercised in drawing conclusions from the results, as the information represents a broad-based view of storage in the basins, but it does not identify differences in storage utilization across the water use-segments surveyed or provide a clear view of potentially significant local hydrology and operational issues. Also, the operation of storage in the basins reported here only reflect historic and current levels of use, not the additional demands placed on storage to meet the future needs for which projects may have been built.

For instance, during a drought a municipal supplier can implement varying degrees of water conservation and drought management measures and manage its operations to target a reasonable level of carryover storage in its system for the end of the summer, providing protection against the drought continuing into the following year. Storage levels drawn down to 10, 20, or even 40 percent of capacity may reflect prudent system management rather than surplus storage water. However, an agricultural user may not have that flexibility – the water available in storage can mean the difference between getting a crop to harvest and losing the crop this year – and storage may be drawn to empty if necessary.

"Storage levels drawn down to 10, 20, or even 40 percent of capacity may reflect prudent system management rather than surplus storage water. However, an agricultural user may not have that flexibility – the water available in storage can mean the difference between getting a crop to harvest and losing the crop this year – and storage may be drawn to empty if necessary."

The seven Colorado basins are also very large in size and climatic and hydrologic conditions can vary widely in any given year not only across the State, but within each basin, affecting both the needs for stored water to supplement natural runoff and the availability of surplus runoff to store for later use. As an example, within the South Platte River basin alone, the NRCS June 2003 forecasts of spring runoff for this year range from only 35 percent of average for Antero Reservoir in South Park to 104 percent of average on Boulder Creek near Orodell.

Figure 6-1: Division 1 Carryover Storage



With these facts in mind, some general observations can be made regarding the utilization of storage in Colorado's river basins:

- ***Division 1 – South Platte River:*** Utilization of storage is significant during periods of drought, with the most significant drawdown occurring in 2002-2003. Prudent management of supplies and storage in 2002 maintained an overall minimum storage level of 24% of capacity at the end of 2002. During high runoff years, storage levels ranged in the 83-93% of capacity level. Though not reflecting full conditions overall, it is likely that some areas of the basin did reach full capacity and could have stored more water during these periods with additional capacity.

- ***Division 2 – Arkansas River:*** Significant drawdowns of storage occur during periods of drought, indicating a high degree of reliance on storage during these periods. Storage levels below 10% were recorded in the 1977 drought, and levels below 20% during the 2002 drought, indicating a significant reliance on storage during drought and the probable full utilization of available capacity. Furthermore, storage levels have exceeded 90% and reached 100% during high runoff periods, indicating the

Figure 6-2: Division 2 Carryover Storage

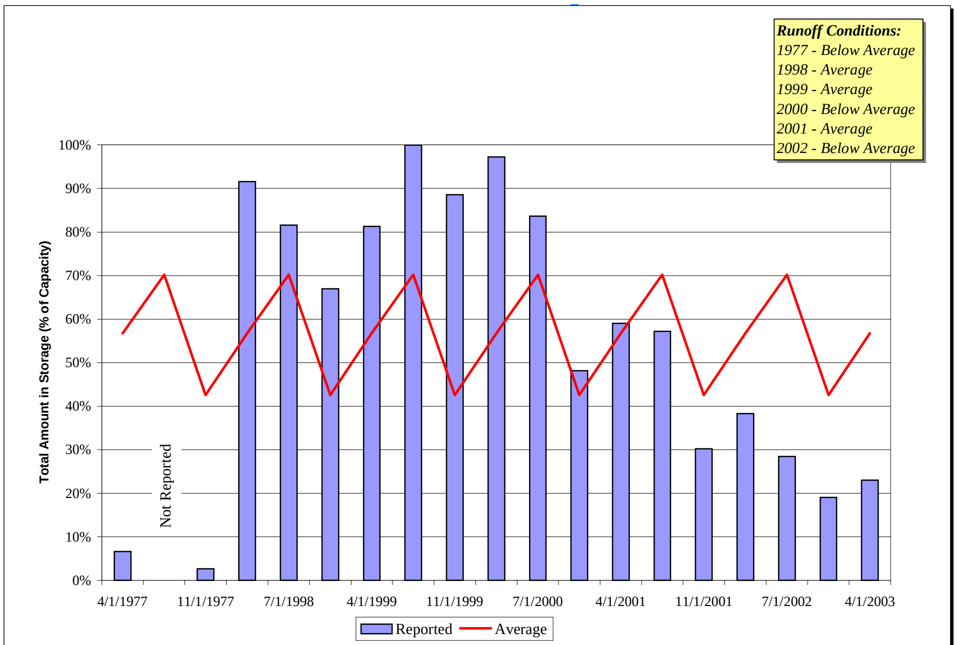
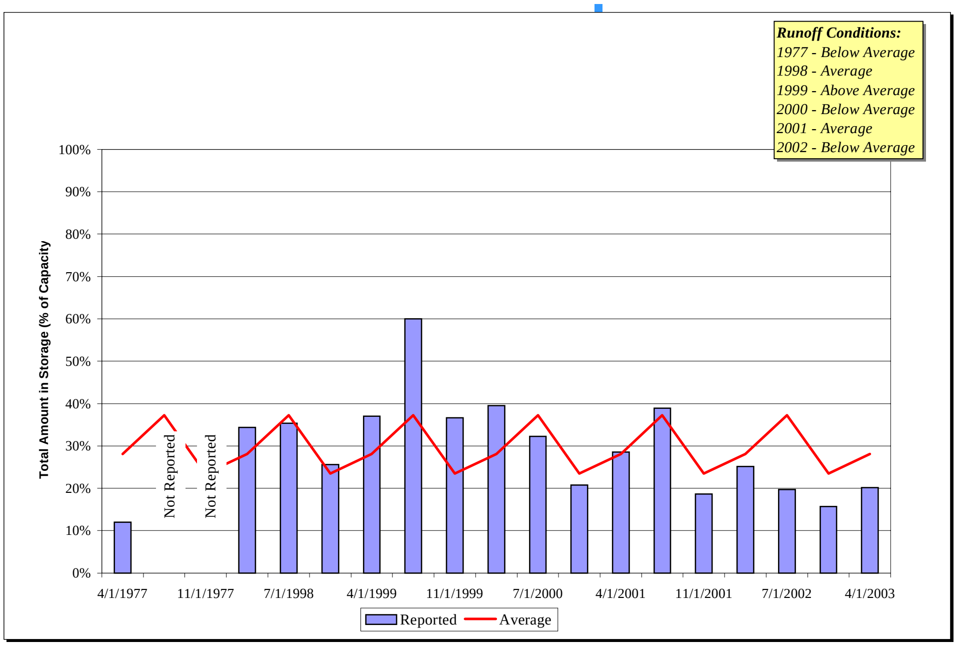


Figure 6-3: Division 3 Carryover Storage

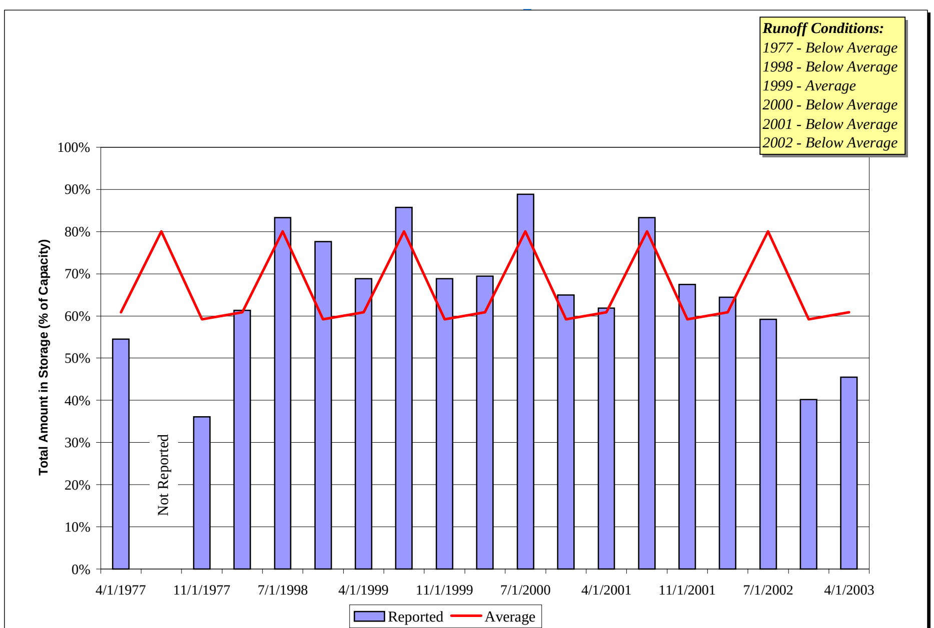


potential availability of runoff to fill additional capacity.

- ***Division 3 – Rio Grande River:*** The results indicate a situation that differs greatly from the other basins. While storage is utilized in the basin, there is not a major difference in usage between wet and dry years. There does not appear to be sufficient runoff to fill the capacity currently available in the basin – whether due to physical availability, legal compact requirements, or a combination of these factors. Storage levels generally run extremely low at all times, ranging from 10-40% of capacity in most years, and exceeding 50% in only one year. There does not appear to be a benefit in increasing storage in the basin.

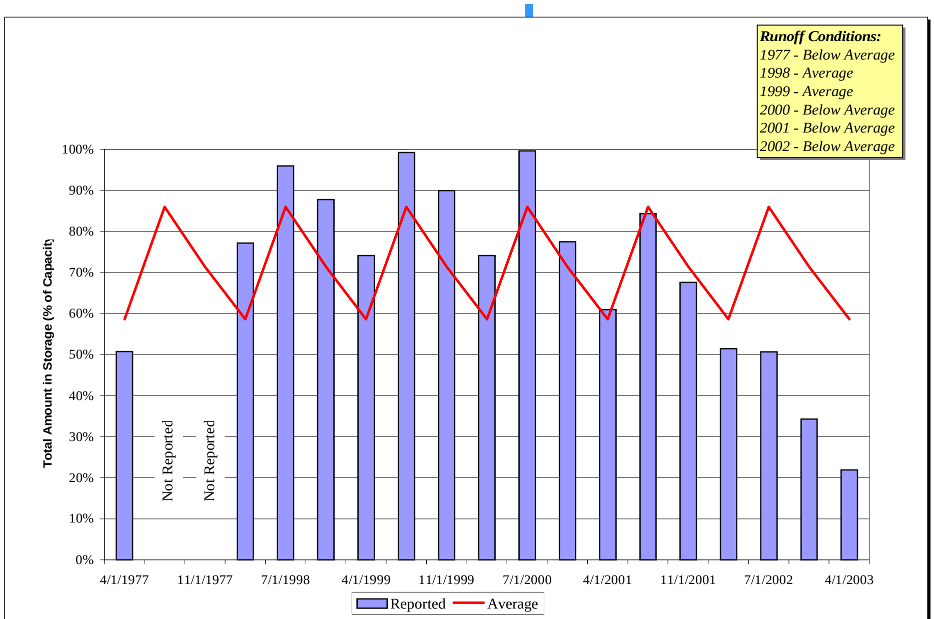
- ***Division 4 – Gunnison River:*** The Aspinall Unit of the Colorado River Storage Project represents over 75% of the total storage capacity monitored in the basin by the NRCS, potentially tempering any conclusions regarding other available storage in the basin. From the results presented, storage is utilized in the basin during periods of drought, with large drawdowns occurring in both 1977 and 2002. Storage appears to be efficiently managed in the basin and there appears to be sufficient storage in the basin to meet current usage levels and possibly some additional demands during significant droughts, as storage did not range below 36-40% of capacity. The management of storage for hydropower production by the Aspinall Unit may also be reflected in these relatively high storage levels. During high runoff years, storage levels ranged in the 83-89% level. Though not reflecting full conditions overall, it is likely that some areas of the basin did reach full levels and could have stored more water during these periods with additional capacity.

Figure 6-4: Division 4 Carryover Storage



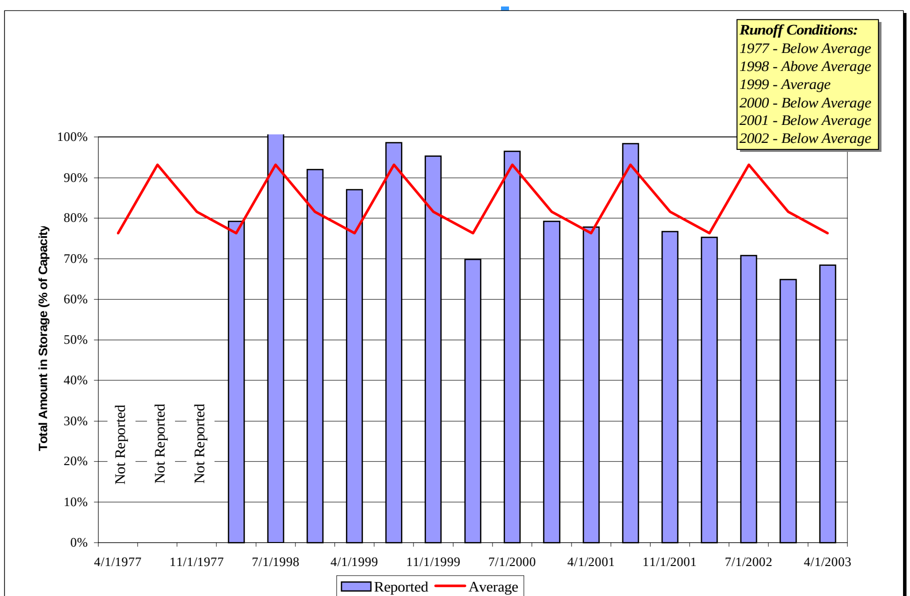
- ***Division 5 – Colorado River:*** Storage levels varied significantly in this basin during the reference years examined. Storage has been heavily utilized in the basin during periods of drought. Even though full status was achieved in July 2000, storage levels dropped to nearly 20% of capacity by April 2003, indicating nearly full utilization of existing storage. Without prudent management by operators throughout the basin, storage depletions could have been much greater. Storage use is likely intensified by the high level of transmountain use in the basin, with existing storage providing supplies to both west and east slope users. Storage levels of 90% capacity were reached in two years and 100% in another two years. This indicates that while storage is heavily utilized, there is a potential benefit of additional storage in the basin with available runoff.

Figure 6-5: Division 5 Carryover Storage



- ***Division 6 – Yampa/White Rivers:*** Storage is utilized in these basins, with greater drawdowns occurring in drought years than in high runoff or average years. However, storage appears to be efficiently managed and potentially underutilized overall, with levels never dropping below 65% during the 2002 drought. Full and nearly full levels were also reached in four of the years examined. These results indicate that existing storage could be more fully utilized, and there is a potential benefit of additional storage in the basin to meet demands beyond current levels.

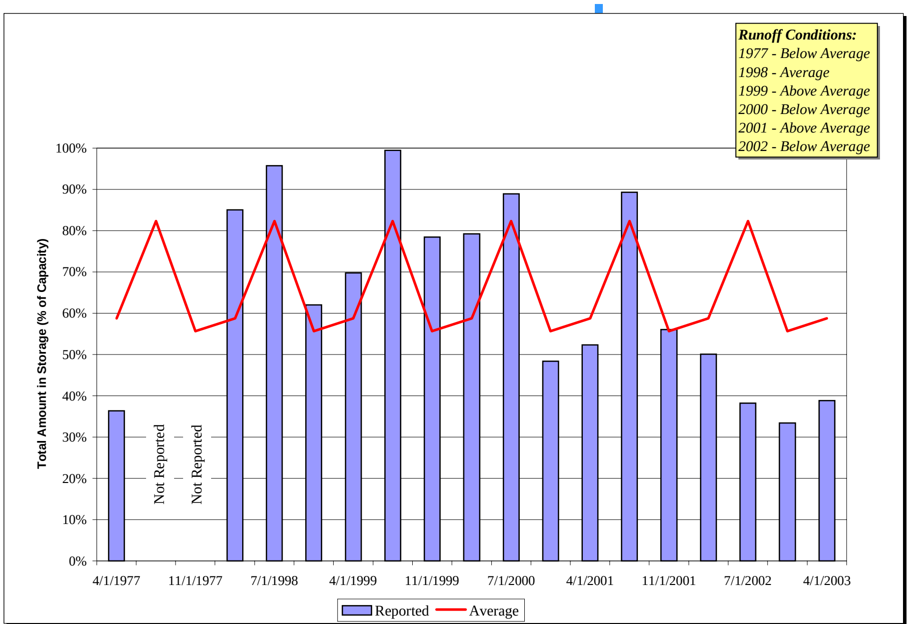
Figure 6-6: Division 6 Carryover Storage



- ***Division 7 – San Juan/Dolores Rivers:*** Storage levels varied significantly in this basin during the reference years examined. Storage has been heavily utilized in the basin during periods of drought. Even though full status was achieved in July 1999, storage levels dropped to 33% of capacity by November 2002, indicating that additional utilization of existing storage is limited.

Storage levels of 89-100% capacity were reached in four years. This indicates that while storage is heavily utilized, there is a potential benefit of additional storage in the basin.

Figure 6-7: Division 7 Carryover Storage



Conclusions

Water planners and managers face numerous challenges in identifying the need for and planning of their water supplies. Ultimately, the challenge faced is to provide a reliable water supply to their users, balancing the current and future needs of their users with the cost of meeting those needs at an acceptable level of risk, including risk to the ecosystem and to the environment. With the extreme variability of runoff in Colorado from season to season and year to year, storage provides a means of managing that variability and meeting the need for water. Given the various and variable uses of storage, risks can be controlled and managed with proper planning and evaluation. Given the complexity, cost, and time required to build reservoirs, storage projects are typically planned and built with future needs in mind on a local, and increasingly, on a regional scale.

From this state-wide and basin-wide assessment, storage is obviously an important component of current and future water supplies throughout Colorado, though levels of usage can vary significantly from basin to basin. The potential for increasing the utilization of existing storage is greatest in the Yampa/White and Gunnison River basins. In some divisions, there is also the potential for capturing additional water to enhance the utilization of supplies – this potential exists in all but the Rio Grande basin, and is most significant in the Colorado, Yampa/White, and San Juan/Dolores basins.

While storage capacity does not create additional water supplies, both the increased utilization of existing storage capacity and the development of additional capacity can improve the overall reliability of the water supplies available throughout Colorado and help ensure the present and future water supply needs of the State can be met.

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Abstract
Chapter 7 presents the tools available to local communities to prepare for and manage the effects of drought, with a focus on the development of policies and procedures that will aide organizations and individuals during periods of scarce water supply. A brief introductory section divides drought management into drought mitigation and drought response, and outlines six key areas of drought management. Additional sections discuss each of the key areas, followed by a table presenting a list of drought management tools drawn from existing plans and planning guidelines available locally and nationally. The table indicates whether the tools are applicable to long-term mitigation or short-term drought response, and whether they help to increase supply, to reduce water use, or to provide other drought management benefits. Finally, a discussion on how local entities may best develop drought management plans is presented.

Introduction

Drought is a natural phenomenon that occurs over different time periods and at various scales. Similarly, drought management can also occur at various times and at various scales. Immediate and long-term impacts of drought are typically experienced most strongly at a local level, such as within a local water district, municipal jurisdiction, or ranch or farm. To this point, this chapter discusses and presents various *drought mitigation* and *response* tools that local entities may use to manage drought.

It is useful to distinguish two aspects of drought management that occur over time. *Drought mitigation* includes actions taken before a drought that reduce the occurrence and severity of water supply shortfalls. *Drought response* refers to actions taken during a drought to manage water supplies and water demand appropriately. Both *drought mitigation* and *response* require careful planning.

The six key areas of local drought management are shown at right.

Key Areas of Drought Management

- Public policy evaluation, development and implementation, including emergency response plans
- Public education and relations
- Water rights management
- Water supply augmentation
- Monitoring and evaluation
- Water conservation and drought-time water use restrictions

These areas of drought management are discussed individually in the sections below. Table 7-1 then summarizes drought management tools related to the six key areas presented. The table identifies drought management tools, indicates whether the tools can be implemented for short-term *response* or long-term *mitigation*, and identifies whether the tools are used to reduce water demand, to increase water supply, or to manage responses to and impacts of drought.

The table contains tools that are useful to a variety of water user segments such as agricultural, municipal, and recreational entities. The needs and concerns surrounding drought management vary from one segment to another, though certain fundamental principals of planning and management outlined below will be pertinent to all entities. This list was compiled from several documents listed in the references section, including Denver Water 2002, Knutson et al. 1998, and Wilhite et al. 2003. Please also note that the category of "other" refers to the fact that in addition to reducing demand or increasing supply, some tools may help offset economic losses, provide information for improved management, or improve public understanding and compliance.

> ***Drought mitigation*** includes actions taken before a drought that reduce the occurrence and severity of water supply shortfalls.

> ***Drought response*** refers to actions taken during a drought to manage water supplies and water demand appropriately.

Drought Management

Public Policy

Drought management will be most effective if it is set in the context of a full understanding of local water supply and demand, which will most likely be addressed in an entity's master water management plan. Water rights management, supply development, and conservation, all discussed below, clearly have both drought and non-drought implications for local water management. In addition, understanding and managing the specific risks and impacts of drought requires integration of long-term and drought-specific planning and policy. Therefore, drought management policy can be effectively developed utilizing risk management analyses and techniques.

Under a risk management focus, drought planning entails impact assessments, economic analyses, and consideration of issues of vulnerability, equity, efficiency, cost and urgency. Understanding the economic, social and physical aspects and impacts of drought allows selection of *drought mitigation* policies, programs, and actions that fit with the overall water management plan and addresses the underlying causes of vulnerability to drought. This will reduce the chances of water supply and demand imbalances in times of drought. Further, the broad perspective afforded by risk management analyses allows entities to develop response plans that minimize economic, social, and other impacts when drought occurs. Development of *mitigation* and *response* plans and related policies should include substantial participation on the part of all affected stakeholders and the general public.

Developing appropriate drought management response plans require that entities have the authority and communication processes in place to take drought response actions, including how and when to declare a drought emergency and determination of when to declare it. The plan should also set out clear objectives and priorities for drought-related actions. Potentially conflicting objectives—which may include reducing economic impacts, minimizing inconvenience to users, avoiding rationing, saving trees and perennial plants, and more—should be addressed and prioritized in the plan, well before an actual drought. A plan should include carefully developed triggers for declaring drought of different levels of intensity (mild, moderate and severe) and the corresponding actions water managers and users should or must take. Specific issues addressed in a drought response plan often include provisions to supply critical uses of water, ways to adjust infrastructure operations to ensure maximum use of available water supplies, water quality monitoring under low flow conditions, water conservation and water use restrictions (and identification of goals for water savings at each level), and identification of state and federal sources of assistance to impacted water users.

Photo Courtesy of USDA NRCS

Public Education and Relations

Attention to public relations is critical to the overall success of drought management tools. It is important that the local entity is prepared internally with consistent messages for the public and media. Strong media relationships established prior to a drought will help facilitate the exchange and broadcast of information during a drought. Various surveys and studies have investigated what attitudes are often found during drought and what issues should be highlighted to foster success in implementing drought measures. These include conveying the seriousness of drought, highlighting social and moral commitment, establishing perceived efficacy of water restrictions, and managing perceptions of inconvenience, cost, and equity among all members of the community (City of Phoenix 2003).

In addition, all members of the water community look for guidance and leadership during periods of drought. A strong public education program can help water users better understand issues and limitations that may affect them individually and collectively during a drought. To this point, cooperative agreements and operational flexibility related to water use are facilitated, in part, by good public education and relations programs.

Water Rights Management

Any tools selected to manage drought will need to work within the relevant water laws. In Colorado, the prior appropriation doctrine provides opportunities and limitations for managing water in a drought scenario. One legal tool employed by some municipalities in Colorado is dry-year leasing, a mechanism that allows for temporary water transfer, usually from agriculture to municipalities, during dry years when farming is less feasible or profitable. Local entities may also explore other forms of interruptible supply agreements and intersystem operational coordination that re-allocate water on a temporary basis during times of water need.

Additional mechanisms to obtain drought-time water supplies are under development in Colorado. These include water banking, where surplus water is pooled for rental to other water users, but available during times of drought or other need for increased water supply. Water banking is not yet a well-established concept in Colorado, but a pilot water banking project is being tested in the Arkansas River Basin and its use may be expanded.

Permanent water transfers are of course also possible—for instance, through acquisition of water rights—but often are typically irreversible and limit operational flexibility once water rights are sold

Supply Augmentation
In addition to water transfers, local entities can secure and augment water supplies through a variety of means. These can include repair and maintenance of existing storage facilities to assure their maximum utility, revision of reservoir operating procedures to increase storage and make more water available, weather modification, ground water use (though effects on surface flows must be considered), and when necessary, establishment of new water storage facilities. Operational and minor infrastructure changes can be very cost-effective, whereas new infrastructure can be costly. Any of these options may require substantial collaboration among several entities.

Monitoring and Evaluation
It is critical to good drought management that information be compiled and maintained on water supply use and infrastructure, and on drought indicators such as precipitation, temperature, evapo-transpiration, meteorological forecasts, soil moisture, stream flow, ground water levels, reservoir and lake levels, and snow pack. Water providers and users can then monitor these data to identify if conditions for drought are developing or persisting. State and federal entities can also collect and monitor these data in support of local drought planning efforts.

In addition, the suite of selected *drought mitigation* and *response* tools should be reviewed periodically to see if they are achieving desired goals related typically to lessening the effects of drought and improving both preparedness and crisis response. Evaluation allows local entities to:

Photo Courtesy of USDA NRCS

- Assess the effectiveness of *mitigation* efforts in reducing the occurrence and impact of drought-related water supply shortfalls.
- Analyze their drought response needs and gauge the appropriateness of the thresholds they have set for varying degrees of drought severity;
- Generate metrics to determine and justify the level of drought response employed;
- Determine the effectiveness, equity and need for the response actions selected and employed.

Water Conservation and Drought-Time Water Use Restrictions

Water *conservation* is a broad term that can encompass water use efficiency (e.g., low-flush toilets), wise water use (e.g., Xeriscape™), system efficiency (e.g., distribution system leak repair), and supply substitution (e.g., wastewater reclamation). While many people refer to water use *restrictions* during a drought as "water conservation," the objective of long-term water conservation is not to curtail water use. Rather it is to increase the productive use of the water supply in order to satisfy water needs without compromising desired water services. A drought management plan that includes curtailment of water services in response to drought may be appropriate, but curtailment is not a desired long-term result of a conservation program (Pinkham 2003).

Photo Courtesy of USDA NRCS

Some people believe that conservation "hardens" demand, resulting in less flexibility to respond when drought occurs. On the contrary, water conservation is a highly appropriate *drought mitigation* strategy. Long-term water conservation reduces future demand, resulting in a larger supply margin than would otherwise be the case. Thus, previous water conservation efforts reduce both the likelihood and severity of water supply shortfalls during times of meteorological drought. Without conservation savings "in the bank," a moderate drought event may become a severe one.

It is also important to realize that many water conservation actions require substantial time for implementation. If water conservation actions are not initiated until a "drought hits," it is usually too late to achieve significant gains from toilet change-outs, landscape selection ordinances or incentives, distribution system repair, construction of water reuse infrastructure, and other "technological" measures and programs. On the other hand, "behavioral" *drought response* measures are still available. For instance, consumers can tighten up landscape irrigation schedules, practice extra diligence in fixing in-home leaks and turning off the tap when shaving, and make other choices to use less water. Publicity campaigns and drought surcharges can encourage users to make these short-term adjustments. Finally, if necessary, the same restrictions on lawn watering, car washing, and so on that have conventionally been used to respond to drought are available even if the community has previously achieved substantial long-term conservation savings.

There are numerous resources for communities interested in water conservation planning and implementation. Some municipalities have been involved in water conservation efforts for many years and have planning staff that may be available to answer questions and share knowledge and experience. Several organizations, both local and national, are active in Colorado and may be of assistance, including the America Water Works Association (www.awwa.org) and the Colorado WaterWise Council. The EPA Office of Water has a thorough document from 1998 on water conservation planning, *Water Conservation Plan Guidelines*, EPA-832-D-98-001. It can be accessed at http://www.epa.gov/owm/water-efficiency/webguid.html. Amy Vickers' book *Handbook of Water Use and Conservation* is a comprehensive resource. Some websites that could contain useful information are shown at right.

Useful Water Conservation Websites

- WaterWiser, http://www.waterwiser.org
- H2Ouse, http://www.h2ouse.org
- Natural Resources Conservation Service, http://www.co.nrcs.usda.gov
- Xeriscape^tm^, http://www.xeriscape.org
- EPA Water Use Efficiency Program, http://www.epa.gov/owm/water-efficiency/index.htm

Discussion

As Table 7-1 presents, a wide variety of drought management tools are available for consideration at the local level. These tools are applicable to many segments of water users and most levels of drought severity, noting that under water rights management dry year leasing, water banks and interruptible water supply agreements are most pertinent in moderate to severe droughts. Weather modification as part of water supply augmentation is most useful in moderate to severe droughts, as are all the emergency *response* tools listed. With water conservation measures, the last tools listed for soil, tillage, and crops are most relevant to agricultural lands.

The table is not a complete list of all tools available. For example, additional legal tools may be available depending on potential water sources, and emergency responses may expand in especially severe droughts. Conversely, it would not be recommended that a local agency adopt all of the tools identified. The best suite of drought management tools can be selected through a local planning process that may include creating a team of qualified people, establishing mechanisms for public input, determining and ranking the severity of likely drought impacts, completing a vulnerability assessment, selecting tools to offset those vulnerabilities, integrating those tools into an action plan, implementing the plan, and periodically reviewing the effectiveness of local-level drought management.

Table 7-1 Local Scale Drought Management Tools

Tool	Planning Horizon: Short-Term Response	Planning Horizon: Long-Term Mitigation	Management Impact: Reduce Demand	Management Impact: Increase Supply	Management Impact: Other
Public Policy and Assessment					
Prepare and regularly update comprehensive water management plan with drought component		✓			✓
Establish drought response principles, objectives, and priorities		✓			
Establish authority for declaring a drought emergency		✓			✓
Develop triggers for drought-related actions (establishing thresholds for mild, medium & severe droughts)		✓			✓
Prepare ordinances on drought measures		✓			✓
Evaluate impacts of drought on different groups, economic segments, and environmental receptors		✓			✓
Emergency Response					
Declare a drought emergency	✓		✓		✓
Establish water hauling programs	✓			✓	✓
Extend boat ramps and docks	✓	✓			✓
Restrict/prohibit new taps	✓				
Identify state and federal assistance	✓	✓			✓
Public Education and Relations					
Prepare position papers for the public, media and elected officials describing public drought policies		✓			✓
Establish a public advisory committee		✓			✓
Organize drought information meetings and workshops for public and media	✓	✓			✓
Create informational materials and establish a drought information center		✓			✓
Water Rights Management					
Review water rights for modifications/flexibility during drought		✓		✓	
Dry year leasing of water rights	✓			✓	
Water banks established for the sale, transfer, and exchange of water	✓			✓	
Interruptible water supply agreements	✓			✓	
Water Supply Augmentation					
Rehabilitate reservoirs to operate at design capacity		✓		✓	
Inventory and review reservoir operation plans		✓		✓	✓
Aquifer storage and recovery; conjunctive use		✓		✓	
Weather modification (cloud seeding)	✓	✓		✓	
New water storage facilities		✓		✓	
Monitoring and Evaluation					
Monitor water supply components (e.g. snow pack, stream flow, etc.)	✓	✓			✓
Monitor water quality	✓	✓			✓
Track public perception and effectiveness of drought measures	✓	✓			✓
Improve accuracy of runoff and water supply forecasts		✓			✓
Water Conservation					
Develop, implement and monitor ongoing water conservation program		✓	✓		✓
Implement, upgrade water metering		✓	✓		
Implement, upgrade water loss control systems		✓	✓		
Water-efficient fixtures and appliances		✓	✓		
Low water use landscapes and efficient irrigation		✓	✓		
Improve commercial and industrial efficiencies		✓	✓		
Educational programs	✓	✓	✓		
Rate structures to influence water use	✓	✓	✓		
Water reuse		✓	✓		
Soil management such as soil-moisture monitoring		✓	✓		
Improved tillage practices		✓	✓		
Use drought or salinity tolerant crops		✓	✓		

It is also important to note that some measures, especially those related to increased storage and some areas of monitoring, would be best accomplished by local communities in coordination with neighboring entities. In some cases significant economies of scale can be realized by coordinating efforts and the end water users will experience a coherent set of drought responses.

For more resources on drought management, several useful websites and documents are shown at right:

Useful Drought Management Sources

- The National Drought Mitigation Center (http://www.drought.unl.edu/index.htm), especially "The Basics of Drought Planning: a 10-Step Process" (http://www.drought.unl.edu/plan/handbook/process.htm) and their "Mitigating Drought" page (http://www.drought.unl.edu/mitigate/mitigate.htm) with numerous links to other useful websites and documents.
- The Western Drought Coordination Council's document, "How to Reduce Drought Risk" (http://drought.unl.edu/wdcc/products/risk.pdf).
- The American Water Works Association's *Drought Management Handbook.*
- The National Oceanic and Atmospheric Administration's (NOAA) drought website, http://www.drought.noaa.gov/
- Drought plans and experiences of other local entities in a region.

Conclusions

Drought management planning at a local level can be very beneficial in managing water supply during periods of drought. Planning helps determine communication and decision-making channels, technical responses, and public education and awareness needs. Key factors influencing the effectiveness of drought planning and *drought response* include:

- Availability of local resources.
- Commitment of resources to evaluation, development and implementation of drought management plans and procedures.
- Adherence to developed procedures.
- Use of feedback mechanisms:
  - From the public (created through public education and stakeholder involvement processes)
  - From environmental factors and water systems (created through monitoring and evaluation processes)

References

1. American Water Works Association. "Drought Management Handbook." 2002.
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4. Knutson, C., Hayes, M., and Phillips, T., "How to Reduce Drought Risk." Prepared for Western Drought Coordination Council. March 1998.
5. Pinkham, R., "Technical Assistance to Covered Entities: Review of Conservation Planning Policies and Practices." Prepared for The Colorado Water Conservation Board. May 2003.
6. Wilhite, D.A., Hayes, M.J., Knutson, C, and Smith K.H., "The Basics of Drought Planning: A 10-Step Process." National Drought Mitigation Center. 2003.

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Abstract
Drought mitigation can be performed through the combined efforts of local and regional management programs and the planning for and implementation of structural and non-structural projects. Given the types of impacts caused by drought, coupled with ever changing water supply and demand factors, existing local and regional management programs may not allow for adequate protection of businesses and individual citizens. Longer range planning and implementation of structural and/or non-structural projects may be needed as conditions change to provide adequate drought protection. This chapter presents a listing of potential structural and non-structural projects that may be considered for drought mitigation.

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Structural Project Components

Non-Structural Project Components

Discussion

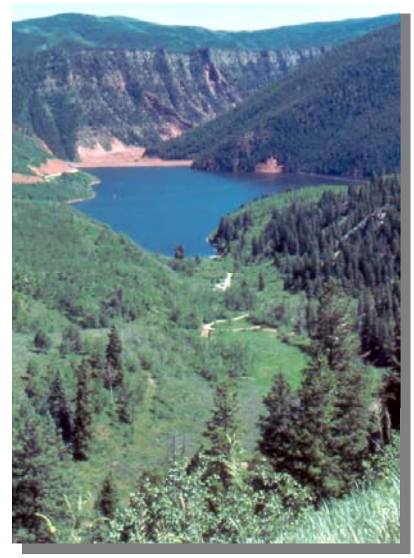
Introduction
The impacts of drought, while often most detrimental on a local scale, may be best mitigated by regional projects depending on the nature and scale of the impact, the availability/scarcity of water, and the nature and location of the water demand. Projects, in this vernacular, refer to the development or improved use of water supply and/or the management of water demand. To this point, projects can be configured of structural or non-structural "components" or some combination thereof, noting that the creation, evaluation, and ultimately, the implementation of any "water project" in Colorado will likely include the efficient combination of both structural and non-structural project components. This chapter gives a brief overview of the structural and non-structural project components for drought mitigation that may be considered for evaluation and implementation at a local and regional scale in Colorado.

"The creation, evaluation, and ultimately, the implementation of any "water project" in the State of Colorado will likely include the efficient combination of both structural and non-structural project components."

In water resources planning, it is useful to analyze projects not only in their global context, but also to identify the various elements of a project that make it complete. For example, a reservoir project would involve numerous "components" including the reservoir itself, delivery pipelines, and pump stations. The term "project component" is therefore used in this chapter to refer to the various individual actions or activities that can be performed for the mitigation of drought.

Structural Project Components
Large-scale structural projects by their very nature relate to the construction of capital improvements utilizing heavy equipment for clearing and earthwork. Large-scale structural projects that have been constructed in Colorado in past years include dams, pipelines and pump stations, wells, treatment facilities, etc. The common thread associated with these types of "classic" water supply projects is that

they typically require considerable planning, permitting, and commitment of financial resources to implement. However, the classic structural water supply projects are, in many cases, the only means available to solve water supply shortages.



Increasingly, various types and levels of concern and objections to classic water supply projects have required water planners and managers to broaden their identification and valuation of alternative means to either expand water supply or reduce water demand. These alternatives include both structural and non-structural project components (non-structural components are presented in the following section). Alternative structural project components, in contrast to traditional large-scale projects, include water reuse and conjunctive use programs, rehabilitation or upgrades to existing structures, and management of water drinking vegetation either along water courses or in forest and recharge areas.

Table 8-1 presents a summary listing of those structural project components that are most applicable to Colorado, both on a local and regional scale. A brief description or definition is provided for each.

Table 8-1: Summary of Structural Project Components Relevant to Colorado

Project Component/Category	*Definitions/Examples*
New or Upgraded Infrastructure (Supply and Demand Sides)	
Storage for Surface Water	New and upgraded dams, dredging of existing dams, expansion of existing dams
Diversions	New and upgraded channel diversions
Pipelines or Ditches	New and upgraded pipelines, ditches and pump stations, lining of ditches and pipelines
Wells	Installing new wells, deepening wells
Raw Water Treatment	New or upgraded water treatment to achieve required quality standards
Water Distribution Systems	New or upgraded pipelines, transmission mains, and pump stations
Infrastructure Maintenance and Repairs (Supply and Demand Sides)	
Maintenance of Existing Infrastructure	Maintenance to all existing structures
Dam Safety Improvements and Repairs	Improvements and repairs as identified by the State Engineers Office
Water Use Measurement (Demand Side)	
Installation and Maintenance of Water Meters	Measurement of water use/delivery through placement of meters in delivery system or at end-user destinations such as fields and homes
Water Reuse and Conjunctive Use (Supply and Demand Sides)	
Water Reuse Projects	Use of wastewater or reclaimed water from one application for use in another application
Aquifer Storage and Recovery/Conjunctive Use	Underground water storage in a suitable aquifer that is recovered when needed/Combined use of surface and ground water in a coordinated manner
Evapotranspiration Management (Demand Side)	
Phreatophyte Controls	Removal or control of plants such as tamarisk whose roots pull from saturated zone under shallow water table and transpire ground water
Forest Management	Management of forest system with intent of optimizing water supply yield and meeting water quality goals

Although many structural projects are built to increase water supply, many of the structural project components are also used to reduce demand. For example, *lining of pipelines and ditches* helps to reduce transmission system losses thus reducing system demand. Similarly, *water metering* which helps to identify system losses, can be used to reduce water demand. *Management of phreatophytes and forest growth* can also reduce existing water use.

Of course the construction of *new dams, the expansion of dams and the repair of old dams* will directly increase water supply. *Raw water treatment and transmission* structures such as pipelines and ditches can increase usable and available water supply; however, improvements in these types of structures can also reduce demand if leaks and inefficiencies are corrected. Regular *operations and maintenance programs* for infrastructure can also improve efficient use of water and thereby reduce demand or increase supply. *Conjunctive use*, which mainly addresses the supply side, typically allows for the capture and storage of surplus surface water in underground aquifers for later use when surface water supplies dwindle. Conjunctive use does not necessarily have a demand side benefit.

Water reuse has benefits on both the demand and supply sides. Reuse water can be a supply for numerous non-potable applications such as irrigation water and industrial non-contact water. On the demand side, a water utility or users that utilize reuse water will reduce its demand for raw water, all factors remaining the same.

Photo Courtesy of USDA NRCS

Although numerous environmental and public impediments impact the viability of structural projects, components of structural projects have the potential to benefit all segments of water users including agricultural, municipal, industrial, environmental, and recreational by providing for availability of water in critical times.

Non-Structural Project Components

In contrast to structural project components, non-structural project components do not necessarily include construction, although limited earthwork or stream restoration may be involved. Non-structural project components include the development and implementation of efficient water supply and demand management tools or methods, allowing water owners, planners and managers flexibility in operating or managing their water resources.

Non-structural project components can be segregated into two areas with respect to Colorado water—those that may require changes to current state law and/or statute and those that may not. The non-structural project components that may require changes to state law include those that address the flexible use and management of water rights allowing water users to lease, transfer, and/or augment their water supplies. The non-structural project components that will not necessarily require changes to state law include cooperative agreements, use of existing state and federal programs (e.g., instream flow programs), public education, water conservation and drought planning, and the purchase of water rights.

Table 8-2 presents a summary listing of those non-structural project components that are most applicable to Colorado, both on a local and regional scale. A brief definition is provided for each. Table 8-2 also presents the applicability of individual non-structural project components to the different major segments of water use in Colorado, in that unlike structural project components selected non-structural project components are more applicable to some water users than others.

Discussion

Long-term development, conservation, protection, and management of the State's water resources will require the complimentary combination of structural and non-structural project components into programs that can be facilitated at a regional level and implemented on a local scale. To this point, water planners and managers, as well as policy makers, will need to package water projects based on the type of components required due to technical challenges and public sentiment. The structural and non-structural project components identified in this chapter provide water planners and managers with a wide range of alternatives from which to select in the development of regional and local mitigation of drought. The listed project components also have the ability to provide benefits to multiple water use segments and groups by increasing available water supply, decreasing water demand, or both.

Photo Courtesy of USDA NRCS

Table 8-2: Summary of Non-Structural Project Components Relevant to Colorado

Project Component/Category	Definitions/Examples	Major Water Use Segments			
		Agricultural	Municipal/ Industrial	Environmental	Recreational
May Require Revision/Change to Colorado State Law					
Water Exchanges	Water taken at a time and place when it would otherwise be out of priority but other water rights that would be injured are satisfied with replacement from another	✓	✓	✓	✓
Water Transfers	Reallocation of water from one use to another through sale or lease, can be a permanent or temporary legal arrangement	✓	✓		
Substitute Water Supply Planning	Planning for temporary transfers of water during periods of shortage or while looking for permanent sources	✓	✓		
Interruptible Supplies	Water rights transferred on a temporary basis for specific needs				
Dry Year Lease	Temporary water transfers negotiated for specific hydrologic and climatic conditions	✓	✓		
Other Leases	Legal agreement between water rights holder and new user for a temporary transfer of a predetermined quantity and duration				
Operating Agreements	Arrangements among water right holders for changes in call priority	✓	✓	✓	✓
Water Banking	Pooling of surplus water rights for rental to other water users	✓	✓	✓	✓
Water Conservation Easements	A voluntary legal agreement with permanent restrictions on the use of a resource to protect values that can include water flows	✓		✓	
Does Not Require Revision/Change to Colorado State Law					
Public Education and Awareness	Programs designed by water managers to increase knowledge of water issues to promote efficient water use	✓	✓	✓	✓
Water Conservation Planning and Implementation	Establishment of a plan to increase productivity of water supply and use and implementation of prescribed measures	✓	✓		
Water Conservation Monitoring and Measurement Methods	Techniques for quantitative and qualitative tracking of the effectiveness of water conservation measures	✓	✓		
Water Supply Master Planning	Planning for water supply needs and management	✓	✓	✓	✓
Drought Planning	Establishment of a drought response plan detailing measures to mitigate the impacts of drought and emergency response	✓	✓	✓	✓
Use of Instream Flow Programs	Acquisition of instream water right for preservation of the environment to a reasonable degree through the CWCB			✓	✓

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Assessment Instrument Design, Review and Testing

Abstract
An assessment instrument was developed to support collection of water use and storage data and water user opinion. The instrument needed to be comprehensive, easy-to-use and ultimately capable of capturing critical water information from each region of the state while also providing a vehicle to the State for strategic guidance on a myriad of drought and water issues. A properly crafted questionnaire, or instrument, not only had to allow for essential end analysis (including statistical testing and segmentation), but also had to maximize potential participation by being user friendly.

Instrument development included a combined effort of question development and review by a technical team, followed by a pilot testing period. A group of 28 representative water users drawn from public and private entities and water districts that reviewed the instrument development, formed the "Pilot Test" group for the assessment. The process of the development of the assessment instrument is overviewed in this chapter.

Introduction
The Drought & Water Supply Assessment is the first statewide project to determine how prepared Colorado has been for drought and identify measures that will better prepare us for the next period of water scarcity, both locally and regionally. To this end, the assessment instrument was developed to provide a mechanism to obtain water use, carry-over storage, and opinion data from a large group of water users[1] representing all the major water user segments (i.e., municipal, industrial, agricultural, federal, state, power, etc.) from each of the State's seven major river basins.

The process for developing the assessment instrument is highlighted in Figure 9-1. The process involved first, identifying the overall assessment objectives with the CWCB and DNR. Next, the group of water users that constitute the target participant list were identified through the characterization of state demography and water user segments to ensure that the messaging and structure of the assessment provided the opportunity to capture issues relevant to each segment of water use type. The assessment instrument was then developed and reviewed for content, clarity and effectiveness in gathering the requisite information and responses.

The instrument had to be comprehensive, easy-to-understand, capable of capturing critical water information from each region of

[1] Water users include those entities that provide, deliver and/or use raw and treated water for agricultural, municipal, industrial, recreational, and other uses.

the State, and ultimately had to provide a vehicle for strategic guidance on a myriad of drought and water issues. A properly crafted instrument not only had to allow for essential end analysis (including statistical testing and segmentation), but also had to maximize potential participation through ease of accessibility to all participants. The final instrument ultimately met CWCB goals and delivered statistically reliable results across the board. Below is a description of the instrument development process.

Assessment Objectives

The assessment instrument was developed to allow the CWCB to gather statistically significant information regarding drought planning and preparedness, and potential drought mitigation measures. The assessment instrument therefore needed to collect information on the following topics:

- Current water use and carry-over storage (for purposes of differentiating water users by amount of water used and stored)
- Current limitations on water supply
- Drought and water conservation planning
- Drought impact
- Concerns in developing and meeting future water demands
- Structural and non-structural project needs for drought mitigation
- Funding needs
- Use of cooperative agreements
- State role in future drought planning and mitigation efforts

The assessment instrument also needed to collect information related to water user perceptions of the CWCB and the technical assistance offered by the CWCB to water users.

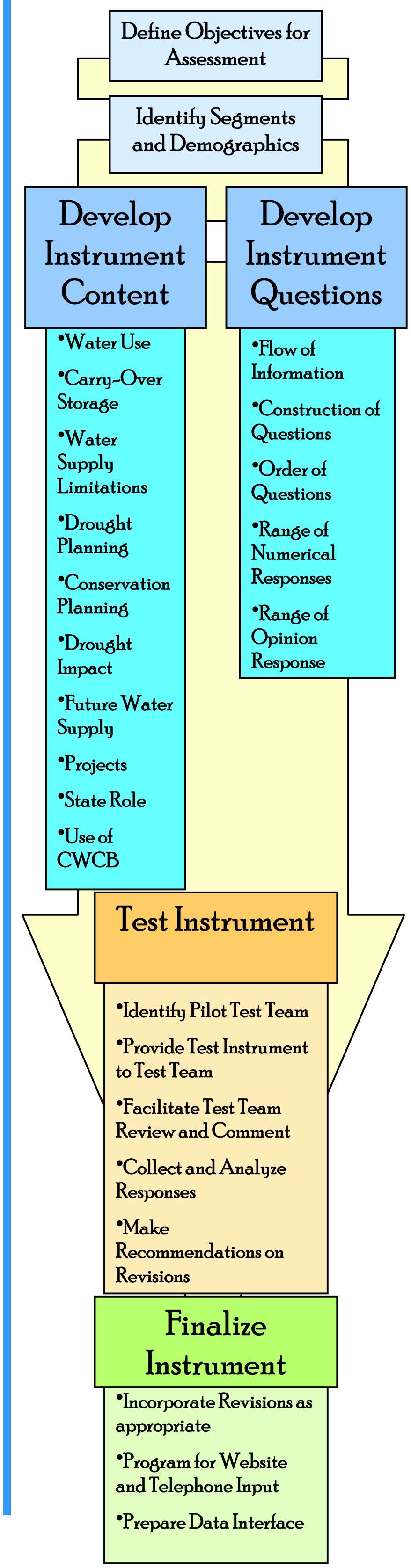
Developing Water Users Segments

For the assessment to be statistically significant – meaning that the results accurately represent the opinions of Colorado's water users as a whole and within each of the major river basins – the list of participants needed to:

- Have adequate representation within each of the major river basins;
- Include entities from all major segments of Colorado water use; and
- Include entities that represent at least 80% of the water diverted and/or delivered on an average year within the State's boundaries.

Having participation from water users that met these "participation criteria" would ensure that the CWCB and other State water planning

Figure 9-1: Process for Development of Assessment Instrument



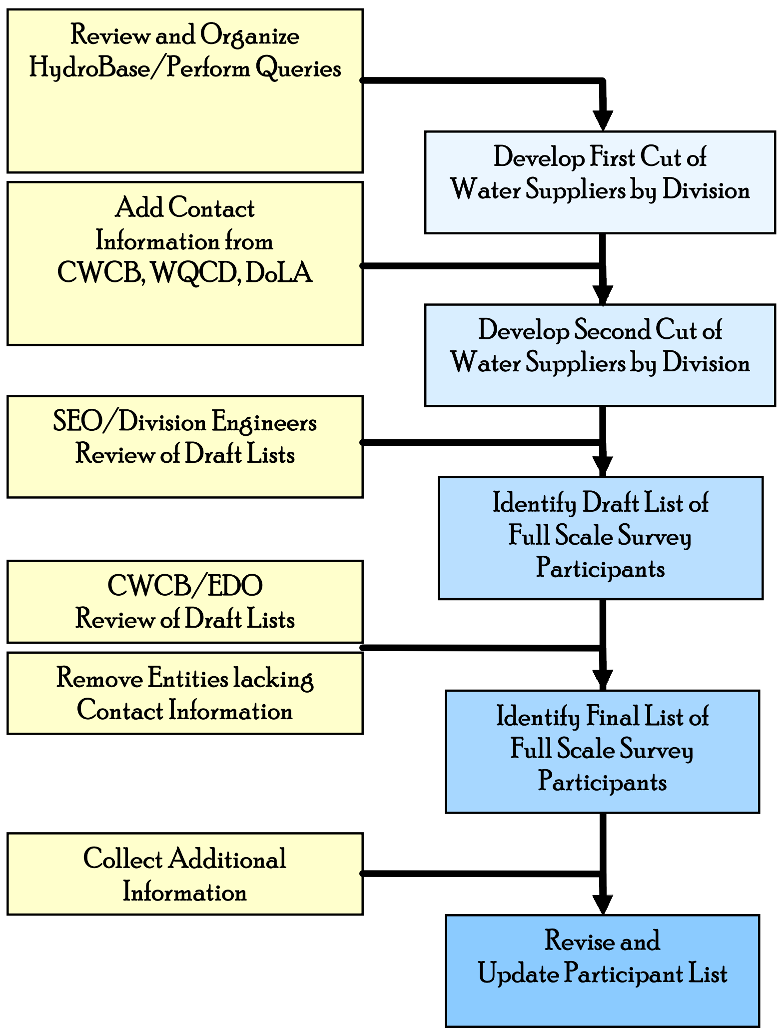
entities could rely on the results of the assessment as the basis of future water policy development and implementation.

To identify the water users that the project team needed to contact to achieve the specified participation criteria, a process was developed and followed, as indicated in Figure 9-2. The State Engineers Office (SEO) water rights accounting database, HydroBase, was used to identify the owners of the structures that either stored or diverted the most water in the State within each river basin. This listing was then embellished to include entity contact information such as address, telephone, and contact name using information made available by the CWCB, the Water Quality Control Division (WQCD) and the Department of Local Affairs (DoLA).

Lists were then generated for each of the seven major river basins and forwarded to the SEO and the division engineer field offices to be reviewed. The Division Engineers provided comments and guidance on water users, based on their unique knowledge of their divisions and water use in their basin. Additional contact information, especially for agricultural entities were developed through this process.

A final review of the participant lists were completed upon receipt of comments from the Division Engineers, including the removal of entities that lacked adequate or accurate contact information. The CWCB and the Executive Directors Office (EDO) provided a final review of the participant list to identify key omissions that needed to be added.

Figure 9-2: Process for Development of Assessment Participants



The final participant list included the following breakdown of water users is presented in Table 9-1.

Table 9-1: Summary of Survey Participants

	Water Division							
Segment	Division 1	Division 2	Division 3	Division 4	Division 5	Division 6	Division 7	**Total**
Power	0	2	0	0	0	3	0	5
Federal	2	1	4	5	6	7	5	14
State	3	4	3	3	4	6	4	9
Municipal	97	50	16	18	25	16	19	241
Agriculture	43	15	15	35	14	60	30	204
WCD*	2	1	5	3	4	6	6	25
Industry	2	4	0	4	2	5	0	16
Other**	5	6	0	2	5	3	3	23
Total	154	83	43	70	60	106	67	537

*WCD is Water Conservancy District.
**Other: a collection of twenty-three entities, ranging from tribes, to home owners associations (HOA's), etc., not fitting into any of the other described entities of Federal, State, Agriculture, Municipal, Power, Industry, or Water Conservation Districts.
Please note that when adding responses across segment and division, the total exceeds the survey response total of 537. This is because some respondents are located across more than one division, thus they are counted in all appropriate divisions. A list of participants is provided in Appendix B.

Assessment Instrument Design, Review and Testing

Design of the assessment instrument was initiated using a long list of drought-related topics, which were organized to ensure that the concerns of all segments and water basins were properly covered to address the State's significant water issues. The instrument's design had to consider how to reach every entity regardless of difficulty. Not only was the instrument developed for ease of administration in order to incent participation from a wide range of entities, it also had to address the needs that each party, segment and water division could express. To streamline the interview process, if a specific issue did not apply to a particular segment or water division, survey branching patterns were prepared to avoid unnecessary questioning. For example, if an entity's water system did not have storage capacity, the entity was not asked to define the volume of storage in the system. Furthermore, questions had to provide data that was ultimately sound, reliable, far-reaching, and in the end, comprehensive enough for critical analysis that would provide direction for the State in its decision-making efforts. Taking all of these necessary factors into account, the instrument had to follow sound statistical methodologies.

The instrument had to also be worded in such a manner as to encourage participation and minimize confusion. For these reasons, the CWCB, the SEO and the DoLA provided review and guidance during the development of the assessment instrument.

Once the content of the instrument was resolved, and the organization of the questions was defined, the means to collect statistically significant information from the questions was added to the instrument. The Likert Scale, a 5-point low to high scale, was used throughout the instrument for ease of answer comparison amongst all participants. Conversely, open-ended questions were seldom used except when necessary to capture information that would not typically be elicited through the more structured format. This design assured that all respondents were exposed to the same questions, ratings, and concepts, and ultimately provided for the facilitation of straightforward segmentation and examination. This resultant instrument included hundreds of questions covering the breadth and depth of the subject matter.

After weeks of significant input, design, communiqués, rewrites and internal testing, the instrument was finalized with the approval of the CWCB, SEO and DoLA. Net external testing of the instrument was needed to verify that the instrument functioned appropriately and provided a means to collect the requisite information. In addition, the external testing would provide a mechanism to allow the trial interviewers to hone their telephone interview methods using the actual instrument.

A pilot group of 28 participants from 27 entities was selected by the CWCB, for their diversity, water wisdom, and willingness to participate in the pilot testing effort. This pilot group (see Table 9-2) represented public and private entities of all sizes and from various state geographies.

Table 9-2: Participants in Pilot Group

Arkansas Groundwater Users Association
Aurora
Breckenridge
Centennial Water and Sanitation District
Central Colorado Water Conservancy District (CCWCD)
Colorado Springs Utilities
Colorado Water Conservation Board
Crested Butte
Denver Water
Dolores Water Conservancy District
Durango West Metro District #2
Fountain
Groundwater Appropriators of the South Platte
Grand Junction
Greeley
Lower Arkansas Water Management
Meeker
Northwest Colorado Council of Governments
Parker Water and Sanitation District
Pine River Irrigation District
Pueblo, Board of Water Works
Steamboat River District
Uncompahgre Valley Water Users Association
United States Forest Service, Rocky Mountain Region
Upper Gunnison River Water Conservancy District
Ute Water Conservancy District

Concurrently, project researchers were educated on the intricacies of Colorado water terminology and issues while receiving intensive survey training. Finally, the instrument was programmed into a computer-assisted-telephone-interview (CATI) system so as to initiate contact with the Pilot group. Interviews were scheduled as needed to conduct the survey. Resulting data was captured and manipulated via a pre-programmed system. Following the post-test interaction, input and review of the survey amongst the parties and pilot group, final modifications were made to the instrument. The CWCB approved the final instrument that was placed into the field in mid-January of 2003.

To incent comprehensive participation, the survey design was conceived so as to be conducted via several methodologies including telephone, mail or fax. In addition, as the collection process progressed and to facilitate participation of those who could not respond via telephone, the same instrument was seamlessly integrated to an online Internet survey hosted on the CWCB website 24-hours a day. All such data was collected on the CATI system and all related tables and reports produced for the assessment were prepared using this system.

To view the instrument in its entirety, see Appendix C.

Nina Nichols[1], Sanjit Kundu[1], Heather Larson[1] and Tracy Bouvette[2]
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Abstract
This chapter presents the methodologies used to administer the Drought & Water Supply Assessment instrument from mid-January to late-April 2003. The methodologies included the combined use of mailings, telephone calling and internet based surveys to reach participants in all major river basins across all identified water use types. As participation increased from January through April, analyses were performed in real time to evaluate the geographic distribution and water use segmentation of the retained data. Finally, participation was evaluated not only on the number and distribution of participants, but also on total water use represented in the assessment versus total water use in the State, using figures provided by the assessment participants.

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Conducting the Survey

Respondent Summary

Sampling Error and Statistical Significance

Water Use Reported by Respondents

Characterization of Respondents by Population and Irrigated Acreage

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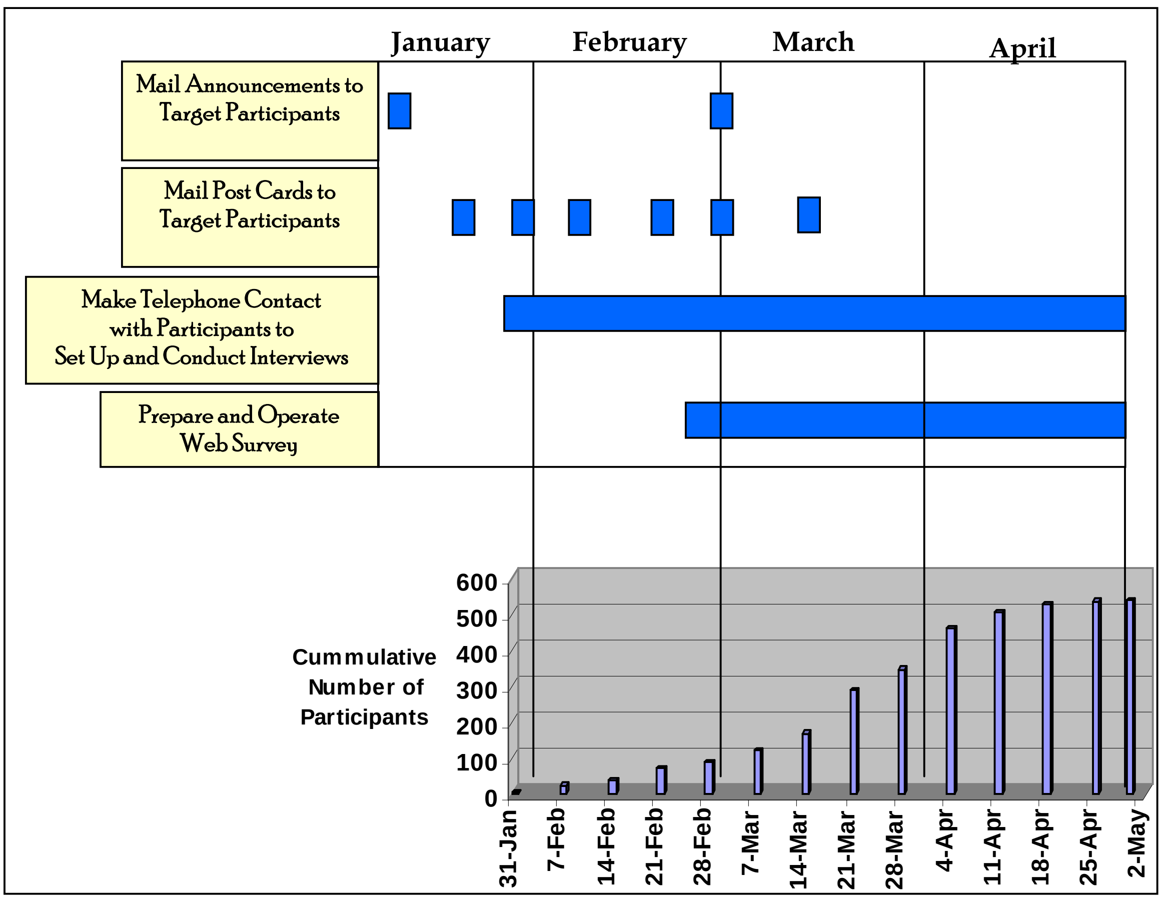
Conducting the Survey

The survey was administered from mid-January to late-April 2003 using a wide variety of methodologies, most common being over the telephone with support from mailings, faxes, and the Internet in order to ensure the ultimate possible participation. The first communications to the selected participating entities were letters sent at the beginning of January announcing the Assessment and the CWCB's intent to gather reliable water information to improve drought conditions in Colorado. Next, postcard reminders were mailed to each targeted participant explaining the purpose of the study and the procedure that would follow to facilitate participation. The mailing included an 800 number that respondents could call between 9am and 9pm Mountain Time to schedule an interview or ask questions, as well as providing preliminary questions so that the participant could gather necessary information ahead of time to expedite the interview. Such preface information included approximate average yearly water use and storage volume. The postcards were sent in waves by water division, beginning in mid-January, and calls began in each division approximately one week after mailing. Figure 10-1 presents the relative timing of the mailings with the administration of the survey.

Each potential participant was contacted upwards of ten times for an initial call to explain the study and to schedule an appointment time convenient for the participant to complete the survey. Interviews were scheduled from 7am – 9pm Mountain Time for the duration of approximately one hour each, depending on the participant's responses. Participants also had the option to fax in water use and storage numbers in order to expedite the scheduled telephone interview. Calls continued through the end of April.

In order to gain participation from those difficult to reach by telephone, a link was posted to the survey on the CWCB website in February. Researchers were able to offer this alternative to participants who found it difficult to schedule an hour of time on the phone, thus increasing participation significantly. At the end of the surveying period, key organizations who had not responded by telephone or via the Internet were re-contacted and encouraged to complete the Assessment.

Figure 10-1: Timing of Survey Mailings and Administration

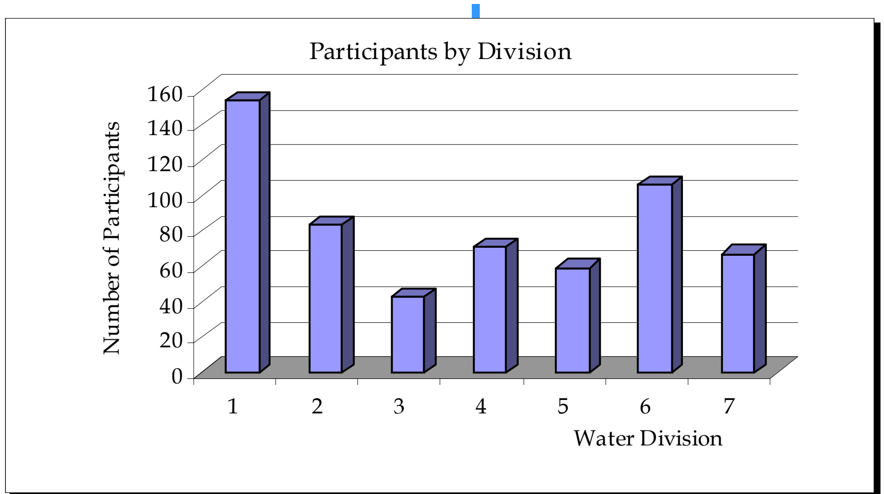


Respondent Summary

Throughout the data-gathering period, participation was closely monitored by segment and division to assure that representation was adequate for final classification. Analyses and reports were sent weekly to the CWCB. By the end of April, it was determined that an appropriate number of entities had been surveyed from each division and segment to produce statistically valid results. The final evaluation was conducted by the aforementioned segmentation as well as by water use.

The initial database of participants included a list of 1094 potential respondents for contact. Wrong numbers and disconnects were diligently pursued to ensure every opportunity of contacting each entity. After determining that some of the participants could not be contacted due to inadequate information, the number of useable numbers proved to be 825 – 75% of the original database. Of these 825 potential respondents, interviews were conducted with 537 – a completion rate of 65%. Please see Figure 10-2 at right for a summary of participants by water division. Please see Plates 10-1 through 10-8 for maps of the distribution of respondents across the state (Plate 10-1) and in every water division (Plates 10-2 to 10-8).

Figure 10-2: Participants by Division



Sampling Error and Statistical Significance

All sample surveys are subject to what is know as sampling error – the extent to which the results of the sample survey may differ from what would be obtained if the entire population being surveyed had been interviewed. The size of the sampling error is almost entirely due to the number of people interviewed for the survey and the variance of responses.

For the assessment, sample sizes were chosen to achieve high levels of statistical significance—95% confidence level with a maximum margin of error of four points—for the gathered data in its entirety. The findings can be regarded with considerable confidence since the sample size allows 95% certainty that the figures reported are within four percentage points (plus or minus) of what they would be if all Colorado water users had been interviewed. Expressing it another way, if the study were repeated 20 times, the results would come out within four percentage points (plus or minus) of the figures reported here in 19 of those 20 studies. In short, one can treat these findings as quite reliable. Additional studies would show the same patterns of data reported herein. A lesser degree of statistical confidence applies separately to the regional populations (each individual water division) in this study, though the sample sizes within each division are large enough to provide stable patterns. The municipal and agricultural sectors had the largest response bases among segments, providing high levels of statistical reliability. Among other sectors, the majority of each target population was interviewed, allowing comparative analysis by segment. Table 10-1 summarizes the survey participants by water division and segment.

The sampling strategy allowed insight from the largest water providers in the State, responsible for over 80% of total water use in the state, as described later in this chapter. Additionally, the strategy provided a vehicle to capture the opinions of a significant number of smaller organizations and providers.

Table 10-1: Summary of Survey Participants

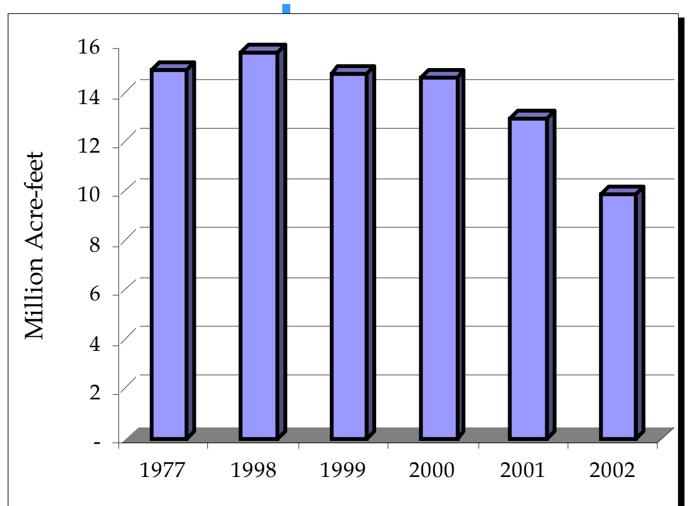
	Water Division							
Segment	Division 1	Division 2	Division 3	Division 4	Division 5	Division 6	Division 7	**Total**
Power	0	2	0	0	0	3	0	5
Federal	2	1	4	5	6	7	5	14
State	3	4	3	3	4	6	4	9
Municipal	97	50	16	18	25	16	19	241
Agriculture	43	15	15	35	14	60	30	204
WCD*	2	1	5	3	4	6	6	25
Industry	2	4	0	4	2	5	0	16
Other**	5	6	0	2	5	3	3	23
Total	154	83	43	70	60	106	67	537

*WCD is Water Conservancy District.
**Other: a collection of twenty-three entities, ranging from tribes, to home owners associations (HOA's), etc., not fitting into any of the other described entities of Federal, State, Agriculture, Municipal, Power, Industry, or Water Conservation Districts.
Please note that when adding responses across segment and division, the total exceeds the survey response total of 537. This is because some respondents are located across more than one division, thus they are counted in all appropriate divisions. A list of participants is provided in Appendix B.

Water Use Reported by Respondents

The water use of these participants was monitored to identify the percentage of Colorado's total reported diversions and/or deliveries (as reported by the State Engineer's Office) represented by the assessment respondents. Figure 10-3 presents the reported water use by all the respondents that answered the question (and including delivery totals for the Bureau of Reclamation estimated from their reservoir discharge figures at 2 million acre-feet annually). On average, the total water use for the assessment participants (measured as delivered or diverted water, not as consumed water) was found on any given year to range from 84 to 93%

Figure 10-3: Water Use Reported by Respondents

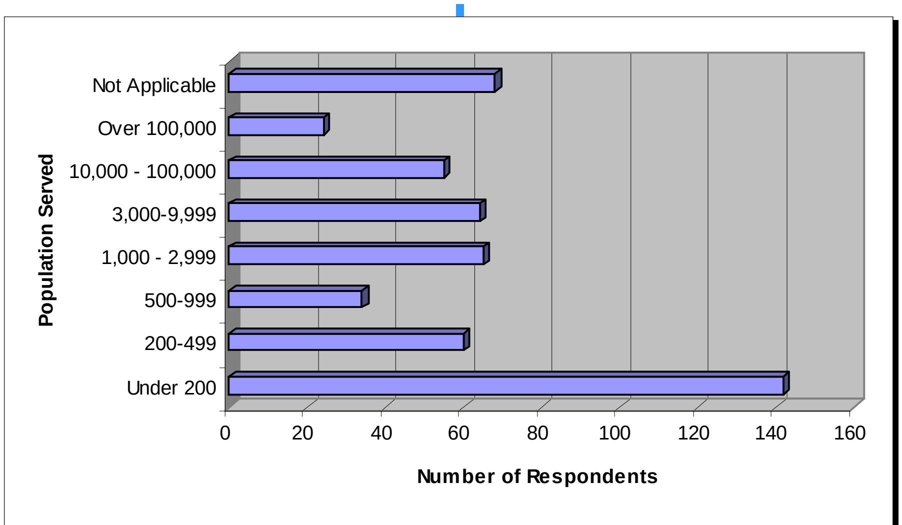


of the total state-wide delivery reported by the State Engineer's Office. Therefore, the survey was determined to have captured the opinion of at least 80% of Colorado's water users.

Characterization of Respondents by Population and Irrigated Acreage

The characteristics of the participants were also developed in terms of population served and irrigated acreage. Figures 10-4 and 10-5 show the total number of respondents who reported water deliveries to serve populations of different sizes and for irrigation of varying acreage, respectively

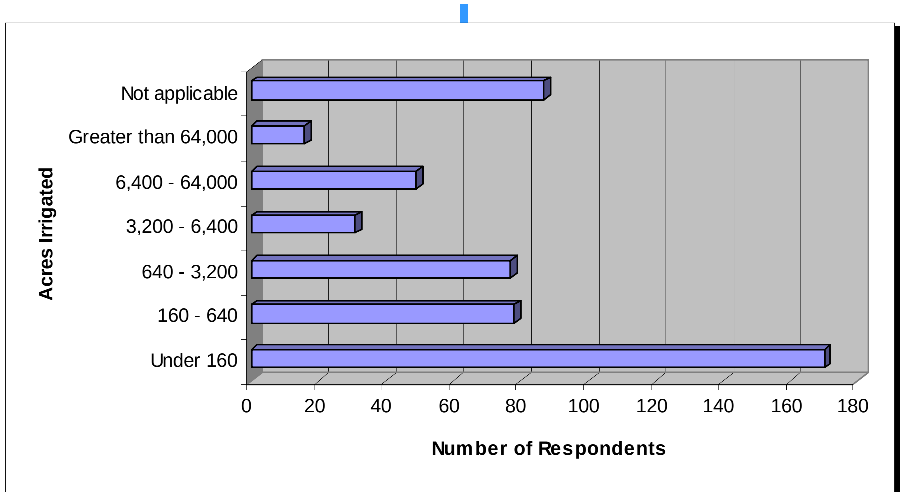
Figure 10-4: Number of Respondents versus Population Served



These figures illustrate some interesting issues regarding water deliveries, among them:

- The largest number of participants responded that they deliver quantities of water at the lowest end of the scale presented in the survey. Over 25% of participants provide water to populations of less than 200; over 30% of participants deliver water for irrigation on less than 160 acres. Of the over 140 participants who reported delivering water to less than 200 people, almost 110 were from the agricultural sector, as should be expected. Similarly, of the over 170 participants who irrigate less than 160 acres, over 130 were from the municipal sector. Therefore, about 30 entities that provide municipal water to less than 200 people, and 40 agricultural entities that irrigate less than 100 acres were interviewed, rounding out the distribution of water user types. These small water users represent an important demographic of water use since they represent a large segment of water users in the state. (As a means of comparison, there are only 30 municipalities with populations over 10,000 in the state.)

Figure 10-5: Number of Respondents versus Acres Irrigated



- A common response for both population and acres irrigated was "Not Applicable." This is largely explained by responses from the municipal and agricultural sectors, with municipalities not delivering irrigation water and agricultural entities not providing domestic water supply for population centers. Industrial and water conservancy districts also had high levels of responses listed as "Not Applicable" as would be expected.
- The distribution of respondents with respect to both population served and irrigated acreage indicates that that survey was successful in the engagement of a wide range of water delivery amounts, within the two key segments of municipal and agricultural water use. In addition, the survey was successful in obtaining opinion information from a fairly even distribution of water use deliveries based on the number of respondents indicated for each of the categories.

Discussion

The administration of the assessment successfully engaged Colorado water users within selected water use segments and geographies (i.e. water divisions) to determine current opinion on:

- Limitations of water supply – current and future
- Drought impacts
- Drought, water supply, and water conservation planning
- Drought mitigation methods
- Cooperative agreements
- State role in drought planning and mitigation efforts.

The survey accessed 537 water users representing eight water use segments in all seven of the major river basins. These water users, which ranged from small to large, represented over 80% of the state's water diversions and/or deliveries in any given year.

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Summary of Responses

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Abstract
Water supply limitations affect nearly all the water users in the water-short west since the available water is called upon to support so many diverse uses in its journey from source to sea. The Drought & Water Supply Assessment allowed participants to identify water supply limitations that affect their individual operations and uses, including those that are both structural and non-structural such as:

- *Availability and presence of water and water rights*
- *Suitability and usability of structures*
- *Regulatory and policy impacts*
- *Public expectations*
- *Other competing factors*

The results of the analyses indicate which types of limitations exist and their severity, and which limitations have the greatest impacts on current water supply.

Introduction
Water supply limitations affect nearly all the water users in the water-short western states as the available water is called upon to support so many diverse uses in its journey from source to sea. To characterize local and regional limitations, an evaluation of Colorado's current water supply was performed as a component of the Drought & Water Supply Assessment, in which participants identified both structural and non-structural water supply limitations that influence their individual operations and uses.

To determine the limitations most affecting Colorado water users, respondents were first asked whether various factors were a limitation to their current water supply. Those who responded in the affirmative were then asked to rate that limitation on a scale of 1 to 5, where 5 represented severely limiting and 1 represented slightly limiting. Using the combination of these questions, the assessment not only was able to demonstrate which factors were seen as limitations, but how severely each limitation affects current water supply. The combination of being ranked by a majority of respondents as a limitation and of being ranked as a severe (4 – 5) limitation indicates issues of widely recognized importance for meeting water supply needs.

Table 11-1 at right presents the complete listing of all limitations included within the survey instrument. Note that all participants were given the opportunity to identify other limitations that may impact their current water supply. A discussion of the "other" responses is included below.

Summary of Responses

Considering the wide range of Colorado water users, it is understandable that the limits of one organization or entity may not be a concern for another. There were, however, common water supply limitations mentioned by a majority of water users—specifically the availability of storage and the availability and reliability of in-basin water rights as indicated in Figure 11-1. These limitations had the most consistently high rating, both as a water supply limitation and a limitation ranked as severe, and should thus be considered among the most significant in the State.

Figure 11-1: Water Supply Limitations Identified by Respondents

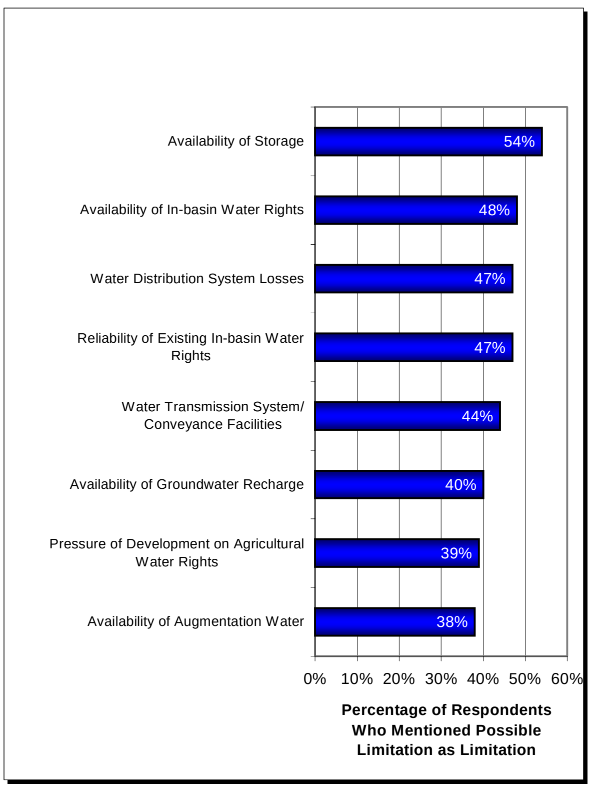
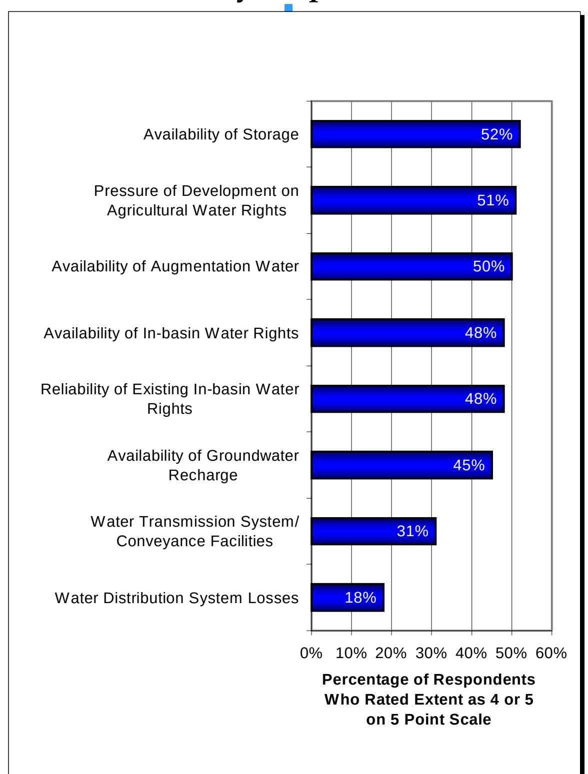


Figure 11-2: Water Supply Limitations Rated as Severe by Respondents



When asked to rate the severity of each identified limitation, water users again opined with a consistent message independent of geography and segment. As indicated in Figure 11-2, the availability of storage and the availability of augmentation water were consistently rated high in the severity of these limitations (by those water users that identified these issues as limitations). The pressure of development on agricultural water rights, which relates to municipal entities pursuing the use of agricultural water (e.g., Aurora and Rocky Ford) was also reported as a severe limitation.

Availability of Storage

One limitation that stands above the rest in affecting organizations regardless of segment (with the exception of power) or river basin is the issue of available water storage (see Table 11-2). Fifty-four percent of respondents indicated that storage deficiencies limit their water supply (Figure 11-1), with a majority of those respondents, 52%, rating the severity of the limitation as a 4 or 5 (Figure 11-2). This response was largely consistent across water divisions (ranging from 48% to 59%). Divisions 1 and 5 had the highest number of respondents declaring the limitation. In addition, Division 1 viewed the severity of the limitation as the most severe with 42% of respondents indicating the highest possible score of 5. This can perhaps be attributed to the large number of groundwater appropriators that are in need of augmentation water to operate, and the fact that Division 1, which must comply with the South Platte compact at the state line, is the largest municipal, industrial and agricultural water user in the State and is therefore perpetually facing the challenge of water scarcity.

With regard to segmentation of water users, it is clear from the survey responses that the larger municipal entities (i.e. those with a population greater than 5,000) feel the most affected by the lack of available water storage, followed closely by the large agricultural users (i.e. those that irrigate over 3,200 acres). In conclusion, the lack of available storage is clearly a statewide concern as displayed in Figure 11-1.

Availability of In-Basin Water Rights

Figures 11-1 and 11-2 also illustrate the other most often-cited water supply limitations identified by the survey participants and their respective severity. The availability of in-basin water rights was widely ranked as an extreme limitation, with almost half of all of respondents indicating its limiting effect on their current water supply and 48% of those rating its severity as a 4 or 5. The responses were fairly comparable across all divisions (ranging from 40-54%) with Divisions 3 and 7 viewing the extent of the limitation as the most severe (see Table 11-3). This is likely due, in part, to the severity of the most recent drought in those areas and the overall lack of available water in those divisions. Although Division 3 had the lowest percentage of participants in the assessment who indicated that the availability of in-basin water

Table 11-2: Response by Segment and Division for Availability of Storage

Segment	Limitation	Severe*
Municipal	56	49
Agricultural	55	55
Power	0	0
WCD	60	67
Industry	19	67
Federal	36	20
State	44	25
Other	61	50
Division	**Limitation**	**Severe***
Division 1	56	57
Division 2	49	52
Division 3	55	56
Division 4	57	40
Division 5	59	32
Division 6	52	49
Division 7	48	57

* percent of respondents who cited this as a limitation and of those % that gave it a 4 or 5 rating on a 5 point scale. WCD = Water Conservancy District

Table 11-3: Response by Segment and Division for Availability of In-Basin Water Rights

Segment	Limitation	Severe*
Municipal	40	55
Agricultural	58	47
Power	20	0
WCD	32	38
Industry	44	43
Federal	50	0
State	56	20
Other	61	64
Division	**Limitation**	**Severe***
Division 1	48	52
Division 2	52	48
Division 3	40	59
Division 4	54	45
Division 5	49	35
Division 6	43	33
Division 7	53	60

* percent of respondents who cited this as a limitation and of those % that gave it a 4 or 5 rating on a 5 point scale. WCD = Water Conservancy District

rights was a limitation, almost 60% of those concerned with this issue rated its severity as a 4 or 5, or very limiting. Division 6 rated the extent of the limitation and severity of the limitation lower than other divisions, which is consistent with the fact that Division 6 has not had to administer water at any time in the past.

Among segments, the small collection of entities in the other[1] category indicated the availability of in-basin water rights as a limitation. Following other by percentage of respondents, agricultural users had the most respondents that mentioned this as a limitation, especially among the larger users. Municipal users rated the severity somewhat higher overall.

Reliability of In-Basin Water Rights
Along with availability, the reliability of existing in-basin water rights ranked similarly high on the list of limitations. Forty-seven percent described it as a limitation and of those, 48% rated the extent of the limitation a 4-5. Again, Divisions 3 and 7 rated the extent of the limitation highest with more than three in five respondents rating the reliability of existing in-basin water rights extremely limiting (see Table 11-4). However, when looking at all divisions collectively, Division 3 respondents rated the reliability of in-basin water rights a 5 (extremely limiting) by a 2:1 ratio over the average divisional response.

Among segments, "other" users had the highest mention of the limitation, with the industry segment rating its severity as the highest: an astounding 84% of those described it as very or extremely limiting (a 4 or 5).

Development Pressure on Agricultural Water Rights
Nearly 40% of all respondents designated pressure of development on agricultural land water rights as a limitation and more than half of them saw it as a significant concern. This is especially a concern in the agricultural entities where more than half stated it is a limitation and 61% rated it a 4 or 5. Among the divisions, Division 7 stands out from the other divisions with 50% naming pressure of development on agricultural land water rights a limitation and 60% rating it as severely limiting (see Table 11-5).

Table 11-4: Response by Segment and Division for Reliability of In-Basin Water Rights

Segment	Limitation	Severe*
Municipal	40	42
Agricultural	53	53
Power	60	66
WCD	60	47
Industry	38	84
Federal	21	66
State	56	60
Other	73	32
Division	**Limitation**	**Severe***
Division 1	46	49
Division 2	47	51
Division 3	55	65
Division 4	37	50
Division 5	43	46
Division 6	46	40
Division 7	48	63

* percent of respondents who cited this as a limitation and of those % that gave it a 4 or 5 rating on a 5 point scale. WCD = Water Conservancy District

Table 11-5: Response by Segment and Division for Pressure of Development on Agricultural Water Rights

Segment	Limitation	Severe*
Municipal	26	35
Agricultural	51	61
Power	0	0
WCD	44	54
Industry	38	66
Federal	29	25
State	22	50
Other	77	47
Division	**Limitation**	**Severe***
Division 1	41	51
Division 2	39	58
Division 3	40	41
Division 4	43	57
Division 5	31	44
Division 6	28	50
Division 7	50	60

* percent of respondents who cited this as a limitation and of those % that gave it a 4 or 5 rating on a 5 point scale. WCD = Water Conservancy District

[1] Other entities: a collection of twenty-three entities, ranging from tribes, to home owners associations (HOA's), etc., not fitting into any of the other described entities of Federal, State, Agriculture, Municipal, Power, Industry, or Water Conservation Districts.

Other Limitations

As Figure 11-1 indicates, other factors that are noteworthy with respect to identified current water supply limitations reported by the water users include the availability of groundwater recharge, the availability of augmentation water, and water transmission conveyance facilities.

For groundwater recharge, 40% named it a limitation with 45% rating it extensive. Divisions 4, 5, and 7 showed considerably lower numbers as most entities in those regions do not have access to significant groundwater supplies. Agricultural entities had high mention of this limitation as well as the highest severity rating among segments, presumably due to the reliance of agriculture on groundwater in numerous locations throughout the state.

Thirty-eight percent of users cited the availability of augmentation water as a limitation and half of those rated it as severe. Approximately half of Division 2 cited this as a limitation and 55% rated it a 4 or 5. It was found to be a severe limitation for large agricultural entities, 44% of which reported it as a limitation and 50% of those respondents ranked it a 4 or 5.

Although nearly half (47%) of all respondents rated water distribution system losses as a limitation (ranked number three on the list of all these limitations to current water supply in Figure 11-1), though only 18% of this same overall population rated it as severely limiting as shown in Figure 11-2.

The remaining limitations were identified by a similar percentage of respondents, roughly 30%. However, significant statistical differences appeared between two Divisions, Divisions 1 and 6, in regards to the identification of limitations to current water supply. For certain limitations (i.e. availability of trans-basin water rights, reliability of existing trans-basin water rights, federal permitting requirements) Division 1 consistently had among the highest percentage of respondents who felt constrained, while Division 6 was always at the low end of that reported limitation concern. System issues, including the need for new or upgraded raw water treatment infrastructure and water transmission systems and/or conveyance facilities are more often a limitation of concern in Division 1 and less of a concern in Division 6 in comparison to the other water divisions.

It is worth noting the unique responses received for two issues: the availability of trans-basin water rights and the Endangered Species Act. Although just over one-third of survey participants indicated that either of these issues is a limitation, those that did indicated that the limitation was severe, which was particularly true for the larger municipal and agricultural entities. The agricultural participants rated the severity of the Endangered Species Act appreciably higher than any other segment.

Table 11-6 presents a listing of the most severe limitations, those ranked as 4 or 5, identified by each segment surveyed.

Table 11-6: Most Severe Limitation as Identified by Segment

Segment	Most Severe Limitation
Municipal	Availability of Storage
Agricultural	Availability of Storage
Power	Availability of In-Basin Water Rights/ESA
Water Conservancy District	Availability of Storage
Industry	Availability of In-Basin Water Rights
Federal	ESA
State	Availability of Storage
Other	Availability of In-Basin Water Rights/Availability of Ground Water

ESA – Endangered Species Act

Finally, less than one out of three respondents mentioned the following limitations: the need for new or upgraded raw water treatment infrastructure (rated extremely low by agricultural entities, but significantly higher for municipal organizations); reliability of production wells; federal land management; CWCB instream flows; and diversion structures. Eighty-three survey participants, 15% of those surveyed, identified other limitations when provided the opportunity during the survey. The most often quoted limitation in the other category was lack of water (20%). Funding limitations were identified by 17% of those that selected to comment on this category.

Discussion

The availability of storage is the single most widespread and severe limitation to current water supply indicated by Colorado water users agreed upon consistently by all divisions and all segments. Division 1 viewed the severity as the most dire, but all other divisions agreed to a considerable extent.

Water availability issues are the next most widespread and severe for Colorado's water users based on the survey results. Depending on the location and use, the availability of groundwater, recharge water, in-basin water rights (surface water), and augmentation water are identified as important and severe.

Infrastructure issues were identified as limitations, including transmission and distribution; however, the severity of these limitations was identified as significantly lower than water availability for the current water supply.

Of particular note is the issue of development pressures on agricultural water rights. This issue reflects the changing demand on agricultural water rights created as these rights are permanently transferred to other users – chiefly municipal. The agricultural community views these pressures as widespread and significant.

Finally, survey respondents did not express widespread concern that environmental, policy, or certain types of infrastructure issues were limitations to the current water supply. However, for those entities (e.g., agricultural entities) that did identify any of these issues as a constraint (e.g., the Endangered Species Act), the constraint was ranked as severe.

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Discussion

Abstract

One of the central assessment themes evaluated by the Drought & Water Supply Assessment regards the preparedness of water users for drought in Colorado – in the past, present and future. The assessment instrument was designed to deliver information on each of the following subjects:

- *Water supply planning*
- *Drought management planning components and mechanisms*
- *Drought tools utilized*
- *Water conservation planning*
- *Water conservation tools used*

The results of the data collection and analysis efforts are discussed in this chapter including a presentation of how many entities have formal drought and water conservation planning in place, by geography and segment, and what types of drought and conservation tools are most effective for each participant's particular location and water use. Significant differences that exist regarding planning and standard practices between municipal and agricultural water users are highlighted.

Introduction

Water availability within the State of Colorado is perceived as a significant limitation to current water supply across all divisions and water use segments. Management of current water supplies would therefore be expected to be of immediate importance to water planners and managers statewide. Insomuch as water supply management begins with planning, the assessment evaluated the level of water, drought and conservation planning that exists within Colorado's water user organizations and by water user entities as a means to judge the overall state of drought preparedness within Colorado.

For those with existing plans, the assessment was used to identify management components and tools that are formally incorporated into current policies and programs. Participants with plans were asked to identify those drought and conservation management tools that are the most effective in managing water supply and demand. The results of this portion of the assessment will help the State identify the degree of drought preparedness and water planning and management as a whole across the state. With this information, the State will be better positioned to allocate state resources to provide and meet technical assistance and other requisite guidance to its citizenry, in general, and water users, specifically, in the planning for and mitigation of future droughts and periods of water scarcity.

Water Supply Master Plan: A comprehensive plan in which a water management entity addresses all technical and political issues related to providing sufficient quantity and quality of water for the entities' clients.

Drought Management Plan: A plan in which an entity or entities address the measures and responses needed to prepare for, monitor, and mitigate the effects of drought.

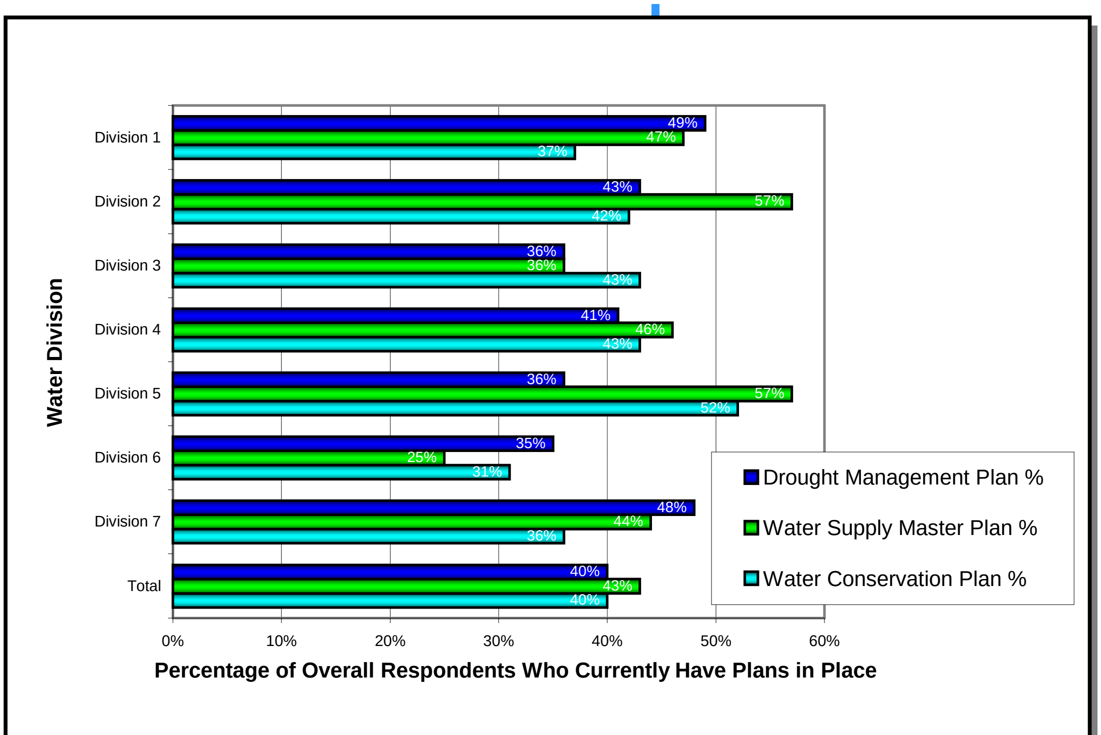
Water Conservation Plan: A plan that outlines how a water management entity or user will improve water use efficiency over the long-term and how this fits within their overall water management needs.

Of course significant differences exist between planning efforts maintained by agricultural and municipal entities. Many agricultural entities plan using informal, yet well tested, methods on a crop-to-crop, or year-to-year basis. In addition, agricultural entities often rely on grassroots and other informal communication methods to coordinate drought management and water conservation efforts. Municipalities, which generate revenue from water sales for water planning, typically manage water supplies over a much longer time horizon – of three to five years or longer. Municipalities also have formal communication pathways from staff to decision-makers and the community by necessity. These basic differences translate to different levels of overall planning and communications for these segments of users. Nonetheless, both segments have the need for planning ahead to manage and prepare for drought, since droughts will undoubtedly occur and have potentially far reaching impacts. Difference between the segments and successful methods for each segment will be highlighted in this Chapter.

Summary of Planning Efforts Statewide

The assessment analyzed three primary types of planning efforts across the State: 1) water supply master plans; 2) drought management plans; and 3) water conservation plans. These plans were analyzed by the seven Colorado Water Divisions as well as by segment. As indicated in Figure 12-1, approximately 40% of those surveyed have these plans in place.

Figure 12-1: Water Management and Planning in Colorado

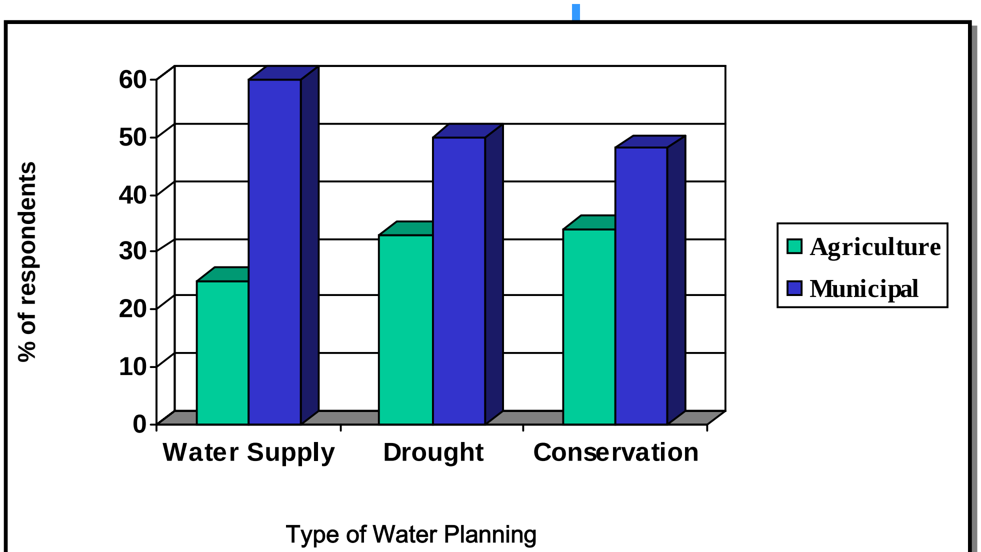


One might imagine that entities with one type of plan in place ("planners"), such as a drought management plan, would be more likely to have another type of plan in place; but assessment results do not support this expectation. For example, only slightly more than half of those with water supply master plans had drought management plans and of those who had drought management plans, 59% had water supply master plans. Indeed, only 16% had implemented all three plans compared to more than a third who had none of these plans in place.

Interestingly, having a water supply master plan (which includes approximately 40% of those surveyed) does not seem to translate into confidence that such plans are effective in managing drought, as only about two in five respondents rated such preparations as somewhat or highly effective. Furthermore, the continuing severity of the drought seems to have prompted a noticeable increase in planning activities; nearly 30% of those with plans had implemented them within the last year. Without this large surge of planning effort during the past drought year, the percentage of entities without a water supply master plan would have been nearly 70%.

When reviewing these three water management plans across the eight segment types defined in the assessment – municipal, agricultural, state, federal, power, industry, Water Conservation District, and other[1] – a disparity consistently appears between the municipal and agricultural segments, as illustrated in Figure 12-2. Sixty percent of municipal entities stated that they had a water supply master plan in place, while only 25% of their agricultural counterparts indicated the same. With respect to drought management plans, about half of the municipal segment had plans in place, as opposed to about one-third of the agricultural segment. (Note that only 30% of respondents who did not currently have a drought management plan indicated that they plan to develop one in the future. Nearly 50% of municipal respondents were among this latter group as opposed to less than twenty percent of agricultural respondents.)

Figure 12-2: Level of Planning for Agricultural and Municipal Water Users



[1] Other entities: a collection of twenty-three entities, ranging from tribes, to home owners associations (HOA's), etc., not fitting into any of the other described entities of Federal, State, Agriculture, Municipal, Power, Industry, or Water Conservation Districts.

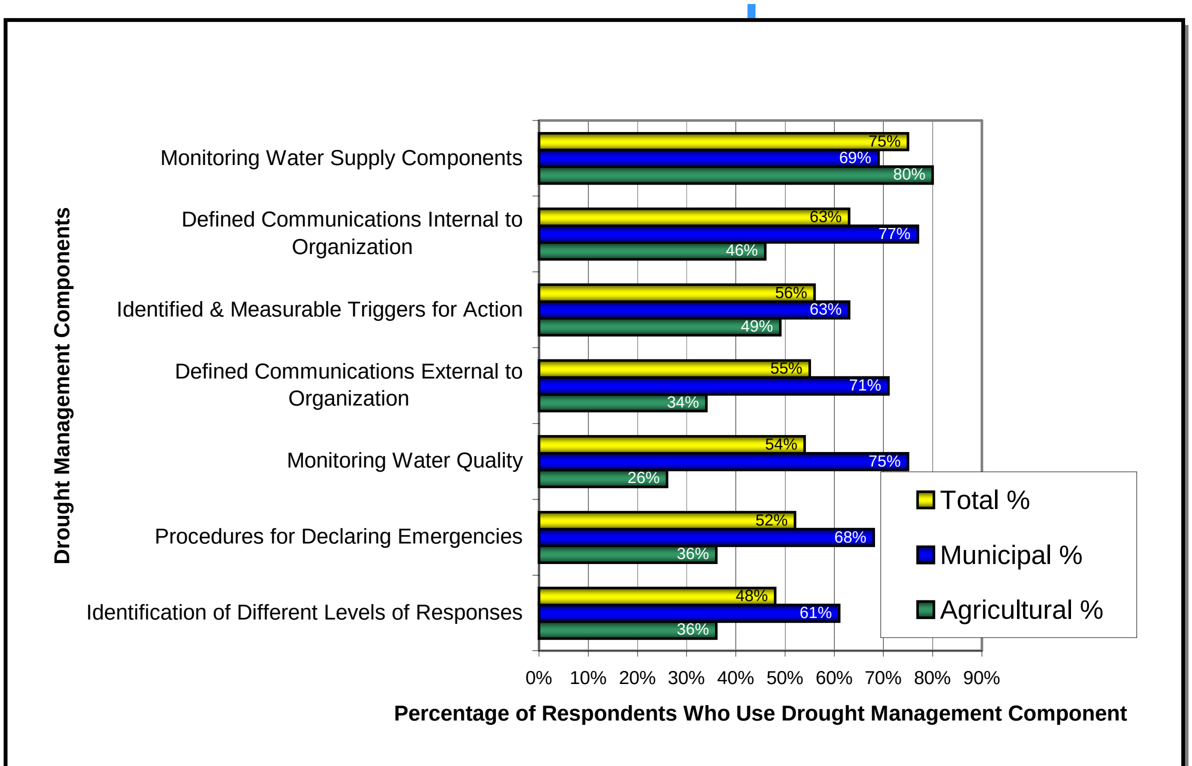
Water conservation plans were maintained by 40% of the respondents, with 48% of municipal and 34% of agricultural entities having these plans. Only 22% of state entities have plans, which is the lowest percentage of any segment. Conversely, industry has the highest percentage of participants with plans at 56%. The range for Divisions was less pronounced – Division 6 is at the 31% level and Division 5 reaching 52%.

Drought Planning

To evaluate the quality of the content of the various drought management plans, the survey instrument requested information regarding management components within each plan. As expected, there were significant differences between the various plan components, especially with respect to the municipal and agricultural users, as illustrated in Figure 12-3.

Three out of every four entities with a drought plan monitor their water supply, which is an effective and appropriate management component of any drought plan, with slightly more agricultural entities performing this activity than municipal entities. It is unclear however, how many of the agricultural entities utilize the water supply data in a formal fashion, since about one-half have identified measurable "triggers" to indicate that drought conditions exist, and fewer still have formal internal or external communication mechanisms defined. Roughly one in three agricultural entities have formal means to declare emergencies or identify different levels of response to drought. In contrast, municipalities with plans appear to focus on

Figure 12-3: Drought Management Components Used in Colorado



communications. More than seven out of every ten municipal entities with plans have formal communication channels defined both internal and external to the organizations. In addition, more than six out of every ten have defined formal triggers for drought, and different levels of drought, incorporated into their planning process. More than two-thirds have formal procedures for declaring drought. Inclusion of management components is appropriate and necessary for meaningful drought management. To this point, it appears that the majority of those municipalities with drought management plans apparently have the appropriate type of management components related to monitoring, triggers, and communications in place to allow for meaningful drought management response.

Unfortunately, roughly half of Colorado's municipalities appear to have no drought management plans. In addition, fewer agricultural entities have drought management plans, and those that do, do not appear to have adequate definition of response actions in place. In fact, it appears based on the survey results, that less than one of every six agricultural entities have formal drought responses in place to declare drought, define drought, or communicate that drought responses are needed internal or external to the organization. Of course the planning needs of agricultural water users are different than the planning needs of municipal entities. However, agricultural water users can still benefit from formal planning as a means to prepare for and mitigate drought impacts. The assessment also probed into the use of specific drought management tools such as aquifer storage and recovery, cloud seeding, and water restrictions. Figure 12-4 details the use of these types of tools in Colorado, in order by frequency of use, including a breakdown by municipal and agricultural use.

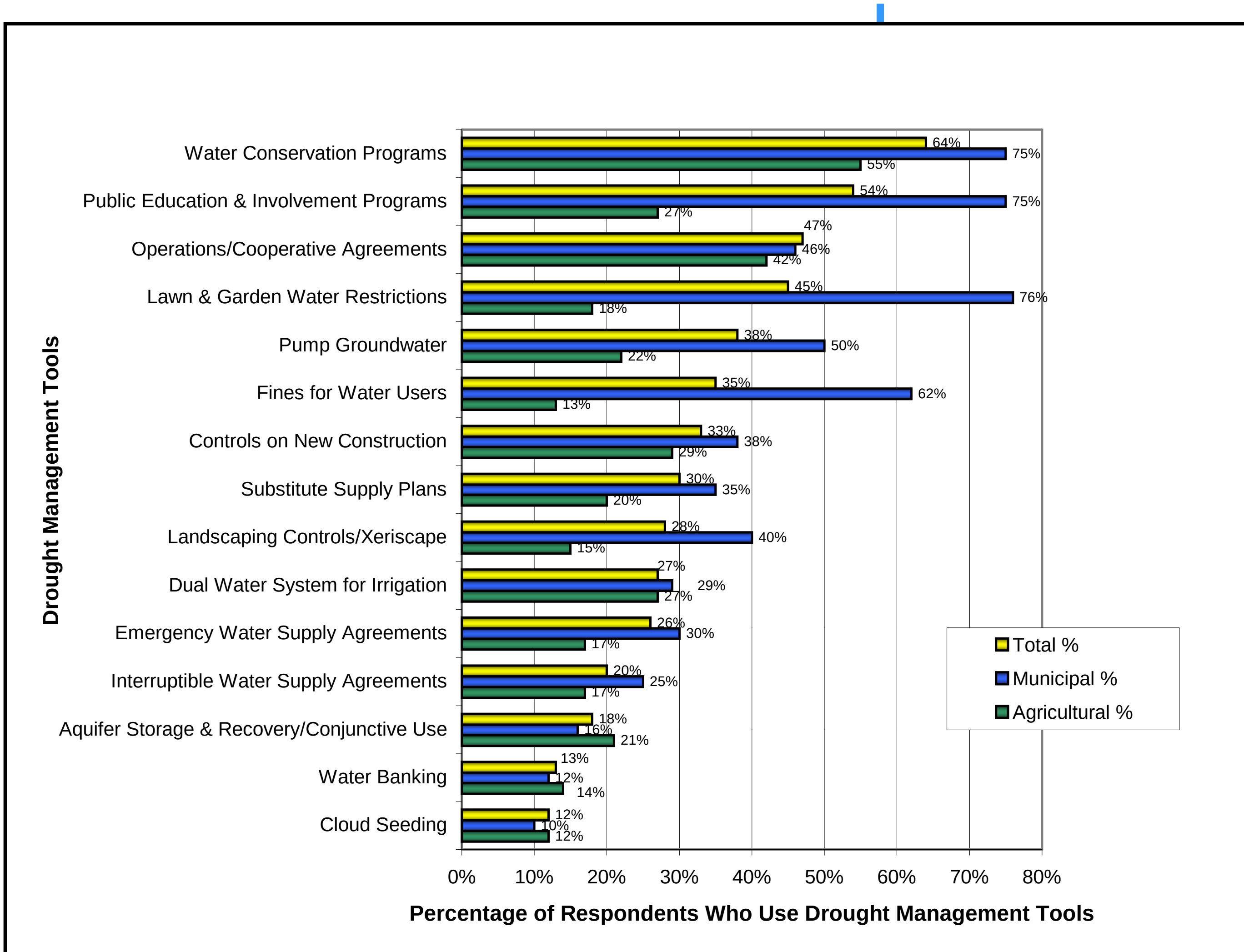
Among divisions, water conservation programs stood out as the most popular tool used to manage drought. This is somewhat ironic since water conservation is not deemed by the experts as an effective tool for managing short-term water scarcities for municipal use. Water conservation programs are effective in helping water users manage both their water supply and water demand over the long term. For some agricultural entities, however, water conservation programs are effective for drought management when connected to short-term activities such as alternative irrigation practices.

Drought management requires shorter term reactions to periods of water scarcity especially for municipal uses, not typically addressed by water conservation practices. In fact, only 14% of municipal entities using water conservation indicated that this was one of the best tools for drought management as shown in Figure 12-5. Among segments, the most popular drought management tool varied substantially. Each of the tools listed below was rated as the most popular by at least one segment:

- Water conservation programs: industry, agriculture, *municipal*
- Public education and involvement programs: federal, other, *water conservancy district*, *municipal*
- Lawn and garden water restrictions: *municipal*
- Operational/cooperative agreements: state, power, *water conservancy district*

Note: segments shown in italics had statistically the same most popular rating for more than one tool.

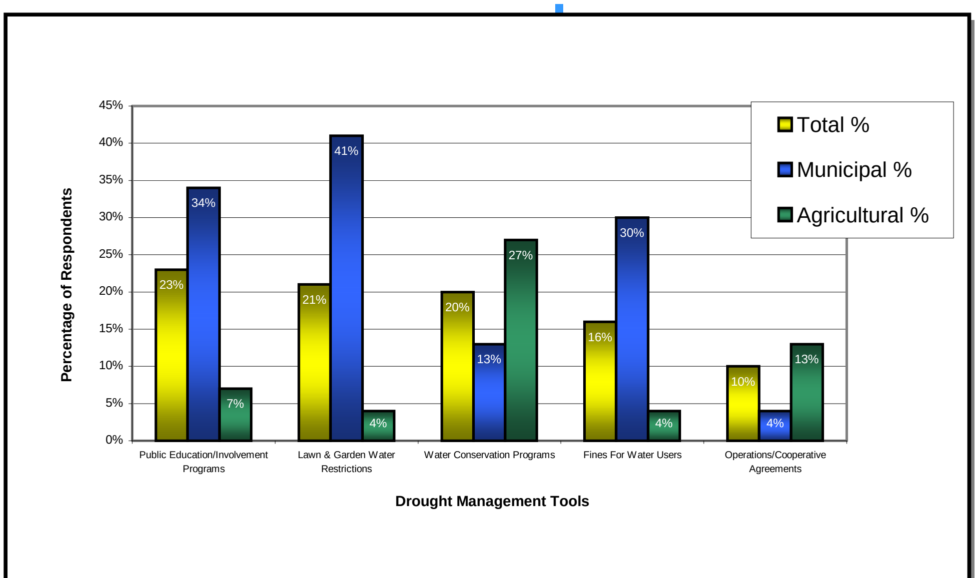
Figure 12-4: Drought Management Tools Used in Colorado



There are a few interesting points of note. The municipal segment clearly relies on the short-term restriction of water use to manage drought through the use of lawn watering restrictions, fines for water use (in severe conditions) and to a lesser extent, land use controls and xeriscaping. These are effective controls for municipalities, as indicated in Figure 12-5, especially when coupled with public education and involvement programs. Municipal water suppliers clearly favor, and in fact rely, on public communications as a means to manage drought. Although some municipalities rely on other means to manage drought, such as using cooperative agreements, pumping groundwater, using controls or new constructions, etc., the best individual tools as indicated by the survey respondents are public education and involvement programs and watering restrictions coupled with fines for water use.

The agricultural community relies on water conservation programs and cooperative agreements to manage drought. Water conservation in the case of agricultural applications relates to short-term changes in irrigation practices and crop selection. Unlike water conservation for municipal entities, in which long-term water supply and demand management occurs, agricultural entities can and do use water conservation practices to manage and mitigate drought. The difference between these water user segments is that agricultural water conservation can include methods to reduce short-term water use such as planting drought tolerant crops, changing irrigation and planting practices, and leasing water rights to other users. These types of water conservation for agricultural entities can be revised from year to year.

Figure 12-5: Best Tools for Managing Drought



As will be seen in the following section on water conservation, agricultural entities view the lining of pipes and ditches as an important tool for water conservation. Clearly, lining of ditches and pipes is more a long-term response than a short-term one, but its effectiveness in reducing transmission losses is significant and noteworthy.

In much the same way, cooperative and operational agreements can be effective for the agricultural community because they can exist for the short-term and help to manage operations during periods of water scarcity. Roughly four in ten agricultural water users utilize cooperative agreements to manage drought.

Table 12-1 presents a summary of those tools preferred by the agricultural and municipal segments.

Table 12-1: Preferred Drought Management Tools

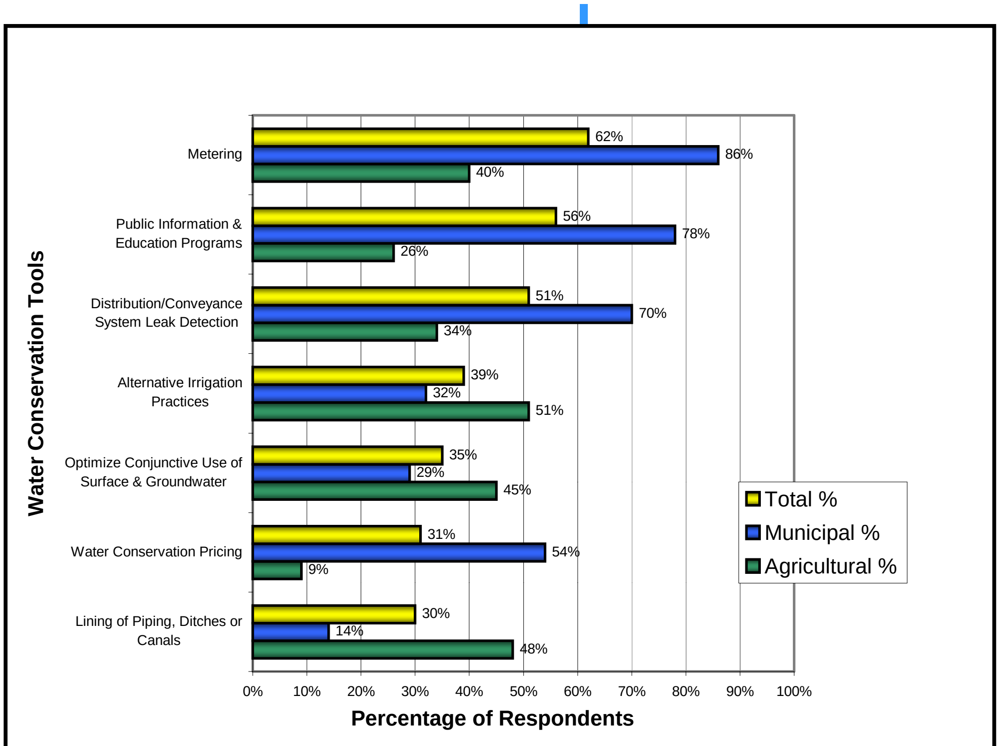
Agriculture		Municipal	
Tool	**Percentage***	**Tool**	**Percentage***
Water conservation	55	Lawn and garden watering restrictions	76
Cooperative agreements	42	Public education	75
Controls on new construction	29	Water conservation	75
Public education	27	Fines for water use	62
Dual water systems	27	Pump groundwater	50

*Percent of water users in segment with plans using the tool

Water Conservation

When examining water conservation plans, the two primary segments – municipal and agricultural – continue to contrast one another regarding preferred water conservation tools, as indicated in Figure 12-6. As noted previously, these differences are expected. Agriculture favored the use of alternative irrigation practices, the lining of piping, ditches or canals; and optimizing conjunctive use of surface and groundwater, although no tools were rated favorably by a strong majority. The municipal segment, on the other hand, favored other water conservation tools for their programs including metering (86%), public information & education programs (78%), and system leak detection (70%). Water conservation pricing was also favored by over one-half of the municipal entities responding.

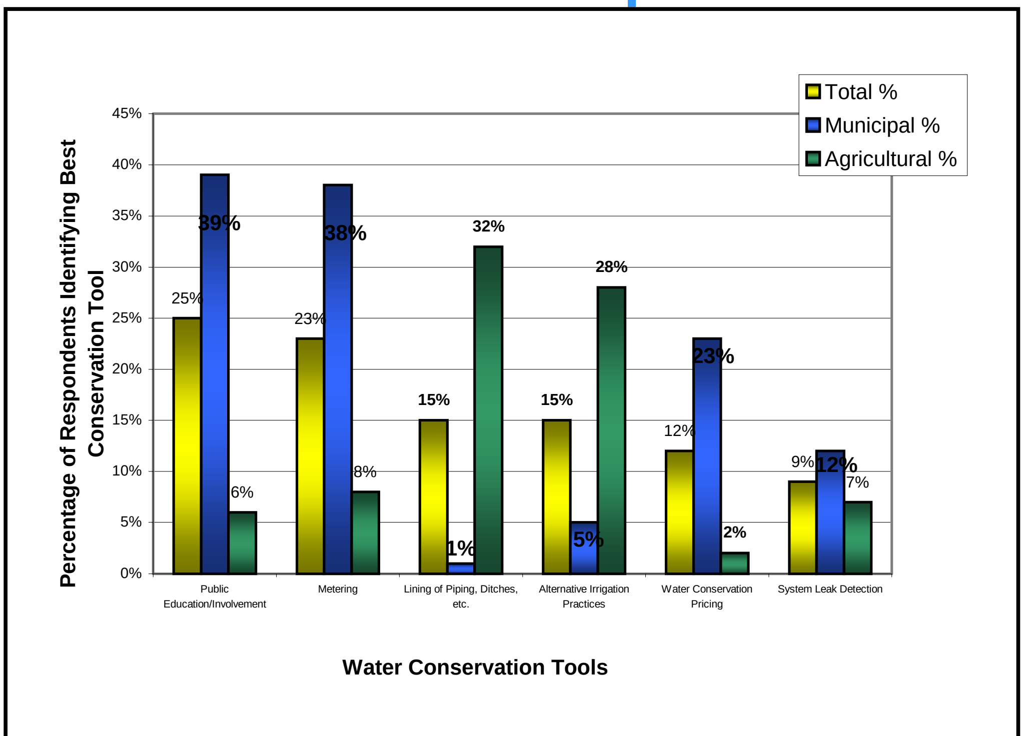
Figure 12-6: Tools Used for Water Conservation in Colorado



These differences clearly reflect the differences in end water use and infrastructure needs between the agricultural and municipal segments. Figure 12-7 further emphasizes the difference between these two water user segments illustrating that there is nearly no agreement between municipalities and agriculture with respect to the best water conservation tools – with the possible exception of system leak detection.

When looking individually at other segments and divisions, a few noteworthy ratings appear. Federal lends the strongest support of any segment or division to public education (86%), strikingly contrasted with 7% for metering, the top rated water conservation tool overall. Power, on the other hand, offers no support (0%) to public education, but rates the use of recycled water the highest (leading all segments and divisions by about thirty percentage points) at 80% support. Neither federal nor power articulated any support (0%) for water conservation pricing. The State offered the only majority support (56%) by segment and division to xeriscape promotions. The State's strong support of public education was also near the 80% level. Among segments/divisions, Division 2 gave the highest single tool rating garnered in the entire assessment – to metering, with almost 90% voting in favor. Division 1 provided the second highest metering rating at 72%. On the other hand, even a simple majority in Divisions 3, 4, and 6 did not support metering. All divisions, except Division 6 (32%), supported public information and education in the majority. Interestingly, Division 6 supported not one conservation tool at the majority level.

Figure 12-7: Best Water Conservation Tools



The best water conservation tools seem to have one trait in common with the best drought management tools: the choices are as varied as the number of divisions and types of water use segment across Colorado. With respect to water conservation tools, public education and metering were virtually tied with the highest score. These same tools received scant ratings from the agricultural segment where the lining of piping, ditches or canals was the most popular tool, closely followed by alternative irrigation practices. The other segment split the vote with the agricultural and municipal segments by giving the highest ratings to alternative irrigation (29%) and the next highest to public education (24%). Although public education ranked as the best tool overall, it received only a quarter of first place votes, assisted by the Water Conservation District (42%) and federal (36%) segments. The use of recycled water emerged as industry's best tool and was the most popular tool for the power segment. The State's votes were so varied that a best tool could not be identified.

Table 12-2: Best Water Conservation Tools in Order of Preference

Agriculture	Municipal
Lining of ditches and canals	Public information and education
Alternative irrigation practices	Metering
Use of recycled water	Water conservation pricing
Conjunctive use	Distribution/Conveyance system leak detection
Sectioning of canals and ditches	New subdivision platting and covenant requirements
Metering	Xeriscape promotions

Table 12-2 summarizes the similarities and differences between the best conservation tools as identified by the agricultural and municipal segments.

The "best" tool also varied by division and segment with the most popular tools identified for water conservation shown in Tables 12-3 and 12-4.

Clearly, water users employ a wide range of planning tools and programs. What seems to be effective for one water user may not be the best for another. The varying methods used by the municipal and agricultural segments alone accentuate the outlook that a multi-faceted approach is necessary to carry out the needs of water planning and management.

Table 12-3 Best Tools by Division

Division 1
Public Information and Education (29%)
Division 2
Metering (35%)
Division 3
Public Information and Education (48%)
Division 4
Lining of Piping, Ditches or Canals (22%)
Division 5
Metering (29%)
Division 6
Alternative Irrigation Practices (23%)
Division 7
Public Information and Education (28%)

Discussion

Planning

More than one-half of Colorado's municipalities have some kind of water supply, drought management, or water conservation plan in place. In addition, for those with plans:

- Seven of every ten have formal drought-related communications protocols and procedures.
- Six of every ten have formal levels and triggers for drought.
- Roughly two-thirds have mechanisms to declare drought.

Unfortunately, nearly one-half of Colorado's municipalities do not have any formal water planning in place.

A summary of other relevant observations includes:

- One in four agricultural entities have formal water planning in place.
- One in six (or fewer) agricultural entities have formal drought response in place (including defined levels and triggers, declaration protocols or procedures and/or communications).
- One in five state entities has formal water planning in place.

Drought Management

The municipal and agricultural segments differ widely with respect to drought preparedness and approaches to managing drought. Some positive findings related to the use of drought management tools by the municipal and agricultural segments are:

- Three of every four municipalities with plans have watering restrictions, water fines, and public education and involvement programs in place – all of which are considered to be effective drought management tools.
- Water conservation is not found by municipalities to be effective for drought management – which is appropriate since drought management requires short-term responses to water scarcity versus the long-term water supply and demand controls typically related to municipal water conservation.
- The agricultural water user community with plans relies on water conservation and cooperative agreements to manage drought. The implementation of short-term water "conservation" methods such as changing irrigation methods or planting schemes that will not adversely impact water rights or long-term return flows were found to be effective.

Some other findings with respect to the use of drought management tools by the municipal and agricultural segments are:

- Other water conservation measures that the agricultural segment may rely on such as lining ditches, etc. are long-term water conservation methods that may not be effective in managing drought.

Table 12-4 Best Tools by Segment

Municipal
Public Information and Education
Agriculture
Lining of Ditches and Canals
Power
Use of Recycled Water
Industry
Use of Recycled Water
Water Conservancy District
Public Information and Education
Federal
Public Information and Education
State
Various
Other
Alternative Irrigation Practices

- Less than one in six agricultural entities have formal drought management tools in place.
- Less than one in two municipalities has coordinated drought management tools.

There are a few other relevant issues to identify when reviewing the overall drought management tools. In particular, there are a number of "lesser used" drought management tools that are of critical importance to some water users. These lesser used tools include:

- Emergency water supplies.
- Aquifer storage and recovery systems (for sustainable groundwater pumping).
- Cloud seeding.

Water Conservation

As with the other planning issues, significant differences exist between the two key water user segments (municipal and agricultural) with respect to their use of water conservation and the respective effectiveness of specific water conservation tools. However, the differences are magnified between segments given that water conservation represents the long-term management of water supply and demand versus drought management, which tends to be effective over a short period of time.

- Municipalities strongly agree on the use and benefit of public education, metering, and system conveyance management, and to a lesser, albeit significant, extent alternative water pricing strategies.
- Agricultural water users agree (not as strongly) on the use and benefit of altering irrigation practices, and the lining of ditches, pipes and canals. Metering, conjunctive use and leak detection efforts were widely identified as tools but did not get wide support for effectiveness from the agricultural community.

Again, there are a limited number of entities with formal plans and therefore tools in place.

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Abstract
Nearly every business in every geography of Colorado was impacted by the 2000-2003 drought in one way or another. This chapter presents a summary of the impacts identified by Colorado's water users and the severity of the impact by both water use type and geographic region of the state as measured by the Drought & Water Supply Assessment.

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Impacts by Water Use

Impacts by Geography

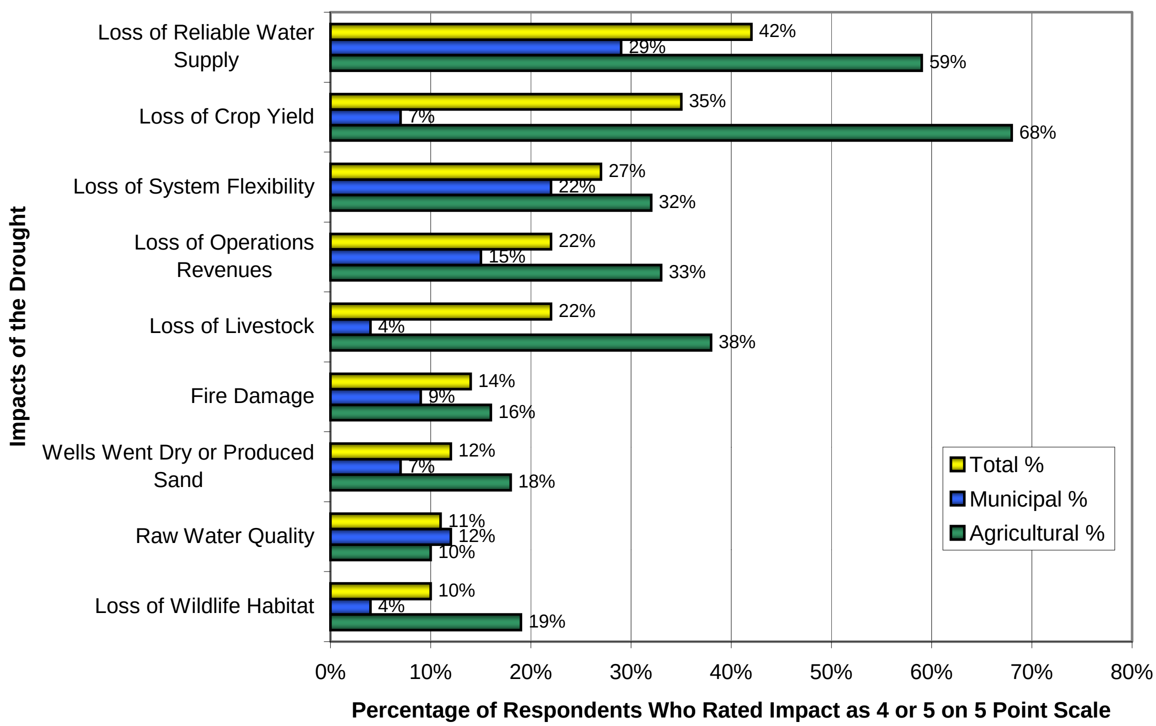
Discussion

Introduction
The severity and duration of drought conditions in Colorado over the past several years has had significant effects on water supply across all regions of the state, without sparing any particular type of water entity or organization. According to Colorado Water Conservation Board (CWCB) estimates, in 2002 Colorado experienced a $1.1 billion impact to agriculture, tourism, and recreation from the drought, related to diminishing crop yields, record low fishing license sales, municipal water restrictions, and other economic losses. These economic impacts will likely have long-term ramifications felt for years to come.

Impacts by Water Use
The assessment was designed to analyze specific types of drought impacts by type of water use and region to identify overall trends by water use and within the major river basins. As might be expected, the drought impacted each segment of water use, such as agricultural, municipal, or industrial, in both unique and common ways. The drought impact analysis of the assessment highlights notable differences between the agricultural and municipal segments, while all other segments (industry, federal, State, water conservancy districts, etc.) parallel overall results. Figure 13-1 illustrates the differences between the impacts to the agricultural and municipal water user segments.

Among agricultural respondents, loss of crop yield is viewed as the largest impact of the drought, with almost 70% of all respondents indicating a severe impact. Loss of reliable water supply followed closely behind, with about 60% severity rating with agricultural water users. Loss of livestock, loss of operations revenues, and loss of system flexibility were also cited by approximately one third or more respondents in the agricultural sector as severe impacts. The severity of the drought impacts was found to increase with the size of agricultural entity as indicated by irrigated acreage. The largest respondents, those that irrigate or provided irrigation water to more than 6,400 acres, rated impacts as more severe than their smaller counterparts.

Figure 13-1: Impacts of Drought on Colorado Water Entities (by Segment)



In the municipal segment, loss of reliable water supply and loss of system flexibility were flagged as the areas of greatest drought impact. As with the agricultural segment, larger municipal entities — those serving populations of more than 10,000 — rated impacts of drought consistently higher than did smaller municipal respondents.

When compared to their agricultural counterparts, significantly fewer municipal respondents rated any specific drought impact in the high 4 and 5 categories. As described above, five separate drought impact categories were cited by at least one third of agricultural entities with 4 and 5 impact ratings. In contrast, in no instance did one third of all municipal entities rate an impact area as being severe. Loss of reliable water supply was the closest with 29% naming this impact as significant. In fact, loss of reliable water supply topped the municipal segment's list of impacts with only 20% indicating a severe impact. In contrast, an overwhelming majority of agricultural respondents, almost 70%, indicated that loss of crop yield was a severe impact of drought. The agricultural sector, as a whole, rated the drought's impact as higher, or more significant, than municipal entities in the survey. Table 13-1 presents a summary of the reported impacts by water user type.

Table 13-1: Top Drought Impacts by Segment (in order of reported severity)

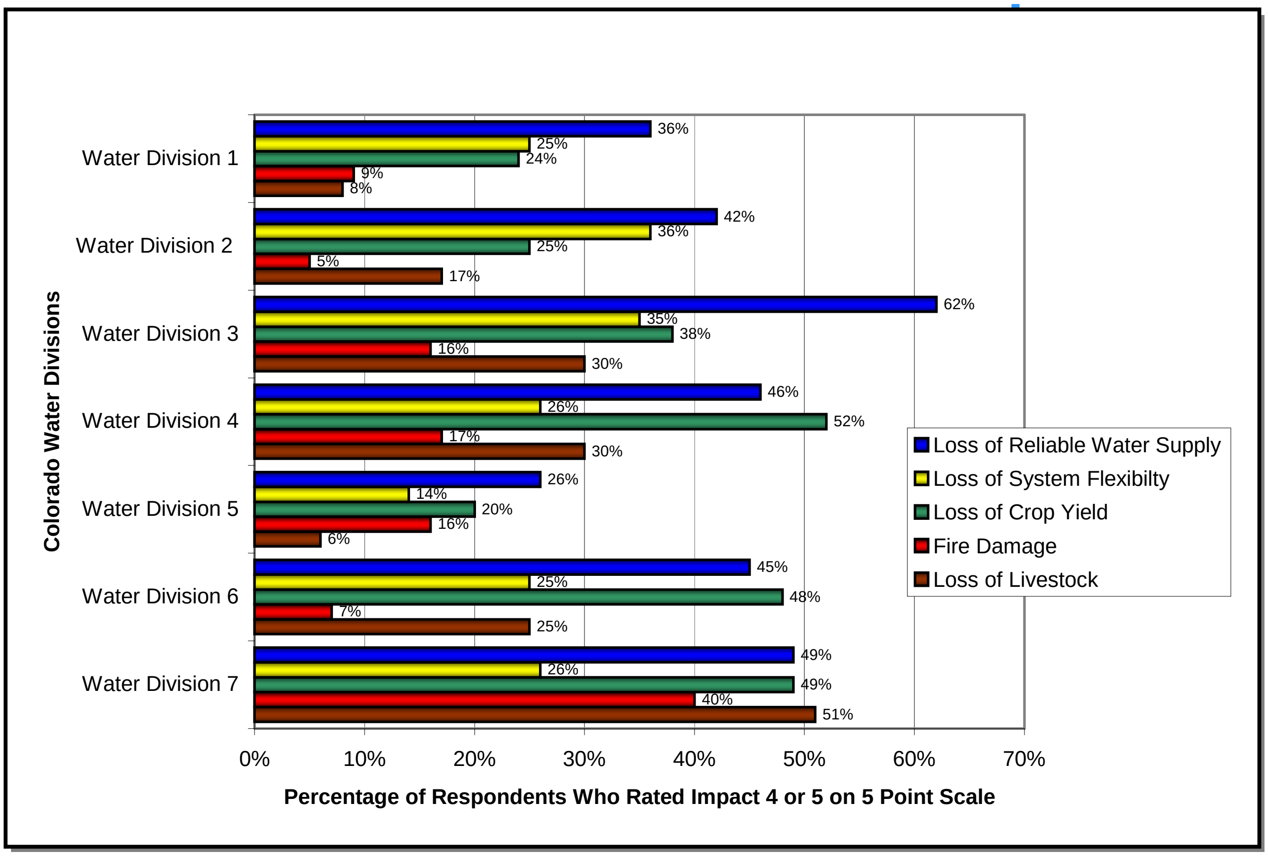
Segment	Impact and Percent of Respondents That Rated Impact as 4 – 5
Agricultural	Loss of crop yield (68%)
Water Conservancy District	Loss of livestock (67%) and Loss of crop yield (63%)
Federal	Fire damage (57%)
State	Loss of crop yield (55%)
Other	Loss of livestock (41%) and Loss of crop yield (41%)
Power	Loss of reliable water supply (40%)
Industry	Loss of system flexibility (38%)
Municipal	Loss of reliable water supply (29%)

Based on the results from all segments, it can be seen that municipalities and industry reported the least severe impacts by the drought, and that agricultural entities and water conservancy districts were the most severe impacts.

Impacts by Geography

Figure 13-2 presents the breakdown of reported drought impacts by major river basin. All the major river basins had severe drought impacts identified by the different water users; however, Divisions 3

Figure 13-2: Level of Specific Impacts of Drought on Water Divisions



and 7 had the most severe impacts reported. Division 3 had the single-most severe drought impact report – a report related to loss of reliable water supply with more than six out of ten entities indicating this as a severe impact. Divisions 1, 2, 4 and 5 also reported loss of reliable water supply as its most severe drought impact, but less than half of the water users in these divisions felt that the impact was severe. In fact, only one in four entities in Division 5 felt the impact related to the loss of reliable water supply was severe.

Division 3 also indicated a+ severe impact related to losses of system flexibility at a rate of about three and one-half in ten. Division 4 had the most severe loss of crop yield based on the number of respondents (over one-half) that indicated a severe impact; Division 7 had just less than one-half of its participants indicate a severe loss of crop yield.

Division 7 had the greatest number of participants that indicated a severe impact related to fire damage and livestock loss. In addition, Division 7 had the greatest total percentage of impacts with an average severity for all reported impacts of over 40%. Division 5, on the other hand, indicated the least severe impacts with an average impact severity of about 15%.

Discussion

Statewide and within each division, the agricultural water users and water conservancy districts reported the most severe impacts from the 2000-2003 drought followed by federal and state entities. About seven of every ten agricultural entities reported a severe impact to crop yield, and roughly the same rate was reported by water conservancy districts regarding the severity of impacts to livestock. Municipalities were affected, but much less severely, with the most significant impact being loss of reliable water supply, which severely impacted three out of every ten entities statewide. Two of every ten municipalities reported severe impacts to water system flexibility. The top five severe drought impacts reported are shown at right.

Top Five Severe Drought Impacts

Loss of reliable water supply
Loss of crop yield
Loss of livestock
Loss of system flexibility
Fire damage

For both municipal and agricultural water users, the larger entities (based on population served or irrigated acres, respectively) had the greatest severity of reported impacts.

Regionally, Division 7 followed by Division 3, were most severely impacted by the recent drought. Most divisions reported that loss of reliable water supply as the most widespread severe impact (with Division 3 reporting the most widespread with six out of ten entities from all water user types reporting an impact). Division 5 had the least reported impacts with just 15% of the entities, on average, indicating a severe drought impact related to the top five identified impacts.

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Contents:

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Abstract

This chapter presents summaries of Drought & Water Supply Assessment participant responses related to planning for future water supply. Participants were asked to rate their ability to predict and meet future water demands, acquire new ground water and/or surface water supplies, maintain and upgrade infrastructure, manage water quality, coordinate operations, utilize cooperative agreements, and develop and fund future water projects – for both the short- and long-term planning horizons. In addition, every participant was asked to rate the relative importance of each of these water supply planning and development activities with respect to their organization.

Introduction

Planning and managing for future water supply requires water users to bring together a diverse range of skills related to the prediction of water supply availability and water demand; the construction and maintenance of infrastructure to deliver, convey and distribute water; and the timely commitment of resources.

To better understand the future water supply planning needs of the water user community statewide, survey questions were developed to identify specific water user needs, the importance of the need, and the capability of the water user to meet the need. The specific set of potential water supply planning needs identified in the survey is presented in Table 14-1 at right.

Note that all survey participants were given the opportunity to identify other water supply planning needs beyond those listed in the survey. A discussion of the other needs identified by the survey participants is also included herein.

Table 14-1: Future Water Supply Planning Needs

Predict future average daily demand
Meet future average daily demand
Predict future peak daily demand
Meet demands with existing surface water supplies
Meet demands with existing ground water supplies
Acquire new surface water supplies
Acquire new ground water supplies
Detect and repair water system shrink or leakage
Manage water quality impacts on water supply
Find reliable/sustainable augmentation water
Implement future coop agreements to manage drought
Implement water re-use programs
Develop future water projects individually
Develop future water projects in a cooperative effort
Fund needed water development/infrastructure
Fund water supply maintenance and repair
Retain existing water rights over time
Implement conjunctive use programs
Meet environmental permitting requirements
Offset demand of growth through construction
Offset demand of growth through agricultural land conversion

Temporal Issues

Survey respondents were asked to rate their organization's need and capability with respect to various water planning issues, both in the short-term (defined as year 2010) and in the long-term (defined as year 2030). The survey also solicited ratings of the perceived importance of each issue in both periods.

The ratings of both capability and importance of water planning issues were remarkably similar for both time periods. Respondents who felt the topics were applicable consistently identified the same items as critical. In fact, only one category – future average daily demand - showed a significant difference in short and long-term ratings. Respondents were less confident in their ability to predict future average daily demand in the long-term (45% rated their ability as a 4 or 5 on the 5-point scale where 1 is not at all important and 5 is extremely important) as opposed to the short–term (56% with 4 or 5 ratings). Due to the level of consistency reported with respect to short- and long-term ratings, it was determined that there is little need to differentiate between the two periods; therefore, this chapter will address only short-term ratings, given that short- and long-term ratings are generally the same.

Future Water Planning Issues

Colorado water planners and managers from across the state are faced with similar challenges, independent of location. Table 14-2 summarizes the most important water planning issues identified by Colorado water users, and indicates the relative importance of the listed issue for municipal and agricultural users. Four of the five most important water planning issues relate to retaining adequate water rights or meeting future water demands either with existing surface water supplies or other supplies. Clearly meeting future water demands is a key concern for water planners and managers. Funding water supply projects, including both future water development and infrastructure, and maintenance and repair of existing and new water supply infrastructure, are also important issues challenging water planners, in that as Table 14-2 shows these issues are included as two of the top seven rated issues. Finally, infrastructure management, which will include monitoring of systems, evaluations and possibly capital projects related to system leakage and shrinkage, and water quality impacts, complete the list of the top eight issues.

Table 14-2: Priority Water Planning Issues for Municipal and Agricultural Segments

Water Planning Issue	Overall Importance*	Municipal Respondents	Agricultural Respondents
1. Retain Existing Water Rights Over Time	92%	92%	90%
2. Fund Water Supply Infrastructure Maintenance & Repair	83%	90%	76%
3. Meet Future Average Daily Demand	82%	88%	74%
4. Meet Demands with Existing Surface Water Supplies	81%	79%	77%
5. Meet Future Peak Daily Demand	79%	87%	67%
6. Detect and Repair Water System Shrink or Leakage	76%	86%	67%
7. Fund Needed Water Development & Infrastructure	74%	84%	65%
8. Manage Water Quality Impacts on Water Supply	70%	88%	47%

* Percentage of Respondents with 4 or 5 importance ratings on the 5-point scale

It is noteworthy that municipal and agricultural users throughout the state generally agree on the list of important water planning issues, and the order of importance of the issues; however, the agricultural community does not generally regard each of the issues to be as important as do the municipalities. This is perhaps indicative of the difference of the level of water supply planning incorporated into each of these water user segments and their cultures. Municipalities generate revenue selling water to customers and increasing their water user base. As a result, they have a revenue stream to apply toward planning. In contrast, agricultural entities are more often end-users that either pay for or at best do not generate revenue for their water, thus they have fewer resources to apply toward planning efforts. Agricultural entities may also be more dependent on direct flows that are less dependent on planning efforts than the complex systems of direct flows, transfers, leases and storage used by many municipalities to provide water to their customers.

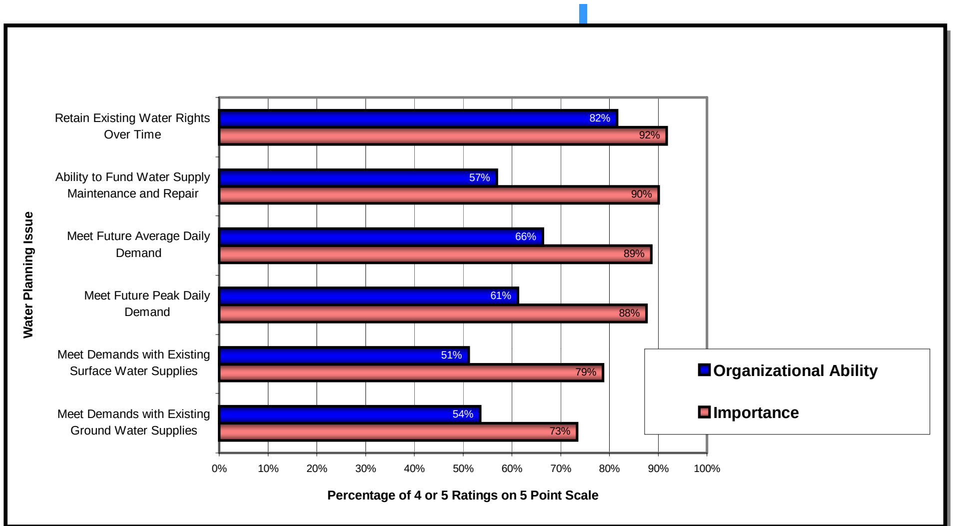
The water planning issues that were of significant importance to less than half of respondents included: implementation of water reuse, growth demand offset by agricultural land conversions, conjunctive use programs, and weather pattern prediction.

Current or Planned System Issues

Figures 14-1a Figure 14-1b present a comparison of a respondent's ability to address specific water planning issues related to their current system to the relative importance of that particular planning issue. For example, retaining existing water rights over time is important to 82% and 69% of the municipal and agricultural entities surveyed, respectively. Ninety two percent of municipalities rated their ability to retain existing water rights as a 4 or 5, whereas 90% of agricultural entities rated their ability to retain existing water rights as a 4 or 5.

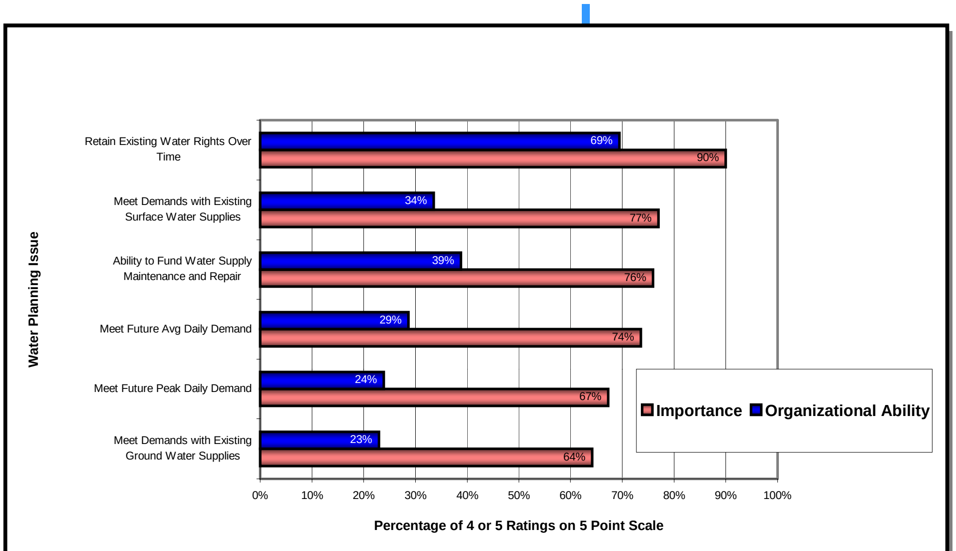
All of these water-planning issues, which focus on current or planned water supply systems and those systems ability to meet demands, earned very high importance ratings across all divisions and segments. However, some of the issues that were identified as of high importance were not rated as being addressed with commensurate abilities. For example, as discussed above, although almost all respondents believed that retaining existing water rights over time was extremely important, with only 10% strongly questioning their ability to retain those rights. To this point, State support is not necessarily needed to aid water users with water rights since water users believe their ability to perform or address this water planning issue is excellent. In contrast, the general ability to meet water demands, as well as the specific ability to address existing surface and ground water supplies, drew lower confidence ratings with no demand category garnering a rating of a 4 or 5 by more than 51% of respondents. (Notably, only 29% of agricultural respondents strongly believed in their ability to meet future average daily demand, while 66% of their municipal counterparts had high ability ratings in this category.) The State may very well have a role in providing technical, policy and financial support to water users that lack the ability to meet future water supply needs.

Figure 14-1a – Water Planning Issues – Current and Planned System Concerns for Municipalities



As pointed out previously, analysis revealed a marked difference in response between municipal and agricultural entities. While importance ratings were very similar, agricultural respondents consistently rated their ability to address water-planning issues lower than the municipal segment. In fact, only one out of twenty-three categories of future water supply planning issues (see Table 14-1), retaining existing water rights over time, drew an ability rating of a 4 or 5 from over half of all agricultural respondents; whereas the municipal entities indicated a similar level of ability in eleven of the twenty three categories.

Figure 14-1b – Water Planning Issues – Current and Planned System Concerns for Agricultural Entities

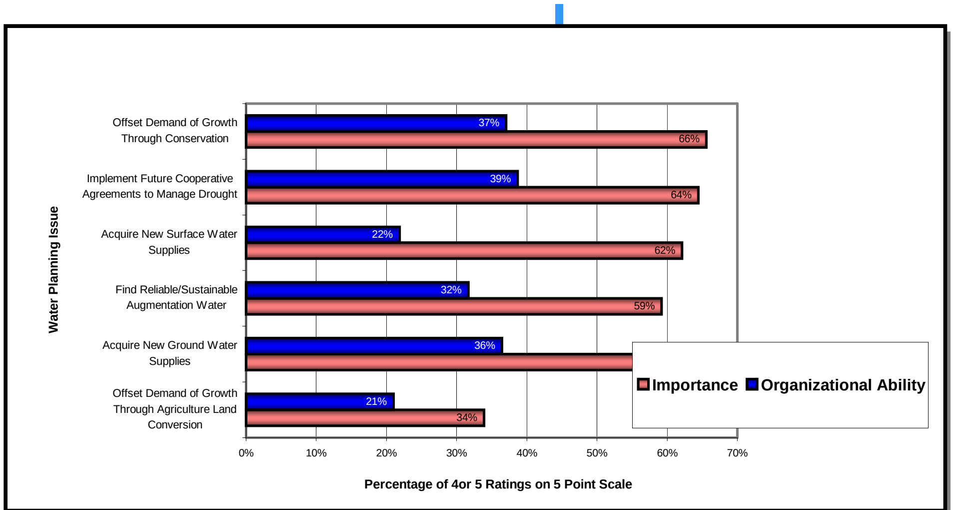


The significance of this difference may well point to the need for State support to provide technical and financial support to the agricultural community, insomuch as the agricultural water users demonstrate a need for planning but a general lack of ability to do so in various key areas.

Acquiring or Managing New Water Supplies

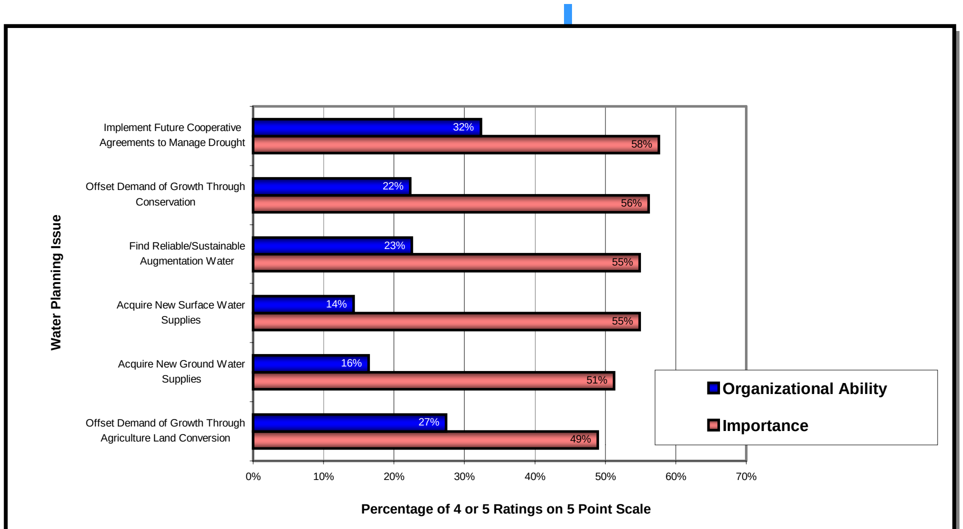
Figure 14-2a and Figure 14-2b provide a comparison of importance to ability for municipal and agricultural water users, respectively, related to acquiring or managing new water supplies. Included in this set of issues are acquiring new surface and groundwater supplies, implementing future cooperative agreements, finding and acquiring reliable augmentation water and use of agricultural land conversions.

Figure 14-2a – Water Planning Issues – Acquiring New Supplies for Municipalities



Not more than 40% of respondents expressed confidence in their ability to acquire or manage new water supplies based on the number of respondents that provided a rating of a 4 or 5, although the same respondents rated the need for new supplies as an important issue at more than 6 of every 10 water users. Acquiring new water supplies, including surface, ground and augmentation water, was noticeable in its low ability ratings as underscored by the low 4 or 5 showings. Only 18% rated ability to obtain new surface water as high; 27% cited the same for ground water, followed by 28% for augmentation water.

Figure 14-2b – Water Planning Issues – Acquiring New Supplies for Agricultural Entities



To this point, it appears that the State may have a role in providing technical and financial support to municipal and agricultural entities that need to expand their current water supply systems and/or acquire new water supplies.

Infrastructure

Apart from demanding that water organizations examine their ability to meet current and future demands, the drought has also highlighted various infrastructure needs related to both aging facilities and the related repair and maintenance costs. As presented in Figures 14-3a and Figure 14-3b, three infrastructure issues stood out as critical regarding organizational ability related to funding water supply maintenance and repair, detecting and repairing water system shrink or leakage, and funding needed water development and infrastructure. While approximately three-quarters of all respondents stated that these issues were important, no more than 54 percent of them rated their ability as a 4 or 5. In fact, less than 30% of respondents rated their ability to fund needed water development as high (i.e., as a 4 or 5).

Figure 14-3a – Water Planning Issues – Infrastructure for Municipalities

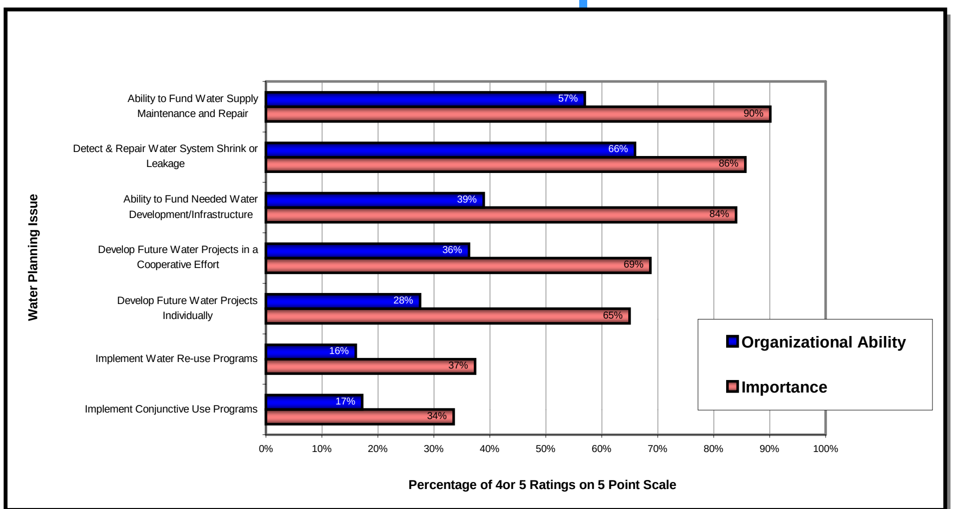
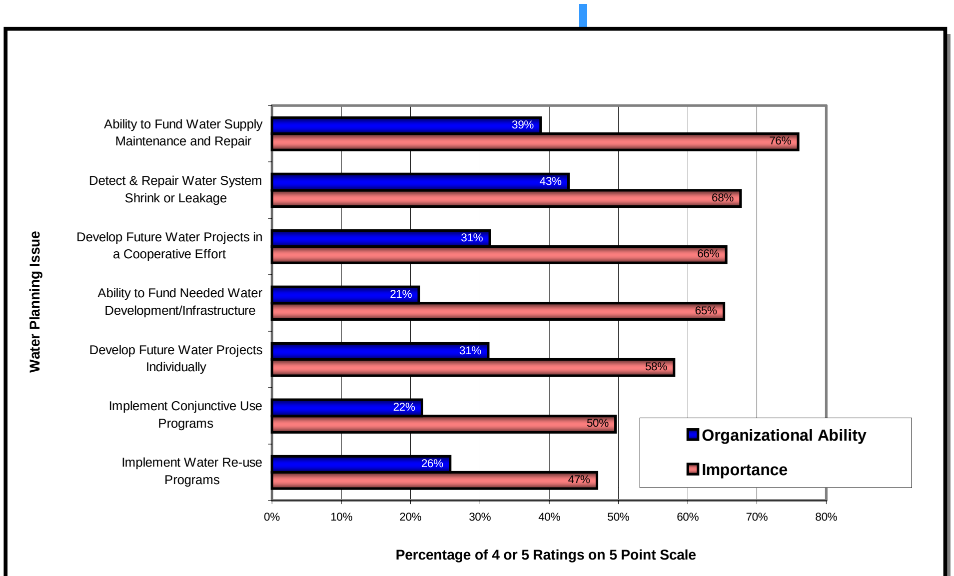


Figure 14-3b – Water Planning Issues – Infrastructure for Agricultural Entities



The top system infrastructure needs also highlighted acute differences between the municipal and agricultural sectors. While both segments viewed these issues as very important, ability ratings demonstrate that agriculture feels significantly less confident in addressing these issues.

Discussion
Table 14-3 presents the results of how all the other segments rated the relative importance of the various water supply planning issues, noting that only those issues receiving a rating of a 4 or 5 from at least 80% of the segment respondents are included in the table.

Table 14-3: Water Planning Issue by Segment other than Municipal and Agriculture

Most Important Water Planning Issue	Percentage Respondents Ranking Importance of 4 or 5*					
	Power	Federal	State	Water Conservancy District	Industry	Other
Retain existing water rights over time	100	91	89	100	100	100
Meet future average daily demand	100	80	--	87	94	--
Meet demands with existing surface water supplies	100	82	100	85	92	86
Meet future peak daily demand	80	--	88	--	93	--
Detect and repair system shrink or leakage	--	--	--	--	--	83
Fund needed water development and infrastructure	--	--	--	--	--	84
Manage water quality impacts on water supply	--	--	88	--	--	80
Predict future peak daily demand	100	--	--	--	--	--
Predict future average daily demand	80	80	--	--	--	--
Meet environmental permitting requirements	100	83	89	89	88	--
Offset demand of growth through agricultural land conversion	100	--	--	--	--	--
Ability to fund water supply maintenance and repair	80	--	--	--	92	84
Implement future cooperative agreements to manage drought	--	100	--	83	--	--

*Percentage of Respondents with 4 or 5 importance ratings on a 5-point scale
-- Did not rank at or above 80%

As Colorado attempts to mitigate the effect of current drought, a myriad of planning options face Colorado water providers. Resources must be allocated to address supply, demand and infrastructure issues. In order to establish priorities for water planning, not only must critical water issues be identified, but also the ability of water entities to address those issues in a beneficial manner must be gauged. Figure 14-4a and Figure 14-4b offers some insight into how priorities might be set by the State through the identification of a "confidence gap" – that is the difference between important planning issues and respondent ability to perform or address the issue. The "confidence gaps," illustrated in Figures 14-4a and 14-4b, are displayed in red and presented in order to draw attention to the difference between ratings of importance and corresponding ratings of ability. Large confidence gaps signify issues that may warrant the allocation of State resources.

Figure 14-4a: Concern over Colorado Water Planning Issues, Organizational Ability vs. Importance for Municipal Respondents

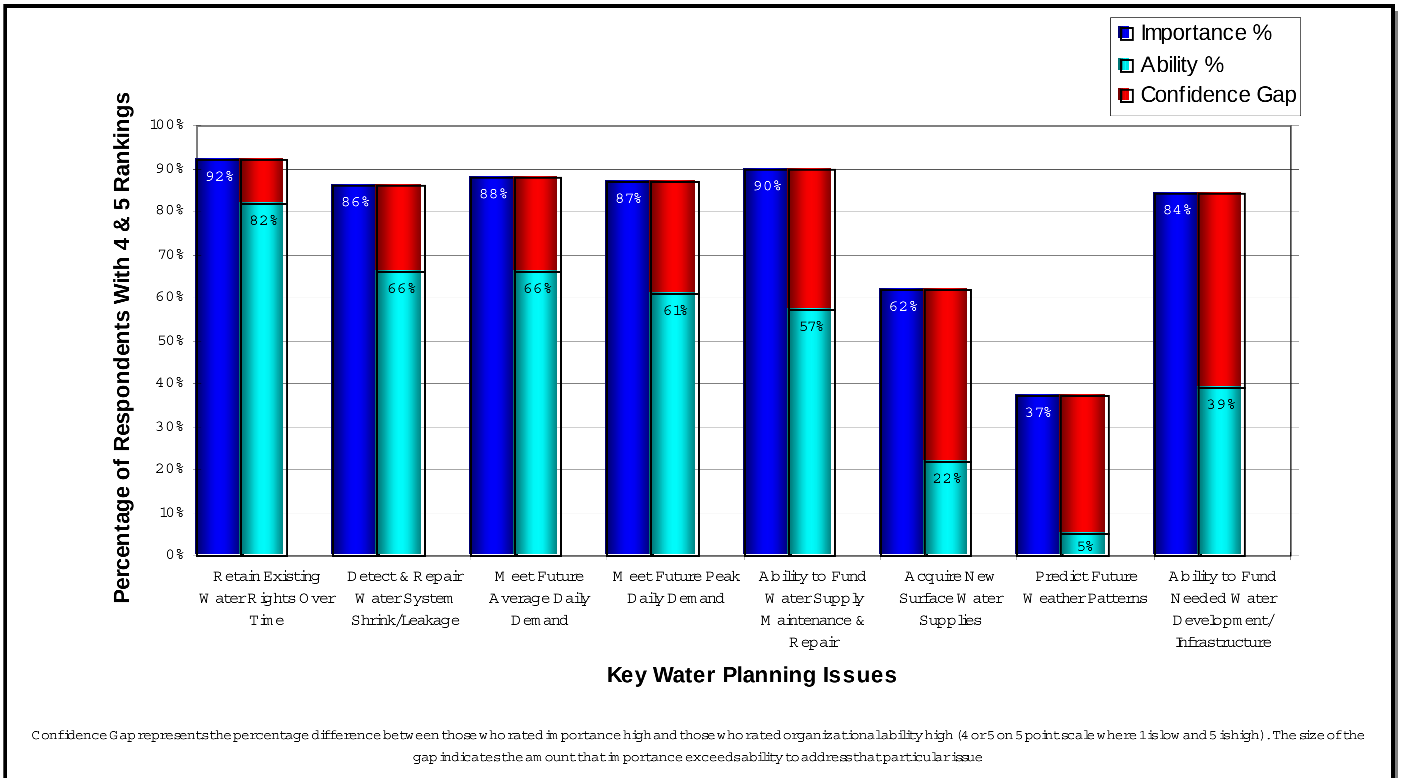
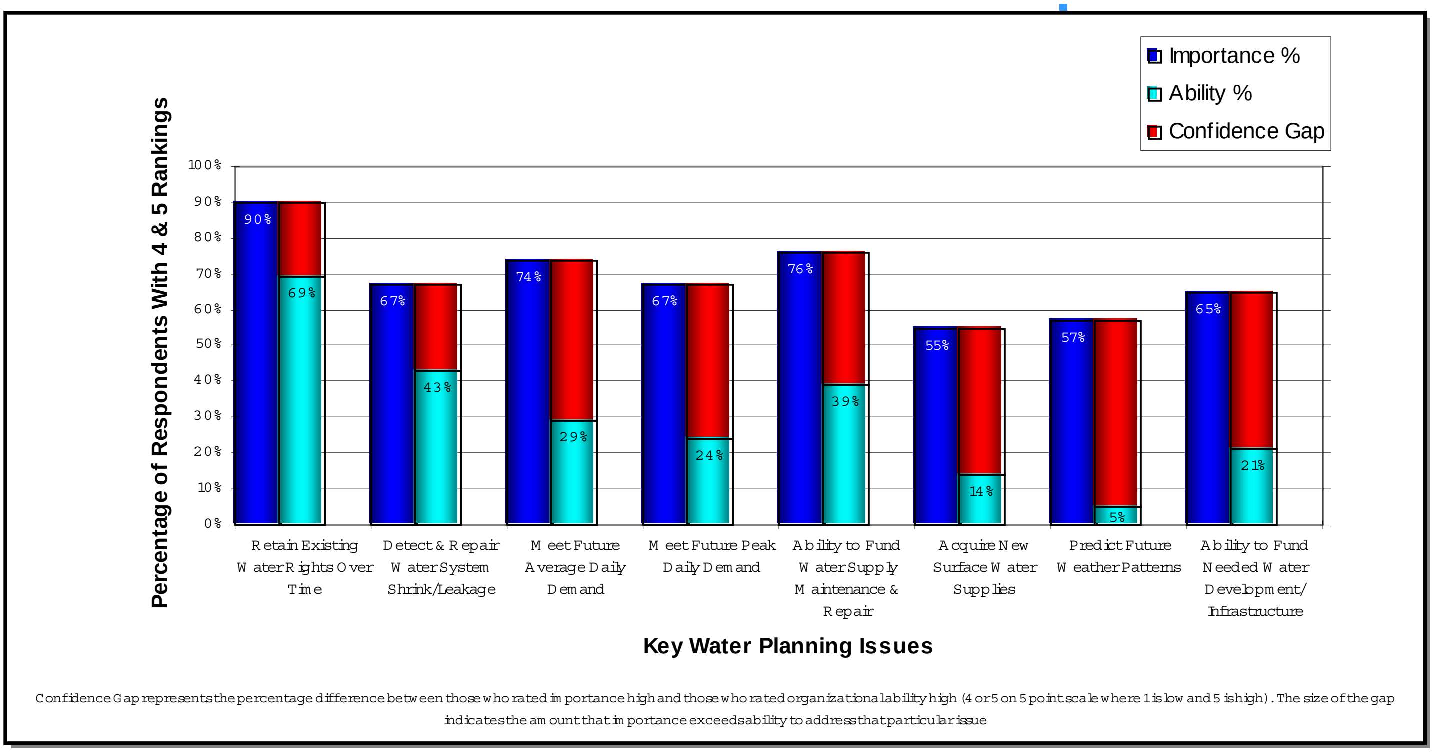


Figure 14-4b: Concern over Colorado Water Planning Issues, Organizational Ability vs. Importance for Agricultural Respondents



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Abstract
To provide useful assistance to the Colorado water community, it is necessary to know what drought mitigation projects the community has used and would prefer to use in the future, as well as the community's need for implementation support. Participants in the Drought & Water Supply Assessment identified structural and non-structural projects that may be used for mitigation of drought impacts on their individual water supplies. A list of potential structural projects for managing periods of low water availability included dam safety upgrades, reservoir dredging, storage systems (new or upgraded), delivery systems and multi-basin projects. Some of the non-structural projects examined by participants for drought mitigation included improved conservation methods, technical support for water planning, and the use of cooperative agreements. Participants were also asked to evaluate the desirability of State involvement in the planning and implementation of structural and non-structural projects.

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Structural Projects

Water Dollars

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Introduction

Colorado water users have indicated that they have:

- Limitations to their current water supplies,
- Limitations in their ability to plan for and manage future water supplies, and
- Suffered through the recent drought with various severe impacts to their operations.

They have also indicated that although additional drought and water conservation planning may be helpful in managing future droughts, additional and more efficient water supply is needed to support currently identified water needs, especially during periods of water scarcity.

With the knowledge and understanding of their individual limitations and impacts, Colorado water users were asked to identify the structural and non-structural projects that would best mitigate the impacts of drought for their particular situations. The water users surveyed were also asked to identify whether or not the state should have a role in the planning and/or implementation of any of the mitigation projects favored.

To ascertain water user preference related to structural and non-structural projects, candidate lists of projects were identified, as presented in Tables 15-1 and 15-2 for structural and non-structural projects, respectively. The survey participants then ranked the relative

Table 15-1: Structural Projects

Storage and water supply projects
Structural improvements or upgrades to meet dam safety requirements
Dredging existing reservoirs
Install and use water meters
Lining of ditches
New or deepened wells
New or improved aquifer storage recovery/conjunctive use programs/groundwater recharge
New raw water treatment facilities
New storage for groundwater
New storage for surface water
Transmission, conveyance, treatment and distribution projects
New or upgraded pump stations
New or upgraded pipelines
New or upgraded distribution systems
Rehabilitation of new diversion structures
Water reuse projects
Implement phreatophyte control
Large-scale and/or multi-basin cooperative projects
Forest management

need for each kind of project listed, plus any other project not on the list, based on a five point scale (with one indicating the lowest need and five the highest). Finally, for the structural projects, each participant was asked to spend five "water dollars" in any way they chose on those projects they considered to be most needed or desirable (i.e. one dollar on five different projects, or five dollars on one project, or anything in between). The allocation of water dollars to structural projects allowed the differentiation of true water user need from mere interest.

Structural Projects
Structural projects, as indicated in Table 15-1, can be lumped into two key groupings: storage and water supply projects; and transmission, conveyance, treatment and distribution projects. Table 15-3 lists the seven most needed structural projects as identified by Colorado water users, plus the level of support indicated overall by all of the segments and by the municipal and agricultural segments, individually, for the projects.

Table 15-3: Need for Structural Projects

Type of Project	Overall Need	Municipal Need	Agricultural Need
New storage for surface water	40%	31%	51%
Large-scale/multi-basin projects	24%	25%	27%
New aquifer storage recovery	21%	21%	22%
New storage for groundwater	19%	23%	16%
New or Upgraded Pipelines	33%	41%	26%
New or Upgraded Water Distribution Systems	33%	34%	34%
Lining of Ditches and Canals	19%	5%	35%

(%) Need displayed represents ratings of 4 or 5 on a 5-point scale.

As this table indicates, 40% of all segments indicated a need for new storage for drought mitigation. This response had the highest overall ranking of the seven projects listed. Various infrastructure projects related to new or upgraded pipelines, and new or upgraded water distribution systems, followed closely with one out of three water users supporting them. Large-scale/multi-basin projects received the support of one out of every four water users.

Table 15-2: Non-Structural Projects

Improved education and awareness of the public with respect to water, water supply and water supply planning
Improved or enhanced water conservation methods and measurement techniques (municipal or agricultural)
Technical support in master planning for future water supply and demand
Technical support in drought and conservation planning (hydrologic studies, water rights studies)
Use of cooperative agreements for each of the following: exchanges, transfers, substitute water supply plans, interruptible supply plans, dry year leases, other leases, operating agreements, water banking, water conservation easement
Need for financing of large-scale or multi-basin cooperative projects, using the same 5-point scale
Organizational loans for: project evaluation/feasibility studies, planning, capital projects

Notably, more than half of all agricultural respondents articultated a significant need for new surface water storage. Also noteworthy was the high support (58% rated a need of 4 or 5) by the Water Conservation District segment as well as the other[1] segment for storage; these statistics are combined with the remaining segments and included in the "Overall Need" column in Table 15-3. All water divisions, with the exception of Division 3, demonstrated high need ratings for storage when compared to other structural projects. Respondents in Division 3 rated projects involving new or upgraded pipelines, the installation of water-use meters, and new or deepened wells at approximately the same rating as storage. The project that garnered the highest need ratings in Division 3 was new aquifer storage recovery – a reflection of the unique physical setting of Division 3.

Survey results also demonstrate the widespread need for infrastructure projects that address water transmission and delivery efficiency. Municipal organizations expressed strong support for new or upgraded pipelines and new or upgraded water distribution systems. Agricultural respondents indicated their preference for the lining of ditched and canals, and new or upgraded water distribution systems.

The State segment rated overall need for new or upgraded pipelines the highest of any segment with 55% rating the need as a 4 or 5. New or upgraded water distribution systems received strong support from the State segment as well, with 44% providing high ratings; however, the other segment rated this the highest of any segment or division, with almost 60% indicating extreme or urgent need. Finally, for the lining of ditches and canals, the State and "other" segments again had higher ratings than most other segments, closely following agriculture at 33% and 32% respectively.

As is the case in most parts of the assessment, differences between the municipal and agricultural segments are apparent when looking at the need for structural water projects. Table 15-4 illustrates both common and different priorities, in order of importance, between these two major segments.

Table 15-5 summarizes the need for structural projects as indicated by each segment other than the two key segments listed in Table 15-4.

[1] Other entities: a collection of twenty-three entities, ranging from tribes, to home owners associations (HOA's), etc., not fitting into any of the other described entities of Federal, State, Agriculture, Municipal, Power, Industry, or Water Conservation Districts.

Table 15-4: Most Needed Structural Water Projects (in rank order*) for Muncipal and Agriculutral Segments

Municipal Segment	Agricultural Segment
1. New or Upgraded Pipelines (41%)	1. New Storage for Surface Water (51%)
2. New or Upgraded Water Distribution Systems (34%)	2. Lining of Ditches (35%)
3. New Storage for Surface Water (31%)	3. Rehabilitation or New Diversion Structures (34%)
4. New or Deepened Wells (27%)	4. New or Upgraded Water Distribution Systems (34%)
5. New Water Treatment Facilities (26%)	5. Large-Scale/ Multi-Basin Projects (27%)
6. Install and Use Water Meters (26%)	6. Forest Management (27%)

* By percentage of respondents who rated need as a 4 or 5 on a 5-point scale

Table 15-5: Most Needed Structural Water Projects (in rank order*) for All Other Segments

Power Segment
New Storage for Ground Water/Aquifer Storage Recovery (40%)
Federal Segment
New Storage for Ground Water/Aquifer Storage Recovery (64%)
State Segment
New or Upgraded Pump Stations (55%) Large-Scale/ Multi-Basin Cooperative Projects (55%)
Water Conservancy District Segment
New Storage for Ground Water/Aquifer Storage Recovery (59%) New Water Treatment Facilities (58%)
Industrial Segment
Install and Use Water Meters (54%)
Other Segments (largely counties, with tribes and farm bureaus)
New Storage for Surface Water (63%) Large-Scale/ Multi-Basin Cooperative Projects (59%)

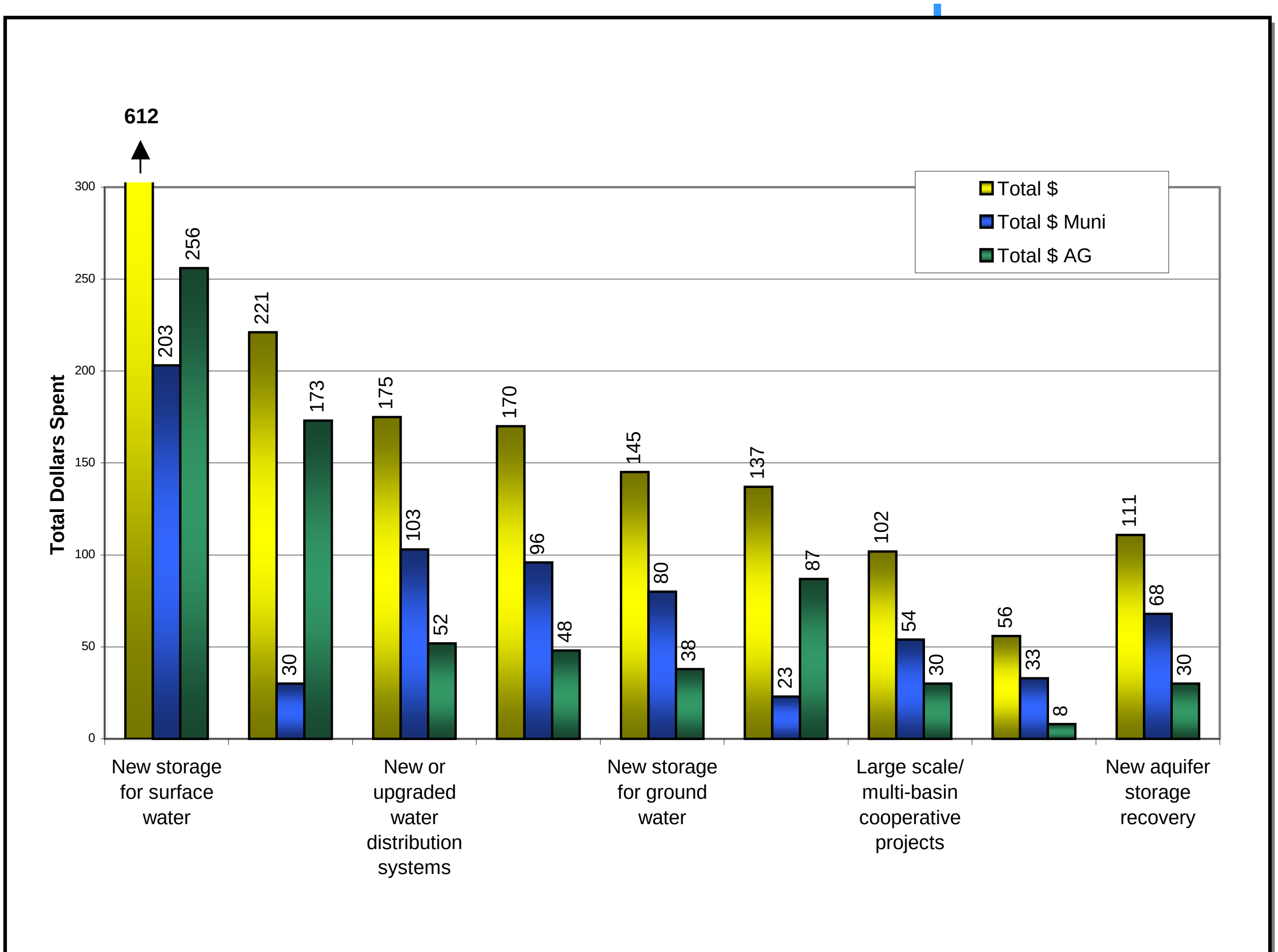
* By percentage of respondents who rated need as a 4 or 5 on a 5-point scale

Water Dollars

In the final analysis, water users surveyed identified a significant number of structural projects that receive general support without clearly identified preferred projects with the possible exception of the agricultural segment that identified the need for storage. A large set of projects was supported by 25 to 35 percent of the various water user segments.

When water users spent their "water dollars," the differences between support for different structural projects were amplified as presented in Figure 15-1. Water users overwhelmingly spent their allocation of water dollars on new surface water storage. In addition, the support for new storage was broad-based and consistent across all divisions and segments.

Figure 15-1: Priority of Structural Projects Based on Expended "Water Dollars"



The differences in water user segment support for various types of structural projects are illustrated by the support of the agricultural and municipal segments for projects other than new storage. Table 15-6 presents the breakdown of the support for each structural project type. The differences illustrate that although water users from all segments have needs for transmission and distribution system improvements, each water user type operates systems comprised of significantly different components.

Table 15-6: Percent of Overall Support (by Segment) for Structural Projects Based on Water Dollars Spent

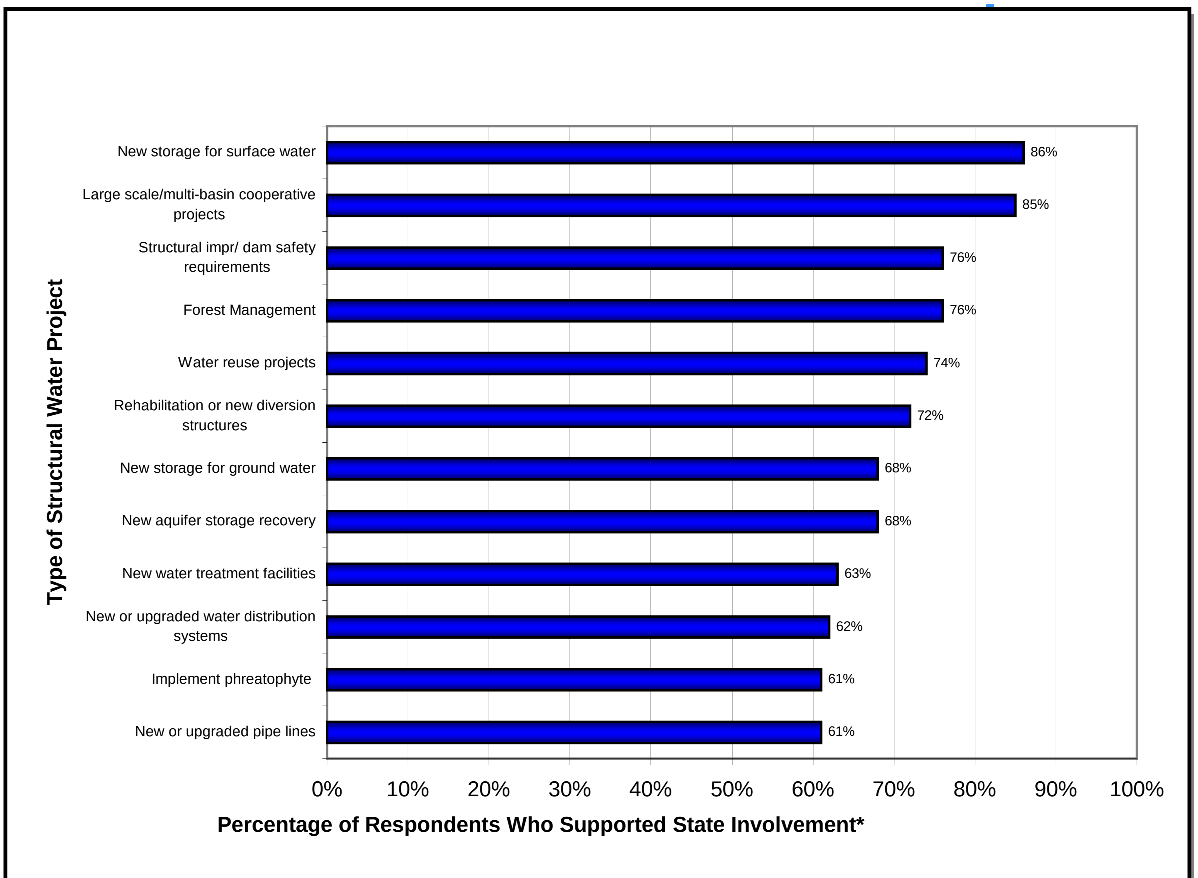
Project (total dollars spent)	Agriculture	Municipal	All Other Segments
Storage			
Surface water (612)	42	33	25
Groundwater (256)	27	58	15
New Transmission and Distribution Infrastructure			
Lining Ditches (221)	78	14	8
Distribution (175)	30	59	11
Pipelines (170)	28	56	16
Other Infrastructure			
Diversion Structures (137)	64	17	19
Large-scale Multi-basin (102)	29	53	18
Water Reuse (56)	14	59	27

State Involvement

The assessment also explored support for State involvement in structural water projects. About three out of four respondents indicated that they would like to see the State involved in structural projects at varying levels of interest. From those that indicated overall support for State involvement, opinions about State contributions to specific projects was also gathered, with strong overall support. Only two project categories - new or deepening wells and installing water use meters – received support from less than half of all respondents regarding State participation (with 4 or 5 ratings on a 5-point scale). The development of new storage for surface water emerged as the area where the most respondents, almost nine out of ten, preferred State involvement. Figure 15-2 details respondent encouragement (at 61% or higher) for State involvement in various water projects.

Support for State involvement varied according to the project priority of the segment or division responding. For example, the agricultural community expressed stronger support than any other segment for State involvement in projects that improved the lining of ditches. Municipal respondents, on the other hand, supported a strong State role in the development of new raw water treatment facilities, a project that serves the municipal segment more than any other. As might be expected, new storage for surface water led all categories and enjoyed widespread support from all divisions and segments. It is clear that Colorado water users would like the State to participate in these areas.

Figure 15-2: Support for State Involvement in Structural Water Projects



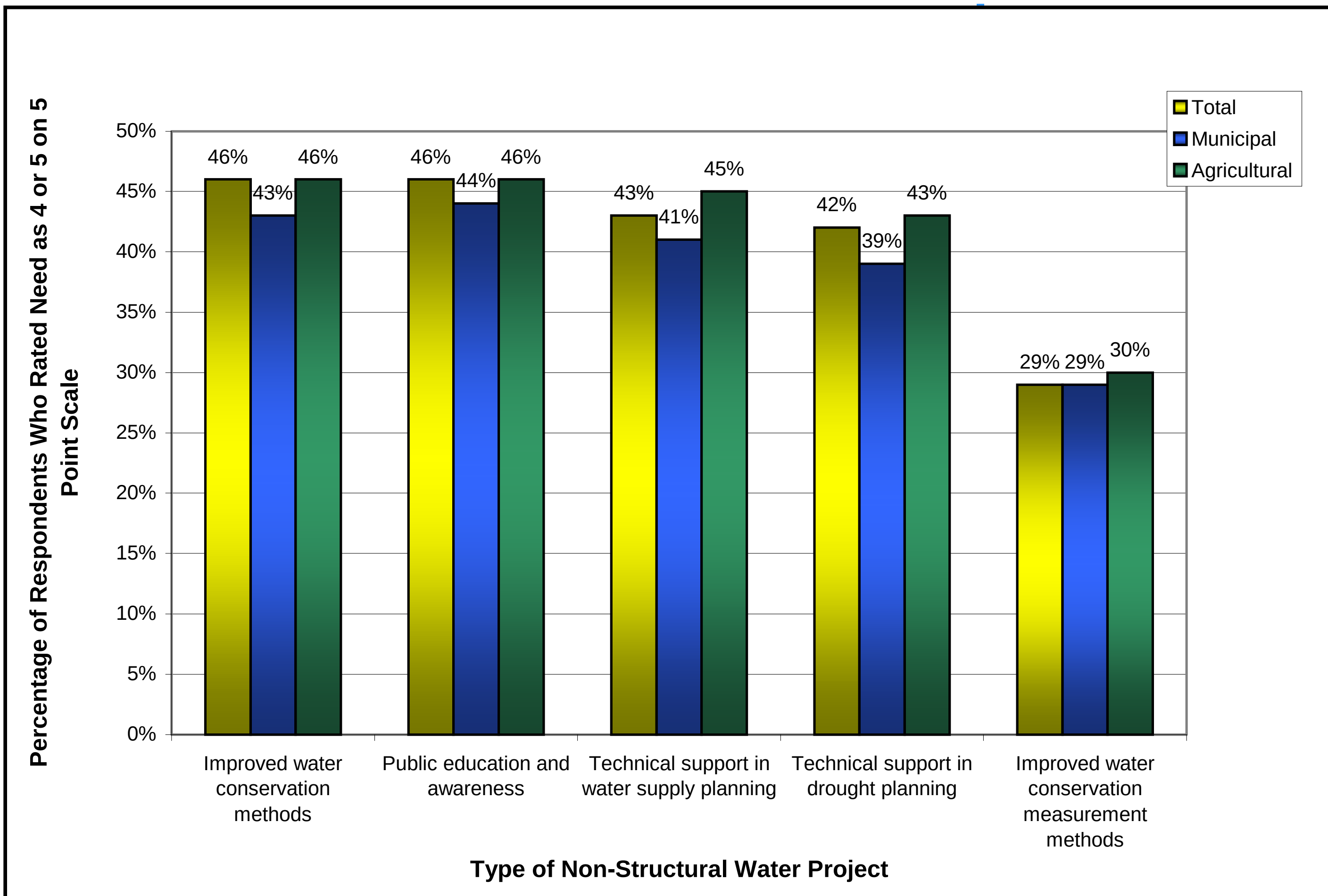
* represents percent support of those respondents that indicated interest that state should have some involvement in structural projects (about 2 of every 3 survey participants)

Non-Structural Projects

Among non-structural projects, survey respondents expressed even greater need, as well as almost unanimous support, for State interaction. The need for most non-structural projects was relatively consistent with slightly less than half of all respondents expressing a strong need for such projects with the exception of improved water conservation measures, which received significantly less support as indicated in Figure 15-3.

The consistency of support between the agricultural and municipal segments for non-structural projects is unique, given the normal lack of consistency between these two segments. Also worthy of note, the agricultural segment was as supportive as the municipal segment for projects such as public education and awareness. With respect to the remainder of respondents in both divisions and segments, ratings did not demonstrate significant differences with the exception of a few cases.

Figure 15-3: Need for Non-Structural Water Projects



The federal segment gave the two highest percentage ratings for non-structural projects of any division or segment: improved education and awareness of the public garnered a positive rating from over 85% of respondents; improved or enhanced water conservation methods rated high with 72% of respondents. For comparison, participants overall rated the need for both of these projects at the 46% level.

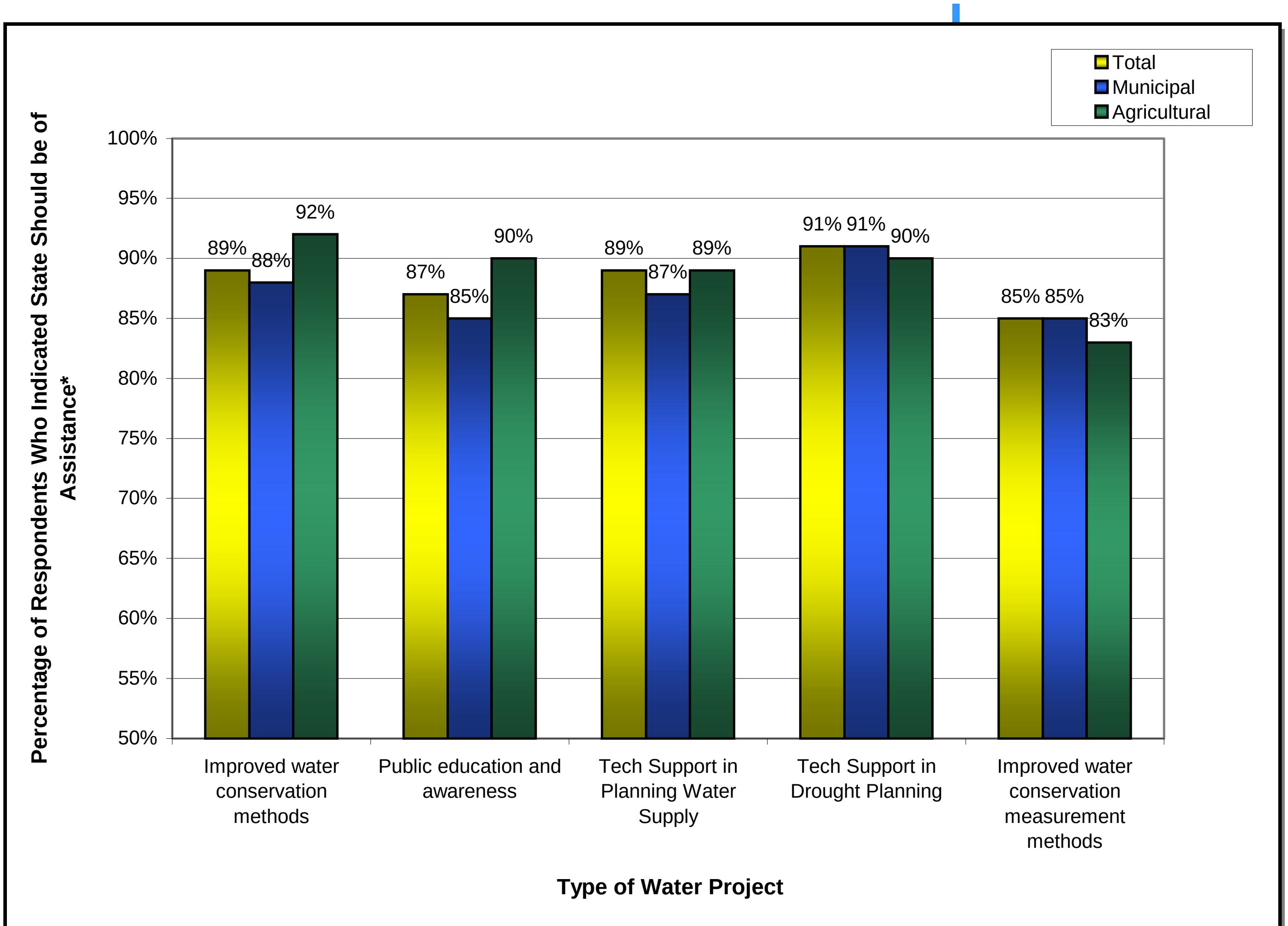
The most disparate ratings between divisions involved technical support in master planning for future water supply and demand. Responses ranged from the 25% level for Division 5 to a 62% level for Divison 3, and a 43% rating overall for all divisions combined. Also noteable were the consistently lower ratings of Division 5 for most non-structural projects.

Approximately two-thirds of respondents overall supported the State's participation in non-structural projects, as indicated in Figure

15-4. Among those two-thirds, nearly nine of ten respondents supported State involvement in the following types of projects:

- Improved water conservation methods
- Public education and awareness
- Technical support in planning water supply
- Technical support in drought planning

Figure 15-4: Support for State Involvement in Non-Structural Water Projects



* represents percent support of those respondents that indicated interest that state should have some involvement in structural projects (about 2 of every 3 survey participants)

Discussion

Water users across Colorado have indicated their broad-based support for structural and non-structural projects to mitigate drought impacts. More than half of agricultural water users strongly support development of new storage as do four out of ten water users. Water users also indicate support for:

- Additional groundwater storage and/or aquifer storage recovery (led by municipal interests)
- Lining of ditches and canals (led by agricultural interests)
- New or upgraded pipelines (led by municipal interests)
- New or upgraded water distribution systems (led by municipal interests)
- Rehabilitated or new diversion structures (led by agricultural interests)

One in four water users indicated strong support for large-scale/multi-basin cooperative water projects.

Four to five out of ten water users strongly support non-structural projects, including:

- Improved water conservation methods
- Public awareness and education
- Technical support in drought planning

Colorado water users also indicated their strong support of state involvement in both structural and non-structural projects. More than seven out of every ten water users that supported State involvement indicated their strong support for State involvement in:

- New storage for surface water
- Large-scale/multi-basin cooperative water projects
- Structural improvements to existing dams/dam safety requirements
- Forest management
- Water resuse projects
- Rehabilitation or new diversion structures

The desire for state support in structural projects was divided: those water user segments with entities needing or supporting the particular structural project were inclined to seek State support, while those water user segments that did not need or support specific structural projects did nor desire State support.

For non-structural projects, the desire for State support was indicated by well-over eight of every ten participants, independent of location or water user type. The non-structural projects that received the strongest call for State suppport included:

- Technical suport in drought planning
- Improved water conservation methods
- Public awareness and education
- Technical support in water supply planning

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Use of and Need for Cooperative Agreements

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Abstract
Colorado water users rely on the doctrine of prior appropriations to utilize and manage their collective water rights for beneficial use. This doctrine guarantees senior water rights holders their entire appropriation, regardless of whether this means flow is available for junior water right holders in times of water scarcity. While Colorado water law strictly defines access to water rights, water users have employed many types of agreements to distribute water in times of scarcity. Respondents to the Drought & Water Supply Assessment were surveyed to determine what cooperative agreements they use and /or need to manage water supply during drought.

Introduction

Colorado's water users rely on the doctrine of prior appropriations to utilize and manage their collective water rights for beneficial use. The "first in time, first in right" principle guarantees those with the most senior rights their entire right as long as there is water available in the system to meet it. More junior rights, therefore, can be "shut out" of water in times of water scarcity in order to protect the more senior rights from injury.

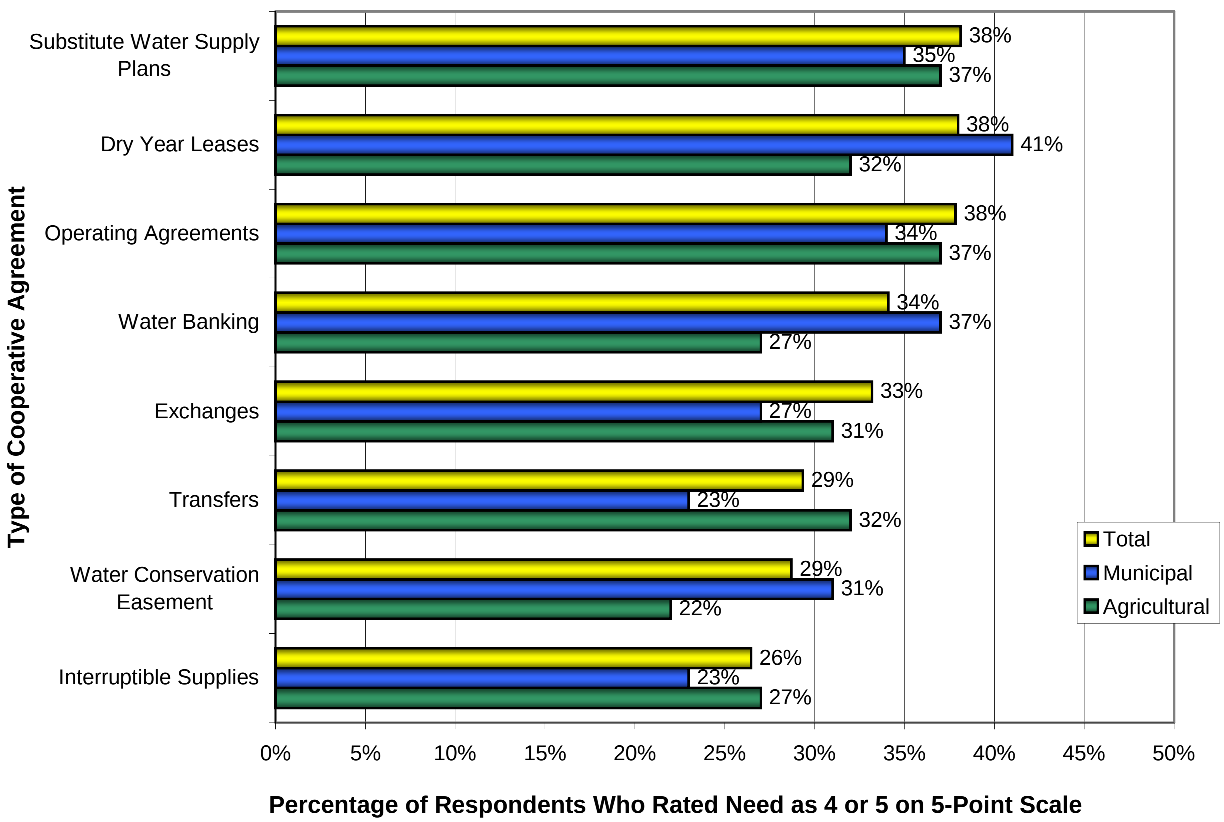
In the courtroom, this doctrine that protects the property rights of water users is inflexible and unyielding. In administration of the state's waters, this doctrine provides strict guidance and definition to the Office of the State Engineer State Engineer's Office (SEO). In practice, however, Colorado water users have repeatedly demonstrated their ability to cooperate with their neighbors and share this most valuable resource during times of water scarcity within the vigilant Colorado water laws. The Division 6 SEO representing the Yampa and White Rivers has not once had to administer water rights, which is a testament to the consistency of the streamflow in this region of the State, as well as the flexibility and cooperative nature of its water users.

There are in fact, many types of cooperative agreements that Colorado's water users have utilized or considered for implementation. The most prevalent cooperative agreements in use, or being evaluated for statewide use, are identified and defined in Table 16-1.

Use of and Need for Cooperative Agreements

This portion of the assessment asked Colorado's water users to identify the types of cooperative agreements that they need to support their operations. Figure 16-1 presents the listing of cooperative agreements that the survey participants were asked to rate, with an indication of the level of need or use for each type that they reported.

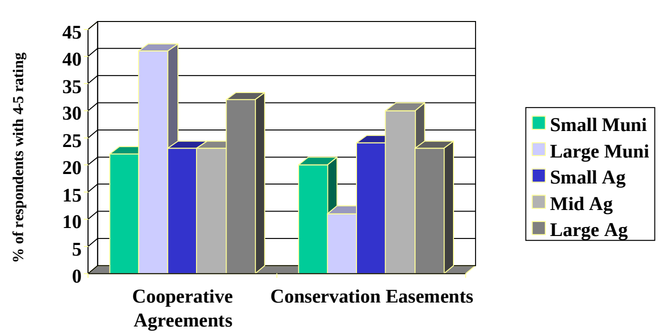
Figure 16-1: Need for Cooperative Agreements



It can be seen from this Figure 16-1 that a large number of Colorado water users rely on temporary methods to manage their water supplies – through either substitute supply plans (the most popular), dry year leases, water banking, and interruptible water supply plans. In addition, operating agreements and water transfers are used to manage water supply, which can be based on either temporary or permanent agreements.

As indicated in Figure 16-2, larger water users employ cooperative agreements more often than small users. In fact, over 40% of large municipalities (i.e. those larger than 10,000 in population)

Figure 16-2: Use of Cooperative Agreements and Conservation Easements



and over 30% of large agricultural entities (i.e. those with over 3,200 acres irrigated) utilize some form of cooperative agreement. It therefore appears that the larger water users either have more need or more resources to develop and use cooperative agreements. If smaller entities are not using cooperative agreements because they lack the resources to do so, then the state may want to evaluate the benefit of providing the needed resources to the smaller water users, both for municipal and agricultural applications.

Other issues that surfaced through the assessment and its analysis regarding the use of cooperative agreements are as follows:

- It would be valuable to evaluate the trend of the use of cooperative agreements to determine if the number of agreements is growing and whether or not that trend will continue.

Table 16-1: Summary of Prevalent Cooperative Agreements in Colorado

Permanent	Temporary	Type of Cooperative Agreement	Description/Definition
	✓	Dry Year Leases	Allows municipalities to buy (lease) water from farmers and ranchers during period of drought.
	✓	Interruptible Supplies	Allows cities to contract with agricultural water users for water in times of declared drought without having to permanently buy the water rights (which could "dry up" future agricultural uses).
	✓	Substitute Water Supply Plans	A "temporary" legal water supply administered by the SEO, prior to a Plan for Augmentation decreed in Water Court, that allows junior diverters to put to beneficial use an amount of water equivalent to the amount supplies in substitute water to a senior priority.
	✓	Water Banking	Water owners with surplus water deposit their excess supplies to be reimbursed as the bank leases the water to other users.
✓	✓	Operating Agreements	A business agreement between one or more entities that define operational cooperations, coordination, and/or any other agreed upon terms and conditions relating to shared or coordinated water use.
✓	✓	Transfers	Transfer of water, from one party with surplus water to another party with temporary or ongoing water needs.
✓		Augmentation Plan	A method for a junior divertor to obtain water supplies through terms and conditions approved by water court that protects senior water rights from depletions. Typically Augmentation Plans involve storing junior water when in priority and releasing the water when a senior call occurs, purchasing stored waters from federal entities or others to release when a call occurs, or purchasing senior irrigation water rights and changing the use of those rights (type, place or time of use, point of diversion, etc.) to off-set the junior users injury to the stream.
✓		Exchanges	A process by which water, under certain conditions, may be diverted out-of-priority at one point by replacing it with an equal quantity of water at another point.
✓		Water Conservation Easement	A legal, perpetual agreement, typically between a landowner and a government entity that contains permanent restrictions on water use.

- Cooperative agreements provide the short-term flexibility that many agricultural and municipal entities need to manage and mitigate drought. The state may need to look for methods to help promote their expanded use.

- The state may need to improve the cooperative agreement review and approval process to make it more accessible to water users, especially if the demand increases.

Discussion

Cooperative agreements play an important role in the management of Colorado's water supply. Five different types of cooperative agreements are used, or would be used, by at least one of three water users. Four of 10 large municipalities utilize cooperative agreements to manage their water supply, as do three of 10 agricultural water users. Cooperative agreements allow for system flexibility within the prior appropriations doctrine of the state, and as such support drought mitigation and management activities. The state may need to evaluate methods to improve the applicability and use of the cooperative agreements to increase their use, and address administrative issues, if any exist, that may limit small water users' from utilizing these important ,valuable and flexible tools.

One of the key reasons for the Colorado Water Conservation Board (CWCB) to perform the Drought & Water Supply Assessment project was to gain direct input into the development of state water policy, policy that relates to the allocation of state technical, administrative and financial resources. Given the historically contentious nature of water and water policy in not only in Colorado, but the Western U.S., and the ever-changing pressures on water conservation, development and use, it is appropriate to provide the reader with an historical, social, legal and technical framework within which to evaluate the results of the assessment. To this point, Section 1 provides a summary of a number of key issues that help to define and illustrate drought and water supply issues relevant to the development and implementation of this project.

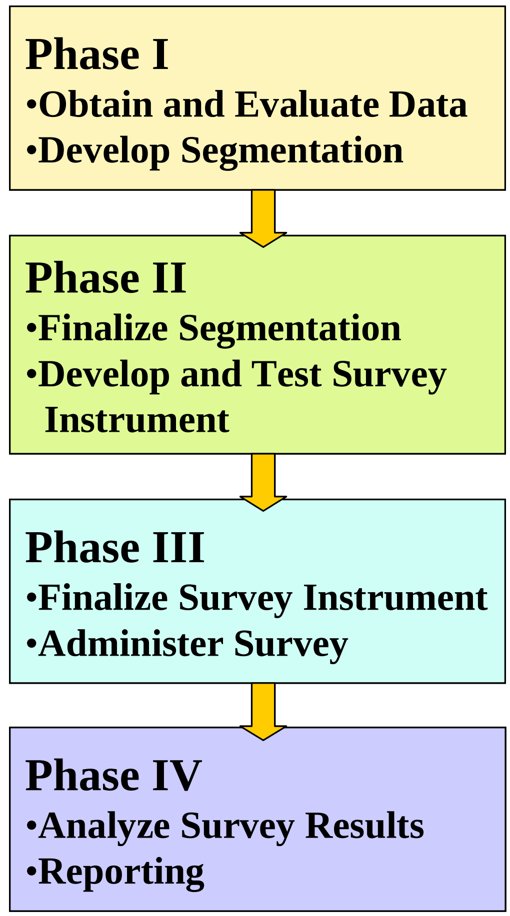
In its eight chapters, Section 1 will:

- Define drought and describe historical drought in Colorado.
- Present social perspectives on the current drought including those from irrigators, recreational users and landscaping businesses.
- Identify the State response to the current drought based on the work of the State's Drought and Water Availability Task Forces.
- Describe the State's population and demographic changes over the last 50 years and the predicted changes for the next 30 years.
- Define the legal frameworks at the federal, state and local levels within which drought and water supply management must occur, with a brief synopsis of local drought mitigation actions.
- Present information on past and current water storage characteristics for each major river basin.
- Identify the tools that are available to individual localities for mitigation of and response to drought.
- And finally, identify the types of structural and non-structural projects that entities can evaluate and implement as appropriate for managing periods of water scarcity—to increase water supply, improve water delivery, or reduce water demand.

The chapters that follow present information on these various issues in a condensed format for purposes of providing the reader with a synopsis of the subject matter. Reference lists are presented when available to provide the reader with additional sources of information for those situations when additional detail is desired.

Many opinions regarding drought and drought preparedness have been informally identified through the media and various state agencies – including state agencies that have worked on response and mitigation planning for drought. However, a thorough understanding of Colorado water users' opinions on drought preparedness, previous to this project, had yet to be compiled. To best establish statewide policy on drought-related water issues, the Colorado Water Conservation Board (CWCB) undertook the Drought & Water Supply Assessment as an exhaustive analysis of water users' opinions throughout the State with respect to drought, and limitations on current and future water supply.

The collection and evaluation of water use opinion data required the planning and implementation of a multi-phased approach to allow for the proper collection of available information, development and testing of an opinion instrument (i.e., survey), administration of the survey, and final analysis and interpretation of the survey results. The phases and their relations to one another are depicted in the figure at right.



The chapters that follow present a summary of the activities that were performed in each phase of the project and a detailed discussion of the opinion data results and implications with respect to future State water policy.

As previously indicated, the opinion data collection focused on determining how prepared Colorado is for drought and identifying drought mitigation measures that may help the State and its citizenry and businesses to be better prepared for future droughts. The specific opinion data collected addressed characterizing those key issues that water managers and planners throughout the State are facing with respect to the short- and long-term management of their water resources:

- Current limitations to water user water supply.
- Current status of water supply, drought and water conservation planning and implementation within each water user organization.
- Impacts observed from the most recent drought by the different.
- Water user needs for structural and non-structural projects to mitigate drought.
- Use of cooperative agreements to manage drought now and into the future.
- State role in future drought planning and mitigation efforts

The final chapter in this section summarizes the water user opinion data with respect to current and future State water policy.

Two issues must be noted with respect to the assessment. First, the results of individual water user surveys are held as confidential, between the surveyors and the survey participants. The intent of the assessment was to identify overall water user sentiment statewide, as well as by major river basin and water use type. Individual water use (defined by the amount diverted or stored) and storage data was collected from 55 to 67% survey participants (the percentage varies dependant on the water year as some entities did not have data available for all years); however, this information was used to determine the statistical significance of overall and regional responses, and to characterize the diversity of municipal and agricultural respondents. Individual water user responses will not be made available as a result of the Assessment.

Second, the opinion data represents Colorado's water users and as such does not necessarily represent voter sentiment or the opinions of the public at large. Nonetheless, the opinions reflected in the assessment results are indicative of how water users and providers throughout the State of Colorado perceive and understand key water resources issues at this time.

Colorado Drought & Water Supply Assessment

Q.1 First, please tell me which of the following best describes your organization:

Power……………..…1
Federal Agency 2
Agriculture (Irrigation/ Ditch or Reservoir)……… ……3
Municipal Water District, Utility, Dept, or Company …4
Intentionally Left Blank…..….. 5
State Agency 6
Intentionally Left Blank……..7
Water Conservancy or Water Conservation District.. 8
Industry.. 9
Other (e.g., Tribe, HOA, or County Govt) 10

Q.2 [AG ONLY] As you know, we've recently sent a postcard which requests numbers for average yearly water use or delivery. We realize that you're an agricultural entity, so before proceeding to those questions, we'd like to know if those are applicable questions or if we could instead look to information regarding your structures.

Structures are best ………………………………..1
I can answer water use or delivery questions….2

[If the answer is 2, skip to Q4]

Q.3 What are your structures? ____

Q.4 Approximately, what is your ***average yearly*** water use or delivery including raw water & treated water, as well as minimum stream flows or reserved water rights?
ENTER NUMBERS ONLY.

____

Q.5 What are the units typically used for this measurement:
1) Volume or acre-feet, 2) Flow or CFS (second feet or feet), 3) Gallons or 4) by Cubic Feet?

Volume or Acre Feet 1
Flow or CFS (second feet or feet) .. 2
Gallons 3
Cubic Feet 4

Q.6 ***If you have your postcard in front of you, you may refer to it for the following questions:***
Please, tell me the amount of total water use, including treated, raw, & delivered water, for each of the following years, beginning with 2002 and working backwards.

Q.7 For the year 2002 -- (What was the approximate amount of water use or delivery?) (ENTER NUMBERS ONLY.)

Q.8 Is that by Volume (acre feet) or Flow or CFS (second feet or feet) or Gallons or Cubic Feet?

Volume (acre feet) 1
Flow (CFS) (second feet or feet) ….2
Gallons 3
Cubic Feet 4

Q.9 For the year 2001 -- (What was the approximate amount of water use or delivery?) (ENTER NUMBERS ONLY.)

Q.10 Is that by Volume (acre feet) or Flow or CFS (second feet or feet) or Gallons or Cubic Feet?

Volume (acre feet) 1
Flow (CFS) (second feet or feet) .. 2
Gallons ……………………………….3
Cubic Feet 4

Q.11 For the year 2000 -- (What was the approximate amount of water use or delivery?) (ENTER NUMBERS ONLY.)

Q.12 Is that by Volume (acre feet) or Flow or CFS (second feet or feet) or Gallons or Cubic Feet?

Volume (acre feet) 1
Flow (CFS) (second feet or feet) .2
Gallons 3
Cubic Feet 4

Q.13 For the year 1999 -- (What was the approximate amount of water use or delivery?) (ENTER NUMBERS ONLY.)

Q.14 Is that by Volume (acre feet) or Flow or CFS (second feet or feet) or Gallons or Cubic Feet?

Volume (acre feet) 1
Flow (CFS) (second feet or feet) .. 2
Gallons 3
Cubic Feet 4

Q.15 For the year 1998 -- (What was the approximate amount of water use or delivery?) (ENTER NUMBERS ONLY.)

____

Q.16 Is that by Volume (acre feet) or Flow or CFS (second feet or feet) or Gallons or Cubic Feet?

Volume (acre feet) 1
Flow (CFS) (second feet or feet) .. 2
Gallons 3
Cubic Feet 4

Q.17 For the year 1977 -- (What was the approximate amount of water use or delivery?) (ENTER NUMBERS ONLY.)

____

Q.18 Is that by Volume (acre feet) or Flow or CFS (second feet or feet) or Gallons or Cubic Feet?

Volume (acre feet) 1
Flow (CFS) (second feet or feet)….2
Gallons 3
Cubic Feet 4

Q.19 In an average year, what is the approximate percentage of water you receive from the following sources, such that the percentage adds up to 100%?

[ANSWER MUST TOTAL 100]

In Basin Surface Water .... ______
Transbasin Surface Water .... ______
Groundwater .... ______
Reused Water (water from waste water treatment that's used) … ______

Q.20 In an average year, please tell me your primary water uses by approximate percentage such that the sum totals 100%.

For example, if your primary water uses were Irrigation & municipal, then I'd need to know if irrigation demanded 80% & municipal 20%, or if they were 50/50, etc.? Were essentially asking for a profile of your entire water resources. In other words, what's your water use & how much of each category is used?

[ANSWER MUST TOTAL 100]

Environmental/Instream Flow % ...... ______
Fire Protection % .... ______
Industrial / Commercial % .... ______
Irrigation % .... ______
Municipal (Multi-use/Multifamily) % .. ______
Recreational % .... ______
Stock Water % .... ______
Other % .... ______
Single-family Residential %.............. ______

Q.21 IF YOU CHOSE "OTHER" ABOVE IN Q.20, PLEASE RECORD THAT USE HERE:

____

Q.22 What percent of your water is consumptively used in an average year?
(FYI-This is water lost from the system.)
PERCENT OF WATER USED FOR CONSUMPTIVE USE/WATER LOST .. ______

Q.23 Looking to 2010, would you predict that the demand for water for you &/or your users will increase, decrease, or remain about the same?

Increase 1
Decrease ....…2
Stay about the same 3

[IF THE ANSWER TO QUESTION 23 IS 3, THEN SKIP TO Q.25]

Q.24 What would you estimate the percentage [increase/decrease] in demand to be?

1-10% 1
11-20% 2
21-30% 3
31-40% 4
41-50% 5
51-60% 6
61-70% 7
71-80% 8
81-90% 9
91%-100% 10
100-150% 11
151-200% 12
200% or greater .. 13
Don't know 14

Q.25 Does you water system have storage capacity?

Yes…..1
No…….2

[IF THE ANSWER IS 2, THEN SKIP TO Q.33]

Q.26 What is the total ***typical*** volume, ***in acre-feet***, of storage capacity in your system?

(NEED TYPICAL) (If you can only answer in gallons, please make a note of that.)

Q.27 ***Again, if you have your postcard handy, please refer to data that you may have retrieved for the following questions.***

Now, we need the approximate amount of total water in storage, measured as a percentage of total storage, on the dates of April 15 (before spring), July 1st (after spring), and November 1st (after use).

Let's begin with year 2002: What was your total volume of storage on April 15?

(ENTER NUMBERS ONLY. IF NONE, ENTER ZERO.)
THESE #'S DO NOT SUM TO 100%. EACH QUESTION HAS A UNIQUE ANSWER.

% of Total Volume in Storage April 15th/Before Spring: 2002 .. ______
% on July 1st/After Spring: 2002 .... ______
% on Nov 1st/After Use: 2002 .... ______

Q.28 Now, let's turn to year 2001.

(ENTER NUMBERS ONLY. IF NONE, ENTER ZERO.)
THESE #'S DO NOT SUM TO 100%. EACH QUESTION HAS A UNIQUE ANSWER.

% of Total Volume in Storage April 15th/Before Spring: 2001 .. ______
% on July 1st/After Spring: 2001 .... ______
% on Nov 1st/After Use: 2001 .... ______

Q.29 Now, let's look at 2000.

(ENTER NUMBERS ONLY. IF NONE, ENTER ZERO.)

% of Total Volume in Storage April 15th/Before Spring: 2000 .. ______
% on July 1st/After Spring: 2000 .... ______
% on Nov 1st/After Use: 2000 .... ______

Q.30 Now, year 1999.

(ENTER NUMBERS ONLY. IF NONE, ENTER ZERO.)

Amt of Total Volume in Storage April 15th/Before Spring: 1999 .. ______
% on July 1st/After Spring: 1999 .... ______
% on Nov 1st/After Use: 1999 .... ______

Q.31 Now, year 1998.

(ENTER NUMBERS ONLY. IF NONE, ENTER ZERO.)

Amt of Total Volume in Storage April 15th/Before Spring: 1998 .. ______
% on July 1st/After Spring: 1998 .... ______
% on Nov 1st/After Use: 1998 .... ______

Q.32 Finally, going back to year 1977.

(ENTER NUMBERS ONLY. IF NONE, ENTER ZERO.)

Amt of Total Volume in Storage April 15th/Before Spring: 1977 .. ______
% on July 1st/After Spring: 1977 .... ______
% on Nov 1st/After Use: 1977 .... ______

Q.33 What is the approximate population you serve?

Under 200 1
200-499 2
500-999 3
1,000-2,999 4
3,000-9,999 5
10,000-100,000 .. 6
Over 100,000 7
Not applicable 8

Q.34 What is the approximate number of acres irrigated excluding residential?

Under 160 acres (less than 1/4 square mile) 1
160-640 acres (1/4 up to 1 square mile) 2
640-3,200 acres (1 up to 5 square miles) 3
3,200-6,400 acres (5 up to 10 square miles) 4
6,400-64,000 acres (10 to 100 square miles) 5
Greater than 64,000 acres (more than 100 sq miles)…. 6
Not applicable 7

Q.35 Now, I'm going to read a list of several possible limitations to your current water supply. First, please tell me which items are limitations by answering yes or no.

Q.36 Availability of In-basin Water Rights
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 36 IS 2, THEN SKIP TO QUESTION 38]

Q.37 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting……….1
2 2
3 3
4 4
5= extremely limiting . .. 5

Q.38 Availability of Storage
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 38 IS 2, THEN SKIP TO QUESTION 40]

Q.39 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting 1
2 2
3 3
4 4
5= extremely limiting .. 5

Q.40 Availability of Trans-Basin Water Rights
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 40 IS 2, THEN SKIP TO QUESTION 42]

Q.41 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting…….. 1
2 2
3 3
4 4
5= extremely limiting…..5

Q.42 Availability of Augmentation Water
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 42 IS 2, THEN SKIP TO QUESTION 44]

Q.43 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting 1
2 2
3 3
4 4
5= extremely limiting ... 5

Q.44 Availability of Groundwater Recharge
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 44 IS 2, THEN SKIP TO QUESTION 46]

Q.45 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting 1
2 2
3 3
4 4
5= extremely limiting ... 5

Q.46 Clean Water Act Overall
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 46 IS 2, THEN SKIP TO QUESTION 48]

Q.47 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting 1
2 2
3 3
4 4
5= extremely limiting.....5

Q.48 CWCB Instream Flows?
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 48 IS 2, THEN SKIP TO QUESTION 50]

Q.49 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting……..1
2 2
3 3
4 4
5= extremely limiting.....5

Q.50 Diversion structures
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 50 IS 2, THEN SKIP TO QUESTION 54]

Q.51 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting……...1
2 2
3 3
4 4
5= extremely limiting….5

Q.52 Intentionally left blank
Q.53 Intentionally left blank

Q.54 Endangered Species Act
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 54 IS 2, THEN SKIP TO QUESTION 56]

Q.55 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting……..1
2 2
3 3
4 4
5= extremely limiting…..5

Q.56 Federal Land Management
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 56 IS 2, THEN SKIP TO QUESTION 58]

Q.57 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting ……..1
2 2
3 3
4 4
5= extremely limiting.....5

Q.58 Federal Special Use Permitting, By-Pass Flows, or Reserved Water Rights
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 58 IS 2, THEN SKIP TO QUESTION 60]

Q.59 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting……...1
2 2
3 3
4 4
5= extremely limiting….5

Q.60 Need for New or Upgraded Raw Water Treatment Infrastructure
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 60 IS 2, THEN SKIP TO QUESTION 62]

Q.61 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting …….1
2 2
3 3
4 4
5= extremely limiting….5

Q.62 Federal environmental permitting requirements
(e.g. NEPA--National Environmental Policy Act)
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 62 IS 2, THEN SKIP TO QUESTION 64]

Q.63 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting……...1
2 2
3 3
4 4
5= extremely limiting….5

Q.64 Pressure of Development on Agricultural Land Water Rights
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 64 IS 2, THEN SKIP TO QUESTION 66]

Q.65 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting……...1
2 2
3 3
4 4
5= extremely limiting….5

Q.66 Reliability of Production Wells
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 66 IS 2, THEN SKIP TO QUESTION 68]

Q.67 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting……...1
2 2
3 3
4 4
5= extremely limiting….5

Q.68 Reliability of Existing In-basin Water Rights
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 68 IS 2, THEN SKIP TO QUESTION 70]

Q.69 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting………1
2 2
3 3
4 4
5= extremely limiting…..5

Q.70 Reliability of Existing Trans-Basin Water Rights
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 70 IS 2, THEN SKIP TO QUESTION 72]

Q.71 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting ……..1
2 2
3 3
4 4
5= extremely limiting….5

Q.72 Restrictions on Use of Existing Storage (dam safety, by way of example)
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 72 IS 2, THEN SKIP TO QUESTION 74]

Q.73 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting………1
2 2
3 3
4 4
5= extremely limiting….5

Q.74 Section 404 Permits (US Army Corp of Engineers permit required for any disturbances in wetlands or waterways)? (Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 74 IS 2, THEN SKIP TO QUESTION 76]

Q.75 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting ……..1
2 2
3 3
4 4
5= extremely limiting….5

Q.76 Water Quality (Surface/Groundwater)?
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 76 IS 2, THEN SKIP TO QUESTION 78]

Q.77 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting………1
2 2
3 3
4 4
5= extremely limiting….5

Q.78 US Fish & Wildlife Service Flow Recommendations?
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 78 IS 2, THEN SKIP TO QUESTION 80]

Q.79 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting ……..1
2 2
3 3
4 4
5= extremely limiting….5

Q.80 Water Transmission System / Conveyance facilities (e.g., ditches, pipes, etc.)
(Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[**IF THE ANSWER TO QUESTION 80 IS 2, THEN SKIP TO QUESTION 82]**

Q.81 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting……...1
2 2
3 3
4 4
5= extremely limiting….5

Q.82 Water Distribution System Losses (Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 82 IS 2, THEN SKIP TO QUESTION 84]

Q.83 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting……...1
2 2
3 3
4 4
5= extremely limiting….5

Q.84 Public Expectation for Instream Water Use (Environmental, Recreational, Aesthetic) (Is this a limitation?)

Yes 1
No / Doesn't Apply ..2

[IF THE ANSWER TO QUESTION 84 IS 2, THEN SKIP TO QUESTION 86]

Q.85 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting………1
2 2
3 3
4 4
5= extremely limiting….5

Q.86 Is there some other important limitation that I didn't mention?

Yes….1
No…..2

[IF THE ANSWER TO QUESTION 86 IS 2, THEN SKIP TO QUESTION 88]

Q.87 RECORD OTHER IMPORTANT LIMITATION

Q.88 Please rate that limitation, with 1 being slightly limiting & 5 being extremely limiting.

1= slightly limiting	1
2	2
3	3
4	4
5= extremely limiting	5

Q.89 Which one of the limitations we've just discussed has the greatest impact on your current water supply? **CHOOSE UP TO THREE.**

Availability of In-basin Water Rights	1
Availability of Storage	2
Availability of Trans-Basin Water Rights	3
Available Augmentation Water	4
Clean Water Act	5
CWCB Instream Flows	6
Diversion Structure(s)	7
Emergency Water Supplies	8
Endangered Species Act	9
Fed Environmental Permitting Reqs (e.g., NEPA)	10
Federal Land Management	11
Fed. Special Use Permitting/By Pass Flows/Resv'd Water Rights	12
Need for New or Upgraded Raw Water Treatment Infrastructure	13
Pressure of Development on Agricultural Land H2O Rights	14
Production Wells	15
Public Expectation for Water Use(Enviro, Recr, Aesthetic	16
Raw Water Treatment Infrastructure	17
Reliability of Existing In-basin Water Rights	18
Reliability of Existing Transbasin Water Rights	19
Requirement for Groundwater Recharge	20
Restrictions on Use of Existing Storage	21
Section 404 Permits	22
US Fish & Wildlife Service Flow Recommendations	23
Water Distribution System Losses	24
Water Quality (Surface/Ground)	25
Water Transmission System/ Conveyance Facilities	26
OTHER--SOMETHING NOT LISTED!!	27
Availability of snowpack/precipitation/runoff	28
Availability of funding	29
Availability of groundwater	30
None/Refused	31

[AVOID Q90, UNLESS Q 89 IS 27]

Q.90 OTHER LIMITATION THAT HAS THE GREATEST IMPACT

Q.91 Now, we'd like to turn your attention to water management tools by focusing on three items: Your water supply plan, your drought plan, and your conservation plan.

First, do you have a Water Supply Master Plan in place, that is a plan in place for development of future water supply needs?

Yes .. 1
No ... 2

[**IF THE ANSWER IS 1, THEN SKIP TO QUESTION 93]**

Q.92 **Do you have one planned for the future? (FYI THIS INCLUDES "working on one")**

Yes .. 1
No ... 2

[**IF THE ANSWER IS 2, THEN SKIP TO QUESTION 94]**

Q.93 How effective is this plan in managing the drought, using the 5-point scale, where 1 is not at all effective and 5 is extremely effective?

1 = not at all effective …...1
2 2
3 3
4 4
5 = extremely effective….5

Q.94 Do you have a Drought Management Plan in place?

Yes .. 1
No ... 2

[IF THE ANSWER IS 2, THEN SKIP TO QUESTION 96]

Q.95 Did you have one in place prior to this year?

Yes .. 1
No ... 2

Q.96 Do you have one planned for the future?

Yes .. 1
No ... 2

Q.97 Please tell me which of the following components you currently utilize in managing drought? Please answer yes or no to each one.

Q.98 Defined communications external to organization related to drought, such as a formal response or release of information to an external entity (e.g., news release)

Yes 1
No 2
Don't know ...3

Q.99 Defined communications internal to organization related to drought (formal release of information to internal entity -- e.g., memo to mayor)

Yes 1
No 2
Don't know ...3

Q.100 Identification of Different Levels of Responses

Yes 1
No 2
Don't know ...3

Q.101 Identified & Measurable Triggers for Action

Yes 1
No 2
Don't know ...3

Q.102 Monitoring Water Quality

Yes 1
No 2
Don't know ...3

Q.103 Monitoring Water Supply Components (e.g., snowpack, stream flow, etc.)

Yes 1
No 2
Don't know .. 3

Q.104 Procedures for Declaring Emergencies

Yes 1
No 2
Don't know ...3

Q.105 Is there another component that I didn't mention (that you utilize to manage drought?)

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 105 IS 2, THEN SKIP TO QUESTION 107]

Q.106 RECORD ANSWER

Q.107 Please tell me which of the following tools you currently utilize in managing drought. Again, you may simply answer yes or no to each item.

Q.108 Aquifer storage & recovery/conjunctive use

Yes .. 1
No ... 2

Q.109 Cloud seeding

Yes .. 1
No ... 2

Q.110 Controls on new construction

Yes .. 1
No ... 2

Q.111 Emergency water supply agreements

Yes .. 1
No ... 2

Q.112 Fines for water users (e.g., Increased costs/sliding scale for water use)

Yes .. 1
No ... 2

Q.113 Substitute supply plans

Yes .. 1
No ... 2

Q.114 Interruptible water supply agreements

Yes .. 1
No ... 2

Q.115 Landscaping controls / Xeriscape, amt of planting allowed

Yes .. 1
No ... 2

Q.116 Lawn and garden water restrictions

Yes .. 1
No ... 2

Q.117 Operations/Cooperative agreements

Yes .. 1
No ... 2

Q.118 Public education and involvement programs

Yes .. 1
No ... 2

Q.119 Pump groundwater

Yes .. 1
No ... 2

Q.120 Water banking

Yes .. 1
No ... 2

Q.121 Water conservation programs

Yes .. 1
No ... 2

Q.122 Dual Water System for Irrigation

Yes….1
No ... 2

Q.123 Is there any other tool that I haven't mentioned?

Yes ...1
No ... 2

[IF THE ANSWER TO QUESTION 123 IS 2, THEN SKIP TO QUESTION 125]

Q.124 What tool?

Q.125 And which of the tools that I've just mentioned have you found to be best in managing drought? UP TO THREE CHOICES ARE ACCEPTABLE

Aquifer storage and recovery/ conjunctive use 1
Cloud seeding 2
Controls on new construction 3
Dual Water System for Irrigation 4
Emergency water supply agreements 5
Fines for water users (Increased costs/sliding scale 6
Interruptible water supply agreements 7
Landscaping controls/Xeriscape /amount of planting allowed ... 8
Lawn and garden water restrictions 9
Operations/Cooperative agreements 10
Public education/involvement programs ....…11
Pump groundwater 12
Substitute Supply Plans 13
Water banking 14
Water conservation programs 15
OTHER tool not listed 16

[**IF THE ANSWER TO QUESTION 125 IS 1-15, THEN SKIP TO QUESTION 127]**

Q.126 OTHER BEST TOOL

Q.127 Do you have a water conservation plan in place?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 127 IS 2, THEN SKIP TO QUESTION 129]

Q.128 Did you have one in place prior to this year?

Yes .. 1
No ... 2

Q.129 Do you have one planned for the future?

Yes .. 1
No ... 2

Q.130 Which tools/programs do you *currently* utilize to conserve water?

	Yes	No
Alternative irrigation practices	1	2
Automated canal structures	1	2
Distribution/conveyance system leak detection	1	2
Dry land farming	1	2
Land use covenants	1	2
Lining of piping, ditches or canals	1	2
Metering	1	2
New subdivision platting and covenant requirements	1	2
Optimize conjunctive use of surface & groundwater		
Public information & education programs		
Residential plumbing retrofits (e.g., low flow toilets)	1	2
Rotating drought tolerant crops	1	2
School education programs	1	2
Sectioning of canals & ditches	1	2
Use of recycled water	1	2
Use of water recovery program	1	2
Water conservation pricing	1	2
Xeriscape promotions	1	2

Q.131 And which one of those tools is the best for conservation?
UP TO TWO CHOICES ARE ACCEPTABLE.

Alternative irrigation practices	1
Automated canal structures	2
Distribution/conveyance system leak detection	3
Dry land farming	4
Land use covenants	5
Lining of piping, ditches or canals	6
Metering	7
New subdivision platting & covenant requirements	8
Optimize conjunctive use of surface water & groundwater	9
Public information & education programs	10
Residential plumbing retrofits (e.g. low flow toilets)	11
Rotating drought tolerant crops	12
School education programs	13
Sectioning of canals & ditches	14
Use of recycled water	15
Use of water recovery programs	16
Water conservation pricing	17
Xeriscape promotions	18

Q.132 Now we'd like to ask you how the current drought has impacted you, specifically as it pertains to the entity that you represent. For the purposes of this study, we are defining the current drought as beginning in 1999 to present.

Please rate the level of impact that drought has had on each of the following areas, using a 5-point scale, where 1 is no impact at all, and 5 is an extreme impact.
1 = NO IMPACT AT ALL -- TO -- 5 = EXTREME IMPACT

	1=low	2	3	4	5=high
Loss of Crop Yield	1	2	3	4	5
Loss of Landscaped Property	1	2	3	4	5
Loss of Livestock	1	2	3	4	5
Limited New Construction	1	2	3	4	5
Loss of reliable water supply	1	2	3	4	5
Wells went dry or produced sand	1	2	3	4	5
Loss of Recreational Revenue	1	2	3	4	5
Loss of Water Amenities (e.g., parks, fountains)	1	2	3	4	5
Loss of Wildlife Habitat	1	2	3	4	5
Loss of Wildlife	1	2	3	4	5

Raw water quality	1	2	3	4	5
Fire damage	1	2	3	4	5
Loss of Operations Revenues (e.g., sale of water)	1	2	3	4	5
Increased expenses for public education	1	2	3	4	5
Loss of system flexibility	1	2	3	4	5

Q.133 Is there some other area that's been impacted that I didn't mention?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 133 IS 2, THEN SKIP TO QUESTION 136]

Q.134 OTHER IMPACTED AREA

Q.135 And how would you rate that on the 5-point scale?

1 = not impact at all….1
2 2
3 3
4 4
5 = extreme impact ….5

Q.136 Now, let's turn our attention to water planning for future water supplies. I'm going to ask you to rate your ability to predict the future requirements for water supply both in the **short term** (<u>defined as 2010</u>) & the **long term** (<u>defined as 2030</u>) using the 5-point scale, where 1 is poor & 5 is excellent ability to predict future requirements. Then, I'm also going to ask how important that requirement is for you (again on the 5-point scale, with 1 being not at all important, and 5 being extremely important.)

Q.137 In the short term, how would you rate your ability to predict future average daily demand?

1 = poor…………1
2 2
3 3
4 …………………4
5 = excellent ……5
Not applicable…..6

[IF THE ANSWER TO QUESTION 137 IS 6, THEN SKIP TO QUESTION 139]

Q.138 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important , ..5

Q.139 How would you rate that ability in the long-term?
(FYI: ability to predict future average daily demand)

1 = poor ,............1
2 2
3 3
4 4
5 = excellent ,.....5
Not applicable…..6

[IF THE ANSWER TO QUESTION 139 IS 6, THEN SKIP TO QUESTION 141]

Q.140 And overall, how important is it to predict future average daily demand?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.141 In the short term, how would you rate your ability to meet future average daily demand?

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable... ..6

[IF THE ANSWER TO QUESTION 141 IS 6, THEN SKIP TO QUESTION 143]

Q.142 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important ...5

Q.143 How would you rate that ability in the long-term? (FYI: ability to meet future average daily demand)

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable 6

[IF THE ANSWER TO QUESTION 143 IS 6, THEN SKIP TO QUESTION 145]

Q.144 And overall, how important is it to meet future average daily demand?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.145 In the short term, how would you rate your ability to predict future peak daily demand?

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable . ..6

[IF THE ANSWER TO QUESTION 145 IS 6, THEN SKIP TO QUESTION 147]

Q.146 And overall, how important is that ability?

1 = not at all important……1
2 2
3 3
4 4
5 = extremely important …5

Q.147 How would you rate that ability in the long-term? (FYI: ability to predict future peak daily demand)

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable 6

[IF THE ANSWER TO QUESTION 147 IS 6, THEN SKIP TO QUESTION 149]

Q.148 And overall, how important is it to predict future peak daily demand?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.149 In the short term, how would you rate your ability to meet future peak daily demand?

1 = poor …..........1
2 2
3 3
4 4
5 = excellent 5
Not applicable 6

[IF THE ANSWER TO QUESTION 149 IS 6, THEN SKIP TO QUESTION 151]

Q.150 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important ...5

Q.151 How would you rate that ability in the long-term? (FYI: ability to meet future peak daily demand)

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable 6

[IF THE ANSWER TO QUESTION 151 IS 6, THEN SKIP TO QUESTION 153]

Q.152 And overall, how important is it to meet future peak daily demand?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.153 In the short term, how would you rate your ability to predict future weather patterns (e.g., El Nino, snow pack, etc.)?

1 = poor ….........1
2 2
3 3
4 4
5 = excellent …...5
Not applicable ...6

[IF THE ANSWER TO QUESTION 153 IS 6, THEN SKIP TO QUESTION 155]

Q.154 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important ...5

Q.155 How would you rate that ability in the long-term? (FYI: ability to predict future weather patterns)

1 = poor 1
2 2
3 3
4 4
5 = excellent …..5
Not applicable…..6

[**IF THE ANSWER TO QUESTION 155 IS 6, THEN SKIP TO QUESTION 157]**

Q.156 And overall, how important is it to predict future weather patterns (e.g., El Nino, snow pack, etc.)?

1 = not at all important……1
2 2
3 3
4 4
5 = extremely important …5

Q.157 In the short term, how would you rate your ability to meet demands with existing surface water supplies?

1 = poor ....…1
2 2
3 3
4 4
5 = excellent 5
Not applicable …6

[IF THE ANSWER TO QUESTION 157 IS 6, THEN SKIP TO QUESTION 159]

Q.158 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.159 How would you rate that ability in the long-term? (FYI: ability to meet demands with existing surface water supplies)

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable 6

[**IF THE ANSWER TO QUESTION 159 IS 6, THEN SKIP TO QUESTION 161]**

Q.160 And overall, how important is it to meet demands with existing surface water supplies?

1 = not at all important. 1
2 2
3 3
4 4
5 = extremely important ...5

Q.161 In the short term, how would you rate your ability to meet demands with existing ground water supplies?

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable 6

[IF THE ANSWER TO QUESTION 161 IS 6, THEN SKIP TO QUESTION 163]

Q.162 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.163 How would you rate that ability in the long-term? (FYI: ability to meet demands with existing ground water supplies)

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable 6

[IF THE ANSWER TO QUESTION 163 IS 6, THEN SKIP TO QUESTION 165]

Q.164 And overall, how important is it to meet demands with existing ground water supplies?

1 = not at all important. 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.165 In the short term, how would you rate your ability to acquire new surface water supplies?

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable 6

[IF THE ANSWER TO QUESTION 165 IS 6, THEN SKIP TO QUESTION 167]

Q.166 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.167 How would you rate that ability in the long-term? (FYI: ability to acquire new surface water supplies)

1 = poor 1
2 2
3 3
4 4
5 = excellent. 5
Not applicable…..6

[IF THE ANSWER TO QUESTION 167IS 6, THEN SKIP TO QUESTION 169]

Q.168 And overall, how important is it to acquire new surface water supplies?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.169 In the short term, how would you rate your ability to acquire new ground water supplies?

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable 6

[IF THE ANSWER TO QUESTION 169 IS 6, THEN SKIP TO QUESTION 171]

Q.170 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.171 How would you rate that ability in the long-term? (FYI: acquire new surface water supplies)

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable.. ..6

[IF THE ANSWER TO QUESTION 171 IS 6, THEN SKIP TO QUESTION 173]

Q.172 And overall, how important is it to acquire new ground water supplies?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.173 In the short term, how would you rate your ability to detect & repair water system shrink &/or leakage?

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable 6

[IF THE ANSWER TO QUESTION 173 IS 6, THEN SKIP TO QUESTION 175]

Q.174 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.175 How would you rate that ability in the long-term? (FYI: ability to detect & repair water system shrink &/or leakage)

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable . ..6

[IF THE ANSWER TO QUESTION 175 IS 6, THEN SKIP TO QUESTION 177]

Q.176 And overall, how important is it to detect & repair water system shrink &/or leakage?

1 = not at all important……1
2 2
3 3
4 4
5 = extremely important….5

Q.177 In the short term, how would you rate your ability to manage water quality impacts on water supply?

1 = poor…………1
2 2
3 3
4 4
5 = excellent …...5
Not applicable…..6

[IF THE ANSWER TO QUESTION 177 IS 6, THEN SKIP TO QUESTION 179]

Q.178 And overall, how important is that ability?

1 = not at all important……1
2 2
3 3
4 4
5 = extremely important …5

Q.179 How would you rate that ability in the long-term? (FYI: ability to manage water quality impacts on water supply)

1 = poor…………1
2 2
3 3
4 4
5 = excellent …...5
Not applicable…..6

[IF **THE ANSWER TO QUESTION 179 IS 6, THEN SKIP TO QUESTION 181]**

Q.180 And overall, how important is it to manage water quality impacts on water supply?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important ...5

Q.181 In the short term, how would you rate your ability to find reliable/sustainable augmentation water?

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable 6

[IF THE ANSWER TO QUESTION 181 IS 6, THEN SKIP TO QUESTION 183]

Q.182 And overall, how important is that ability?

1 = not at all important……1
2 2
3 3
4 4
5 = extremely important …5

Q.183 How would you rate that ability in the long-term? (FYI: ability to find reliable/sustainable augmentation water)

1 = poor 1
2 2
3 3
4 4
5 = excellent……5
Not applicable…..6

[IF THE ANSWER TO QUESTION 183 IS 6, THEN SKIP TO QUESTION 185]

Q.184 And overall, how important is it to find reliable/sustainable augmentation water?

1 = not at all important……1
2 2
3 3
4 4
5 = extremely important …5

Q.185 In the short term, how would you rate your ability to implement future cooperative agreements to manage drought?

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable …..6

[IF THE ANSWER TO QUESTION 185 IS 6, THEN SKIP TO QUESTION 187]

Q.186 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.187 How would you rate that ability in the long-term? (FYI: ability to implement future cooperative agreements to manage drought)

1 = poor ..…........1
2 2
3 3
4 4
5 = excellent 5
Not applicable .. 6

[IF THE ANSWER TO QUESTION 187 IS 6, THEN SKIP TO QUESTION 189]

Q.188 And overall, how important is it to implement future cooperative agreements to manage drought?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important ...5

Q.189 In the short term, how would you rate your ability to implement water reuse programs?

1 = poor ..….......1
2 2
3 3
4 4
5 = excellent 5
Not applicable .. 6

[IF THE ANSWER TO QUESTION 189 IS 6, THEN SKIP TO QUESTION 191]

Q.190 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important ...5

Q.191 How would you rate that ability in the long-term? (FYI: implement water reuse programs)

1 = poor 1
2 2
3 3
4 4
5 = excellent……5
Not applicable….6

[IF THE ANSWER TO QUESTION 191 IS 6, THEN SKIP TO QUESTION 193]

Q.192 And overall, how important is it to implement water reuse programs?

1 = not at all important …..1
2 2
3 3
4 4
5 = extremely important ...5

Q.193 In the short term, how would you rate your ability to develop future water projects individually?

1 = poor ....…......1
2 2
3 3
4 4
5 = excellent …...5
Not applicable…...6

.

[IF THE ANSWER TO QUESTION 193 IS 6, THEN SKIP TO QUESTION 195]

Q.194 And overall, how important is that ability?

1 = not at all important …..1
2 2
3 3
4 4
5 = extremely important ...5

Q.195 How would you rate that ability in the long-term? (FYI: ability to develop future water projects individually)

1 = poor ......…...1
2 2
3 3
4 4
5 = excellent……5
Not applicable …6

[IF THE ANSWER TO QUESTION 195 IS 6, THEN SKIP TO QUESTION 197]

Q.196 And overall, how important is it to develop future water projects individually?

1 = not at all important …..1
2 2
3 3
4 4
5 = extremely important . ..5

Q.197 In the short term, how would you rate your ability to develop future water projects in a cooperative effort?

1 = poor ...…........1
2 2
3 3
4 4
5 = excellent……5
Not applicable….6

[IF THE ANSWER TO QUESTION 197 IS 6, THEN SKIP TO QUESTION 199]

Q.198 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important ...5

Q.199 How would you rate that ability in the long-term? (FYI: ability to develop future water projects in a cooperative effort)

1 = poor ..…........1
2 2
3 3
4 4
5 = excellent……5
Not applicable….6

[IF THE ANSWER TO QUESTION 199 IS 6, THEN SKIP TO QUESTION 201]

Q.200 And overall, how important is it to develop future water projects in a cooperative effort?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.201 In the short term, how would you rate your ability to fund needed water development or infrastructure projects?

1 = poor ....…......1
2 2
3 3
4 4
5 = excellent……5
Not applicable…..6

[IF THE ANSWER TO QUESTION 201 IS 6, THEN SKIP TO QUESTION 203]

Q.202 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.203 How would you rate that ability in the long-term? (FYI: ability to fund needed water development or infrastructure projects)

1 = poor 1
2 2
3 3
4 4
5 = excellent……5
Not applicable….6

[IF THE ANSWER TO QUESTION 203 IS 6, THEN SKIP TO QUESTION 205]

Q.204 And overall, how important is it to fund needed water development or infrastructure 0rojects?

1 = not at all important……1
2 2
3 3
4 4
5 = extremely important….5

Q.205 In the short term, how would you rate your ability to fund water supply infrastructure maintenance and repair?

1 = poor ...….......1
2 2
3 3
4 4
5 = excellent …...5
Not applicable….6

[IF THE ANSWER TO QUESTION 205 IS 6, THEN SKIP TO QUESTION 207]

Q.206 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important …5

Q.207 How would you rate that ability in the long-term? (FYI: ability to fund water supply infrastructure maintenance and repair)

1 = poor ….........1
2 2
3 3
4 4
5 = excellent……5
Not applicable….6

[IF THE ANSWER TO QUESTION 207 IS 6, THEN SKIP TO QUESTION 209]

Q.208 And overall, how important is it to fund water supply infrastructure maintenance and repair?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important….5

Q.209 In the short term, how would you rate your ability to retain existing water rights over time (e.g., versus development pressure to switch ag rights to municipal rights)?

1 = poor ...….......1
2 2
3 3
4 4
5 = excellent……5
Not applicable…..6

[IF THE ANSWER TO QUESTION 209 IS 6, THEN SKIP TO QUESTION 211]

Q.210 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.211 How would you rate that ability in the long-term? (FYI: ability to retain existing water rights over time)

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable . ..6

[IF THE ANSWER TO QUESTION 211 IS 6, THEN SKIP TO QUESTION 213]

Q.212 And overall, how important is it to retain existing water rights over time (e.g., versus development pressure to switch ag rights to municipal rights)?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.213 In the short term, how would you rate your ability to implement conjunctive use programs?

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable …6

[IF THE ANSWER TO QUESTION 213 IS 6, THEN SKIP TO QUESTION 215]

Q.214 And overall, how important is that ability?

1 = not at all important …..1
2 2
3 3
4 4
5 = extremely important ...5

Q.215 How would you rate that ability in the long-term? (FYI: ability to implement conjunctive use programs)

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable ...6

[IF THE ANSWER TO QUESTION 215 IS 6, THEN SKIP TO QUESTION 217]

Q.216 And overall, how important is it to implement conjunctive use programs?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.217 In the short term, how would you rate your ability to meet environmental permitting requirements?

1 = poor 1
2 2
3 3
4 4
5 = excellent 5
Not applicable . ..6

[IF THE ANSWER TO QUESTION 217 IS 6, THEN SKIP TO QUESTION 219]

Q.218 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important ...5

Q.219 How would you rate that ability in the long-term? (FYI: ability to meet environmental permitting requirements)

1 = poor ..….........1
2 2
3 3
4 4
5 = excellent……5
Not applicable ...6

[IF THE ANSWER TO QUESTION 219 IS 6, THEN SKIP TO QUESTION 221]

Q.220 And overall, how important is it to meet environmental permitting requirements?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important ...5

Q.221 In the short term, how would you rate your ability to offset increased demand of future growth thru water conservation programs?

1 = poor ..….........1
2 2
3 3
4 4
5 = excellent 5
Not applicable 6

[IF THE ANSWER TO QUESTION 221 IS 6, THEN SKIP TO QUESTION 223]

Q.222 And overall, how important is that ability?

1 = not at all important …..1
2 2
3 3
4 4
5 = extremely important …5

Q.223 How would you rate that ability in the long-term? (FYI: ability to offset increased demand of future growth thru water conservation programs)

1 = poor ..….......1
2 2
3 3
4 4
5 = excellent 5
Not applicable . ..6

[IF THE ANSWER TO QUESTION 223 IS 6, THEN SKIP TO QUESTION 225]

Q.224 And overall, how important is it to offset increased demand of future growth thru water conservation programs?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important ...5

Q.225 In the short term, how would you rate your ability to offset increased demand of future growth thru ag land conversion programs?

1 = poor ..….......1
2 2
3 3
4 4
5 = excellent 5
Not applicable. ..6

[IF THE ANSWER TO QUESTION 225 IS 6, THEN SKIP TO QUESTION 227]

Q.226 And overall, how important is that ability?

1 = not at all important 1
2 2
3 3
4 4
5 = extremely important . ..5

Q.227 How would you rate that ability in the long-term? (FYI: ability to offset increased demand of future growth thru ag land conversion programs)

1 = poor 1
2 2
3 3
4 4
5 = excellent……5
Not applicable…...6

[IF THE ANSWER TO QUESTION 227 IS 6, THEN SKIP TO QUESTION 229]

Q.228 And overall, how important is it to offset increased demand of future growth thru ag land conversion programs?

1 = not at all important …...1
2 2
3 3
4 4
5 = extremely important….5

Q.229 Next, please identify your current need for the following types of structural projects to manage periods of low water availability, using the 5-point scale where 1 is no need at all and 5 is an extreme or urgent need.

Q.230 Structural improvements or upgrades to meet dam safety requirements

1= no need at all 1
2 2
3 3
4 4
5 = extreme or urgent need . ..5
Not applicable .....…................6

Q.231 Dredging existing reservoirs

1= no need at all ....….......1
2 2
3 3
4 4
5 = extreme or urgent need . ..5
Not applicable ....…..6

Q.232 Install and use water meters

1= no need at all ....…..........1
2 2
3 3
4 4
5 = extreme or urgent need ...5
Not applicable 6

Q.233 Lining of ditches

1= no need at all ....….......1
2 2
3 3
4 4
5 = extreme or urgent need . ..5
Not applicable ....…........6

Q.234 New or deepened wells

1= no need at all ………………1
2 2
3 3
4 4
5 = extreme or urgent need ….5
Not applicable…………………6

Q.235 New or improved aquifer storage recovery/conjunctive use programs/ groundwater recharge

1= no need at all .....…...........1
2 2
3 3
4 4
5 = extreme or urgent need ...5
Not applicable ....….....6

Q.236 New raw water treatment facilities

1= no need at all …..................1
2 2
3 3
4 4
5 = extreme or urgent need ...5
Not applicable 6

Q.237 New storage for groundwater

1= no need at all …..................1
2 2
3 3
4 4
5 = extreme or urgent need ...5
Not applicable ....….........6

Q.238 New storage for surface water

1= no need at all …..................1
2 2
3 3
4 4
5 = extreme or urgent need . ..5
Not applicable ....…..6

Q.239 New or upgraded pump stations

1= no need at all ....…........1
2 2
3 3
4 4
5 = extreme or urgent need . ..5
Not applicable ....…..6

Q.240 New or upgraded pipelines

1= no need at all ..….................1
2 2
3 3
4 4
5 = extreme or urgent need ...5
Not applicable ....…..6

Q.241 New or upgraded water distribution systems

1= no need at all ....….......1
2 2
3 3
4 4
5 = extreme or urgent need ...5
Not applicable ....…..6

Q.242 Rehabilitation or new diversion structures

1= no need at all ....….......1
2 2
3 3
4 4
5 = extreme or urgent need . ..5
Not applicable ....…...6

Q.243 Water reuse projects

1= no need at all ....….........1
2 2
3 3
4 4
5 = extreme or urgent need . ..5
Not applicable ....…...6

Q.244 Implement phreatophyte (*FYI: weed type trees that drink water*) control

1= no need at all ......…...........1
2 2
3 3
4 4
5 = extreme or urgent need . ..5
Not applicable ....…...6

Q.245 Large scale and/or multi-basin cooperative projects

1= no need at all 1
2 2
3 3
4 4
5 = extreme or urgent need ...5
Not applicable ....…..6

Q.246 Forest management

1= no need at all 1
2 2
3 3
4 4
5 = extreme or urgent need ... 5
Not applicable 6

Q.247 Is there some other structural project needed that I didn't mention?

Yes .. 1
No …..2

[IF THE ANSWER IS 2, THEN SKIP TO QUESTION 250]

Q.248 RECORD STRUCTURAL PROJECT

____

Q.249 And how would you rate your need for that using the same 5-point scale?

1 = no need at all . ..1
2 2
3 3
4 4
5 = extreme need ...5

Q.250 Do you believe that the State should be involved in the structural projects that were just mentioned?

Yes 1
No 2
Don't know ...3

[IF THE ANSWER TO QUESTION 248 IS 2, THEN SKIP TO QUESTION 271]

Q.251 Which of the following items could the State be of assistance? Please answer yes or no to each one.

Q.252 Structural improvements or upgrades to meet dam safety requirements

Yes .. 1
No ... 2

Q.253 Dredging existing reservoirs

Yes .. 1
No ... 2

Q.254 Install and use water meters

Yes .. 1
No ... 2

Q.255 Lining of ditches

Yes .. 1
No ... 2

Q.256 New or deepened wells

Yes .. 1
No ... 2

Q.257 New or improved aquifer storage recovery/conjunctive use programs /groundwater recharge

Yes .. 1
No ... 2

Q.258 And should the State be involved in new raw water treatment facilities

Yes .. 1
No ... 2

Q.259 New storage for groundwater

Yes .. 1
No ... 2

Q.260 New storage for surface water

Yes .. 1
No ... 2

Q.261 New or upgraded pump stations

Yes .. 1
No ... 2

Q.262 New or upgraded pipelines

Yes .. 1
No ... 2

Q.263 New or upgraded water distribution systems

Yes .. 1
No ... 2

Q.264 Rehabilitation or new diversion structures

Yes .. 1
No ... 2

Q.265 Water reuse projects

Yes .. 1
No ... 2

Q.266 Implement phreatophyte (*fyi: weed type trees that drink water*) control

Yes .. 1
No ... 2

Q.267 Large scale and/or multi-basin cooperative projects

Yes .. 1
No ... 2

Q.268 Forest management

Yes .. 1
No ... 2

Q.269 Is there some other structural project needed that I didn't mention?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 269 IS 2, THEN SKIP TO QUESTION 271]

Q.270 Other structural project for which State could assist

Q.271 Assume that you had a budget of **5 water dollars** to be used to support structural projects that we have just described. Using even $1 dollar increments, please tell me in which areas would you spend the budget?

You may spend in even dollar increments only --in other words, you cannot spend 50 cents. However, you can spend all 5 in one spot if desired. And we need to spend all 5 dollars.

[ANSWER MUST TOTAL 5]

Structural upgrades to meet Dam Safety requirements	____
Dredging existing Reservoirs	____
Install water use meters	____
Lining of ditches	____
New or deepened Wells	____
Aquifer storage recovery/conjunctive/groundwater recharge	____
New raw water treatment facilities	____
New storage for groundwater	____
New storage for surface water	____
New or upgraded pump stations	____
New or upgraded pipelines	____
New or upgraded water distribution systems	____
Rehabilitation or new diversion structures	____
Water reuse projects	____
Implement phreatophyte control (weed-type-trees that drink H20) ..	____
Large scale &/or multi-basin cooperative projects	____
Forest management	____
OTHER AREA NOT MENTIONED	____

Q.272 PRESS ENTER/ LEAVE BLANK -- ***UNLESS*** PERSON CHOSE OTHER.

Q.273 Now, please identify your current need for the following types of *non-structural* projects to manage drought, using the same 5-point scale, where 1 is no need at all and 5 is extreme or urgent need.

Improved education & awareness of the Public with respect to water, water supply, and water supply planning?

1 = no need at all ....…............1
2 2
3 3
4 4
5 = extreme or urgent need 5
Not applicable ....…......6

Q.274 Improved or enhanced water conservation methods (municipal or agricultural)

1= no need at all 1
2 2
3 3
4 4
5 = extreme or urgent need ...5
Not applicable 6

Q.275 Improved or enhanced water conservation measurement methods

1= no need at all 1
2 2
3 3
4 4
5 = extreme or urgent need. ..5
Not applicable 6

Q.276 Technical support in master planning for future water supply & demand

1= no need at all 1
2 2
3 3
4 4
5 = extreme or urgent need ...5
Not applicable 6

Q.277 Technical support in drought & conservation planning (hydrologic studies, water rights studies)

1= no need at all 1
2 2
3 3
4 4
5 = extreme or urgent need . ..5
Not applicable 6

Q.278 Now, please use the same scale to rate the use of cooperative agreements for each of the following on a 5-point scale, with 1 being no need at all to 5 being an extreme or urgent need.

	1=low	2	3	4	5=high
Exchanges	1	2	3	4	5
Transfers	1	2	3	4	5
Substitute Water Supply Plans	1	2	3	4	5
Interruptible Supplies	1	2	3	4	5
Dry Year Leases	1	2	3	4	5
Other Leases	1	2	3	4	5
Operating Agreements	1	2	3	4	5
Water Banking	1	2	3	4	5
Water Conservation Easement	1	2	3	4	5

Q.279 Are there any other cooperative agreements that I didn't mention?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 279 IS 2, THEN SKIP TO QUESTION 281]

Q.280 What is that cooperative agreement?

Q.281 And how would you rate your need for the financing of large scale or multi-basin cooperative projects, using the same 5-point scale?

1 = no need at all 1
2 2
3 3
4 ....…4
5 = extreme or urgent need…..5
Not applicable ...….................6

Q.282 What about your need for better availability of loans to your organization for:

(Using the same 5-point scale, where 1 is no need at all & 5 is an extreme or urgent need.)

	1=low	2	3	4	5=high
Project evaluations/ feasibility studies	1	2	3	4	5
Planning	1	2	3	4	5
Capital projects	1	2	3	4	5

Q.283 Is there some other loan use that I didn't mention?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 283 IS 2, THEN SKIP TO QUESTION 285]

Q.284 What is that?

Q.285 How do you rate your need for that using the 5-point scale?

1 = no need at all 1
2 2
3 3
4 4
5 = extreme or urgent need . ..5

Q.286 Do you believe that the State should be involved in the non-structural projects that were just mentioned?

Yes 1
No 2
Not sure .. 3

[**IF THE ANSWER IS 2, THEN SKIP TO QUESTION 297]**

Q.287 Which of the following items could the State be of assistance? Please answer yes or no to each one.

Q.288 Improve education of and awareness of the community with respect to water, water supply, & water supply planning

Yes .. 1
No ... 2

Q.289 Improved or enhanced water conservation methods (municipal or agricultural)

Yes .. 1
No ... 2

Q.290 Improved or enhanced water conservation measurements methods

Yes .. 1
No ... 2

Q.291 Technical support in master planning for future water supply and demand

Yes .. 1
No ... 2

Q.292 Technical support in drought and conservation planning (hydrologic studies, water rights studies)

Yes .. 1
No ... 2

Q.293 Should the State be involved in the use of **cooperative agreements** for:

	Yes	No
Exchanges	1	2
Transfers	1	2
Substitute Water Supply Plans	1	2
Interruptible Supplies	1	2
Dry Year Leases	1	2
Other Leases	1	2
Operating Agreements	1	2
Water Banking	1	2
Water Conservation Easement	1	2

Q.294 Is their some other use that I didn't mention?

Q.295 Should the State be of assistance with better availability of loans to your organization for:

	Yes	No
Project evaluations/ feasibility studies	1	2
Planning	1	2
Capital projects	1	2

Q.296 Is there some other loan use that I didn't mention?

Q.297 We would like to know to what extent you believe the State should be involved in water projects to manage drought in periods of low water supply. Please indicate how much you agree with the following statements on the 5-point scale where 1 indicates that you strongly disagree and 5 means that you strongly agree.

The State should own water projects.

1 = strongly disagree ...1
2 2
3 3
4 4
5 = strongly agree 5

Q.298 The State should perform statewide water planning

1 = strongly disagree ...1
2 2
3 3
4 4
5 = strongly agree 5

Q.299 The State should enforce the Water Metering Act

1 = strongly disagree ...1
2 2
3 3
4 4
5 = strongly agree 5
Don't know 6

Q.300 The State should enforce the Water Conservation Act

1 = strongly disagree . ..1
2 2
3 3
4 4
5 = strongly agree 5
Don't know 6

Q.301 The State should develop State/Federal partnerships for management of Federal projects

1 = strongly disagree. ..1
2 2
3 3
4 4
5 = strongly agree 5

Q.302 The State should provide support in cooperative relationships with respect to financing, regulatory matters, and leadership

1 = strongly disagree. ..1
2 2
3 3
4 4
5 = strongly agree 5

Q.303 Using the 5-scale, where 1 is poor & 5 is excellent, please rate the level of communications received regarding the 2002 drought, its management and resources from the following entities.

	1=poor	2	3	4	5=excellent	DK
Colorado Water Conservation Board	1	2	3	4	5	6
Governor's Office	1	2	3	4	5	6
Dept of Natural Resources	1	2	3	4	5	6
Executive Director of the DNR	1	2	3	4	5	6
State Engineers Office	1	2	3	4	5	6
Federal Government overall	1	2	3	4	5	6
State Government overall	1	2	3	4	5	6

Q.304 The last part of the survey describes some services that CWCB provides to water users & suppliers. First, were you aware that CWCB offers loans for infrastructure Improvements?

Yes .. 1
No ... 2

Q.305 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive 1
2 2
3 3
4 4
5 = extremely attractive . ..5

[IF THE ANSWER TO QUESTION 304 IS 2, THEN SKIP TO QUESTION 308]

Q.306 Have you ever used this CWCB service?

Yes .. 1
No 2

[IF THE ANSWER TO QUESTION 306 IS 2, THEN SKIP TO QUESTION 308]

Q.307 And how would you rate that program on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor 1
2 2
3 3
4 4
5 = excellent .. 5

Q.308 Were you aware that CWCB offers grants for feasibility studies?

Yes .. 1
No ... 2

Q.309 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive 1
2 2
3 3
4 4
5 = extremely attractive. ..5

[IF THE ANSWER TO QUESTION 308 IS 2, THEN SKIP TO QUESTION 312]

Q.310 Have you ever used this CWCB service?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 310 IS 21, THEN SKIP TO QUESTION 312]

Q.311 And how would you rate that program on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor 1
2 2
3 3
4 4
5 = excellent .. 5

Q.312 The next series of questions are all related to CWCB technical assistance with particular issues. I am going to address a few issues individually. Were you aware that CWCB provides assistance with biological opinions, and wildlife and habitat assessments?

Yes .. 1
No ... 2

Q.313 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive ,....1
2 2
3 3
4 4
5 = extremely attractive , ..5

[IF THE ANSWER TO QUESTION 312 IS 2, THEN SKIP TO QUESTION 316]

Q.314 Have you ever used this CWCB service?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 314 IS 2, THEN SKIP TO QUESTION 316]

Q.315 And how would you rate the assistance on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor , ...1
2 2
3 3
4 4
5 = excellent .. 5

Q.316 Were you aware that CWCB provides assistance with compact issues?

Yes .. 1
No ... 2

Q.317 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive, ...1
2 2
3 3
4 4
5 = extremely attractive ,..5

[IF THE ANSWER TO QUESTION 316 IS 2, THEN SKIP TO QUESTION 320]

Q.318 Have you ever used this CWCB service?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 318 IS 2, THEN SKIP TO QUESTION 320]

Q.319 And how would you rate the assistance on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor , ...1
2 2
3 3
4 4
5 = excellent .. 5

Q.320 Were you aware that CWCB provides assistance with conservation planning?

Yes .. 1
No ... 2

Q.321 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive ,....1
2 2
3 3
4 4
5 = extremely attractive , ..5

[IF THE ANSWER TO QUESTION 320 IS 2, THEN SKIP TO QUESTION 324]

Q.322 Have you ever used this CWCB service?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 322 IS 2, THEN SKIP TO QUESTION 324]

Q.323 And how would you rate the assistance on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor ,,........1
2 2
3 3
4 4
5 = excellent .. 5

Q.324 Were you aware that CWCB provides assistance with dam safety?

Yes .. 1
No ... 2

Q.325 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive , ...1
2 2
3 3
4 4
5 = extremely attractive , ..5

[IF THE ANSWER TO QUESTION 324 IS 2, THEN SKIP TO QUESTION 328]

Q.326 Have you ever used this CWCB service?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 326 IS 2, THEN SKIP TO QUESTION 328]

Q.327 And how would you rate the assistance on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor 1
2 2
3 3
4 4
5 = excellent .. 5

Q.328 Were you aware that CWCB provides assistance with drought planning?

Yes .. 1
No ... 2

Q.329 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive …..1
2 2
3 3
4 4
5 = extremely attractive ,..5

[IF THE ANSWER TO QUESTION 328 IS 2, THEN SKIP TO QUESTION 332]

Q.330 Have you ever used this CWCB service?

Yes .. 1
No…….2

[IF THE ANSWER TO QUESTION 330 IS 2, THEN SKIP TO QUESTION 332]

Q.331 And how would you rate the assistance on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor 1
2 2
3 3
4 4
5 = excellent .. 5

Q.332 Were you aware that CWCB provides assistance with flood studies and evaluations?

Yes .. 1
No…….2

Q.333 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive 1
2 2
3 3
4 4
5 = extremely attractive . ..5

[IF THE ANSWER TO QUESTION 332 IS 2, THEN SKIP TO QUESTION 336]

Q.334 Have you ever used this CWCB service?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 334 IS 2, THEN SKIP TO QUESTION 336]

Q.335 And how would you rate the assistance on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor ………1
2 2
3 3
4 4
5 = excellent .. 5

Q.336 Were you aware that CWCB provides assistance with interpretation of water law?

Yes .. 1
No ... 2

Q.337 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive……1
2 2
3 3
4 4
5 = extremely attractive …5

[IF THE ANSWER TO QUESTION 336 IS 2, THEN SKIP TO QUESTION 340]

Q.338 Have you ever used this CWCB service?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 338 IS 2, THEN SKIP TO QUESTION 340]

Q.339 And how would you rate the assistance on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor 1
2 2
3 3
4 4
5 = excellent .. 5

Q.340 Were you aware that CWCB provides assistance with instream flow protection programs?

Yes .. 1
No ... 2

Q.341 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive……1
2 2
3 3
4 4
5 = extremely attractive….5

[IF THE ANSWER TO QUESTION 340 IS 2, THEN SKIP TO QUESTION 344]

Q.342 Have you ever used this CWCB service?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 342 IS 2, THEN SKIP TO QUESTION 344]

Q.343 And how would you rate the assistance on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor 1
2 2
3 3
4 4
5 = excellent .. 5

Q.344 Were you aware that CWCB provides assistance with maintaining natural lake levels?

Yes .. 1
No ... 2

Q.345 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive 1
2 2
3 3
4 4
5 = extremely attractive….5

[IF THE ANSWER TO QUESTION 344 IS 2, THEN SKIP TO QUESTION 348]

Q.346 Have you ever used this CWCB service?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 346 IS 2, THEN SKIP TO QUESTION 348]

Q.347 And how would you rate the assistance on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor 1
2 2
3 3
4 4
5 = excellent .. 5

Q.348 Were you aware that CWCB provides assistance with project feasibility studies?

Yes .. 1
No ... 2

Q.349 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive 1
2 2
3 3
4 4
5 = extremely attractive . ..5

[IF THE ANSWER TO QUESTION 348 IS 2, THEN SKIP TO QUESTION 352]

Q.350 Have you ever used this CWCB service?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 350 IS 2, THEN SKIP TO QUESTION 352]

Q.351 And how would you rate the assistance on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor 1
2 2
3 3
4 4
5 = excellent .. 5

Q.352 Were you aware that CWCB provides assistance with fiver and ecosystem restoration?

Yes .. 1
No ... 2

Q.353 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive 1
2 2
3 3
4 4
5 = extremely attractive . ..5

[IF THE ANSWER TO QUESTION 352 IS 2, THEN SKIP TO QUESTION 356]

Q.354 Have you ever used this CWCB service?

Yes .. 1
No 2

[IF THE ANSWER TO QUESTION 354 IS 2, THEN SKIP TO QUESTION 356]

Q.355 And how would you rate the assistance on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor ,.........1
2 2
3 3
4 4
5 = excellent .. 5

Q.356 Were you aware that CWCB provides assistance with stream and lake hydrology and hydraulics?

Yes .. 1
No ... 2

Q.357 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive 1
2 2
3 3
4 4
5 = extremely attractive ...5

[IF THE ANSWER TO QUESTION 356 IS 2, THEN SKIP TO QUESTION 360]

Q.358 Have you ever used this CWCB service?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 358 IS 2, THEN SKIP TO QUESTION 360]

Q.359 And how would you rate the assistance on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor 1
2 2
3 3
4 4
5 = excellent ...5

Q.360 Were you aware that CWCB provides assistance with water conservation planning?

Yes .. 1
No ... 2

Q.361 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive 1
2 2
3 3
4 4
5 = extremely attractive . ..5

[IF THE ANSWER TO QUESTION 360 IS 2, THEN SKIP TO QUESTION 364]

Q.362 Have you ever used this CWCB service?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 362 IS 2, THEN SKIP TO QUESTION 364]

Q.363 And how would you rate the assistance on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor 1
2 2
3 3
4 4
5 = excellent....5

Q.364 Were you aware that CWCB provides assistance with water systems sampling and monitoring?

Yes .. 1
No ... 2

Q.365 And how attractive (is that) (would that be) to you, on the 5-point scale where 1 is not at all attractive and 5 is extremely attractive?

1 = not at all attractive 1
2 2
3 3
4 4
5 = extremely attractive . ..5

[IF THE ANSWER TO QUESTION 364 IS 2, THEN SKIP TO QUESTION 368]

Q.366 Have you ever used this CWCB service?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 366 IS 2, THEN SKIP TO QUESTION 368]

Q.367 And how would you rate the assistance on the 5-point scale, where 1 is poor and 5 is excellent?

1 = poor 1
2 2
3 3
4 4
5 = excellent .. 5

Q.368 Finally, I'd like you rate several communication methods that the State might use to disseminate information to you regarding water & drought issues. Please rate each one on the 5-point scale, where 1 is poor and 5 is excellent for you personally.

	1=low	2	3	4	5=high
E-mail	1	2	3	4	5
Internet	1	2	3	4	5
Mail	1	2	3	4	5
Workshops/ Seminars	1	2	3	4	5
Attending CWCB Board Meetings	1	2	3	4	5
Phone Consultations	1	2	3	4	5
Face-to-Face	1	2	3	4	5
Media	1	2	3	4	5
Organizational Meetings	1	2	3	4	5

Q.369 Is there some other communication method that you would prefer that I didn't mention?

Yes .. 1
No ... 2

[IF THE ANSWER TO QUESTION 369 IS 2, THEN SKIP TO QUESTION 371]

Q.370 OTHER COMMUNICATION METHOD

Q.371 **Finally, please verify your first name:**

____

Q.372 **Your Last Name:**

____

Q.373 **Your Organization:**

____

Q.374 **Your Title:**

____

Q.375 **Your Basin:**

____

Q.376 Your Division:
(NOTE: MORE THAN ONE CHOICE IS ACCEPTABLE.)

Division 1 ..1
Division 2 ..2
Division 3 ..3
Division 4 ..4
Division 5 ..5
Division 6 ..6
Division 7 ..7

Q.377 **Your E-mail address:**

____

Q.378 **Your telephone number:**

____

Q.379 **And your fax number:**

____

Q.380 **Your proper mailing address, including suite # if you have one:**

____

____

Q.381 **Your City:**

____

Q.382 **Your zip code:**

____

Q.383 **Your county:**

____

Q.384 That's the end. Thank you very much for your participation in the Colorado Drought & Water Supply Assessment! The opinions of water users like you are invaluable in planning for and managing future drought in Colorado. We anticipate having results from this study posted on the CWCB website by the end of the year. As you may know, there are some upcoming large-scale water projects and initiatives *(if asked: CRRP, SWSI, CWCB Technical Project assistance)* that are going to be studied throughout the coming years to help address Colorado water concerns and needs. We encourage your participation in those studies to provide the State with information and your opinions. Thanks Again. Good- bye.

RECORD ANY NOTES/COMMENTS HERE:

____

____

____

Should you have questions about how to fill out this survey, please call 303-830-2345 or email info@re-search.com. If you have completed this survey & wish to mail it back to us, please return to:
Resolution Research
Attn: Colorado Drought & Water Supply Assessment
625 E 16th Ave., Suite 202
Denver CO 80203-2052

Appendix B – List of Participants

Academy Water & Sanitation District
Acord Land and Cattle Co.
Aldasoro Ranch & Homeowners Co
Alpha-Rockridge Metro District
American Soda
Amity Mutual Irrigation Co.
Anderson Ditch
Animas Citizens Irrigation Co
Animas Consolidated Ditch Co.
Arapahoe County
Arapahoe Estates Water District
Arapahoe Ranch
Arkansas Groundwater Users Ass
Avondale Water & Sanitation District
Badger Beaver Irrigation Co
Baller Livestock Co.
Bar A Ranch
Battlement Mesa Metropolitan District
Bear River Reservoir Co
Beaver Park Water Inc.
Beeler Ditch
Bergen Ditch & Reservoir Co
Beulah Water Works District
Bijou Irrigation Co & Dist
Blanca/Fort Garland Metro. District
Blue Mountain Energy
Blue Valley Metropolitan District
Board of Water Works of Pueblo
Bonus Ditch Co.
Boulder County Parks & Open Space
Braiden Cattle Company
Breckenridge Ski Resort
Buffalo Creek Water District
Buffalo Mutual Irrigation Co.
Bull Basin Res. and Irrigation Co.
Burke Brothers
C.R. Brown Ditch
Camp Redcloud Inc.
Castle Homestead New Ross Ditch
Castle Pines Metropolitan District
Catspaw Ranch
C-C Ditch Company
Centennial Water and Sanitation District
Central Colorado Water Conservancy District
Chaffee County
Chedsey Cattle Company
Cherokee Metropolitan District
Chevron Oil Company
Chipeta Water District
Chromo Ranches

City and County of Broomfield
City of Alamosa
City of Aspen
City of Aurora
City of Boulder
City of Brighton
City of Brush
City of Burlington
City of Cherry Hills Village
City of Cortez
City of Craig Public Works Department
City of Cripple Creek
City of Dacono
City of Durango
City of Engelwood
City of Federal Heights
City of Florence
City of Fort Collins
City of Fort Morgan
City of Fountain, Water Utility
City of Fruita
City of Glendale
City of Glenwood Springs
City of Golden, Public Works
City of Grand Junction
City of Greeley
City of Greenwood Village
City of Holyoke
City of Idaho Springs, Public Works
City of La Junta
City of Lafayette
City of Lakewood
City of Lakewood/Fox Hollow GC
City of Longmont
City of Louisville
City of Loveland
City of Monte Vista
City of Montrose
City of Northglenn
City of Ouray Public Works
City of Rifle
City of Rocky Ford
City of Salida
City of Steamboat Springs
City of Sterling
City of Thornton
City of Thornton Water Resource
City of Westminster
City of Wray
City of Yuma
Clear Creek County

Climax Mine
Clinton Ditch and Res Co
Clyncke Bear River Ranch
CMIRRA
Coal Ridge Ditch Co
Cold Spring Ranch Inc
Colorado Canal Co.
Colorado City Metropolitan District
Colorado Division of Water Resources
Colorado Division of Wildlife
Colorado Farm Bureau
Colorado Land Board
Colorado Parks
Colorado River Water Conservancy District
Colorado Springs Utilities
Colorado State Forest Service
Colorado Water Conservation Board
Colorado Water Protective Dev.
Colowyo Cole Co.
Commonwealth Irrigation Co.
Conejos Water Conservancy District
Copper Mountain Consolidated Metropolitan District
Costilla County Conservancy District
Cottonwood Reservoir Company
County of Hinsdale
Craig Station D&PL
Crawford Clipper Ditch
Crested Butte South Metropolitan District
Crowley County
Crystal Park Metropolitan Dist
CSU Cooperative Extension
Cucharas Sanitation & Water District
Custer County
Cyclone Ranch
Davis and Downey Ditch Co.
DD&E Reservoir
Deep Cut Irrigation Ditch
Deer Creek & Morapos Ditch
DeLine Land & Cattle Co.
Denver Water
Deweese Dye Ditch
Dewey Sheridan Ditch
Disappointment Creek
Dolores River Transbasin
Dolores Water Conservancy District
Donala Water & Sanitation District
Double RL Ranch Company
Duncan Ditch No. 1
Durango West Metro District #1
Durango West Metro District #2

E. M. Cooper
Eagle Ridge Ranch
Eagle River Water & Sanitation
East Alamosa Water & Sanitation District
East Boulder County Water District
East Dillon Water District
East Larimer County Water District
East Mesa Ditch Company
Eastdale Mutual Ditch & Reservoir Co
Echo Ditch Company
Edgemont Ranch Metro District
Eggleston No 1 Ditch Co
El Paso County
El Rancho Florida Metropolitan
Elk Head Ranch (McKinlay Ditch)
Elk Park Ranch
Elkhorn Irrigation Ditch/Wolf Ditch
Escalanta Ranch
Esty Ranch
Everett Marolf
Evergreen Metropolitan Dist.
Excel Energy Hayden Station
Family Ranch
Farmers Independent Ditch Co.
Farmer's Pawnee Canal Co.
Farmers Water Development Co.
Ferguson Ditch/Lazy EH Ranch
Fisher Ranch
Flat, Beckwooth, Island Ditches
Florida Water Conservancy District
Forest Lakes Metropolitan Dist
Fort Lyon Canal Co.
Fountain Mutual Metropolitan District
Fruitland Irrigation Co.
Garden Valley Water & Sanitation District
Garfield County
German Ditch Co
Grand Mesa Conservation District
Grand Mesa/Compadre & Gunnison
Grand Valley Irrigation Company
Grand Valley Water Users Assn
Grant Family Farms
Green Mesa Ranch
Grieser Ditch
Griffith Family Partnership
Groundwater Appropriators of the South Platte
Groundwater Association of South Platte
Gunnison River Water Conservancy District
H.H. Ditch Co.

Hartong Ranch
Hay Gulch Ditch, Inc.
Heather Gardens District
Henrylyn Irrigation District
Heritage Hills Metropolitan District
Highland Ditch Co
Hinsdale City Planning Commission
Hodgson Ditch
Holcim US Inc .
Holsinger Ranch
Hyde Canal
J. Braiden
Jackson County Water Conservancy District
Jackson Lake Reservoir & Irrigation Co
JB Ranch
Jim Porter
John Peroulis and Sons
John Rozman
John S. Sutton Ditch & Garland
Julesberg Irrigation District
Kent Rickenbaugh Estate
King Ditch Co.
Kirk Alexander
Knott Land & Livestock
Lake Catamount # 1 Metropolitan District
Last Chance Ditch Co
Left Hand Water District
Leggett Ditch Company
Lightner Canal Company
Lilylands Res. Co.
Little Thompson Water District
Logan County
Longmont Supply Ditch Co
Lost Lake Reservoir
Lost Miner Land Co.
LOV Ranch
Lower Arkansas Water Management
Lowline Ditch Co
Manassa Land & Irrigation
Mancos Water Conservancy District
Maybell Irrigation District
McKinlay Ditch #1 and #2
Meadow Island #1 Irrigation Co.
Meadow Island #2 Ditch Co
Menge Ranch
Menoken Water District
Meredith Res. Co.
Meridian Metropolitan District
Mesa County

Mesa View Water District
Meyring Livestock Co.
Michelle Veltri
Mid Valley Metropolitan Distri
Miners Mesa Residential Metro.
Missouri Heights Irrigation Co
Moffat County
Moncrief Ranch
Montezuma County Water District
Morrison Creek Water & Sanitation District
Mount Werner Water & San District
Mt. Crested Butte Water & Sanitation District
Multi-Trina Ditch - WD 45
Navajo Western Water District
Niblock Ditch
Nix Ranch
North Carter Lake Water District
North Pecos Water & Sanitation
North Range Metropolitan District
North Sterling Irrigation Dist
Northern Colorado Water Conservancy District
Northgate Water District
Northwest Council of Governments
Oldland Bros
Oneco Pump No. 2
Otero County
Otero County Farm Bureau
Owl Creek Ranches
Panorama Improvement District
Park Center Water District
Park Ditch Co. Inc.
Park Forest Water District
Parker Water and Sanitation District
Patterson Ditch
Peck Ditch CO
Peck Irrigation Ditch
Penrose Water District
Phillips County
Piedra Park Metropolitan Improvement
Pilcher Ranches
Pine Drive Water District
Pine River Canal Company
Pine River Irrigation District
Pinewood Springs Water District
Pioneer Lookout Water District
Platteville Irrigation and Milling Co
Pleasant View Metropolitan District
Post Ranch

Powderhorn Metro District
Powell Park Ditch
Power Ditch
Pueblo West Metropolitan District
Purgatory Metropolitan District
Rampart Range Metro. Districts
Red Mesa Res & Ditch
Red Mesa-Ward Reservoir & Ditch
Redden Ranches
Ridgewood Water District
Rio Blanco County
Rio Blanco Water Conservancy District
Rio Grande Water Conservation District
Riverbend Subdivision
Riverside Dairy
Riverside Irrigation Co.
Robert Morrison Ditch Company
Rocky Mountain Steel
Rockyford Canal Co.
Romero Irrigation Co.
Round Mountain Water & San. District
Routt County
Roxborough Park Metropolitan District
Runyon Ditch Co.
San Juan River Village Metro District
San Luis Valley Canal.
San Luis Valley Irrigation District
San Luis Water & Sanitation District
San Luis Water Conservancy District
San Miguel County
San Miguel Water Conservancy District
Sanchez Ditch and Reservoir Co
Sand Creek Metropolitan District
Sanford Canal Company
Schalnus Brothers Ditch
Scholl Ranch Inc
Section 3 Ditch (Godfrey Ditch)
Security Water District
Sedalia Water & Sanitation District
Sellers Crowell Reservoir
Seneca Coal Co.
Several Oak Creek Ditches
Sheridan Sanitation District 1
Silver Heights Water & Sanitation District
Silver Spur Ranches
Slate Ditch Co
Smith Ditch
Snake River Water District
Snow Mountain Ranch

Snyder and Smith Ditch Co
Snyder Ranches LLC
Soda Creek Ditch
South Adams County Water & Sanitation District
South Ledge Ditch Co.
South Platte Ditch Co
South Reservation Ditch Co
Southgate Water District
Southwestern Conservation District
Spann Ranches
St. Charles Mesa Water District
St. Vrain & Left Hand Water Co
State Line Ranches
Steamboat II Metropolitan Dist
Steamboat Lake State Park
Steamboat River District
Stetson Ranches
Stillwater Ditch Co
Stratmoor Hills Water District
Summit County Government
Summit Reservoir & Irrigation
Summit Ridge Water District
Sunset Water District
Superior/McCaslin Interchange
Supply Ditch Co
Taylor Park Trading Post
Teller County Water & Sanitation District
Terrace Irrigation Company
Thomas Doudle Ditch
Todd Shallbetter
Town of Aguilar
Town of Akron
Town of Alma
Town of Antonito
Town of Arriba
Town of Avon
Town of Bayfield
Town of Bennett
Town of Berthoud
Town of Bethune
Town of Boone
Town of Breckenridge
Town of Brookside
Town of Campo
Town of Carbondale

Town of Cedaredge
Town of Center
Town of Crawford
Town of Creede
Town of Crested Butte
Town of Crestone
Town of Del Norte
Town of Dillon Public Works
Town of Dinosaur
Town of Eads
Town of Eaton
Town of Eckley
Town of Estes Park
Town of Fairplay
Town of Flagler
Town of Fowler
Town of Foxfield
Town of Frisco
Town of Grand Lake
Town of Green Mountain Falls
Town of Gypsum
Town of Hayden
Town of Hudson
Town of Hugo
Town of Ignacio
Town of Jamestown
Town of Keenesburg
Town of Kersey
Town of Kiowa
Town of Kremmling
Town of La Veta
Town of Lake City
Town of Limon
Town of Lochbuie
Town of Log Lane Village
Town of Lyons
Town of Mancos
Town of Manzanola
Town of Meeker
Town of Monument, Water Dept
Town of Morrison
Town of New Castle
Town of Norwood
Town of Nucla
Town of Oak Creek Public Works
Town of Orchard City
Town of Otis

Town of Ovid
Town of Pagosa Springs
Town of Palisade
Town of Palmer Lake
Town of Paonia
Town of Peetz
Town of Phippsburg
Town of Poncha Springs
Town of Rangely
Town of Rico
Town of Ridgway
Town of Romeo
Town of Saguache
Town of Sanford
Town of Sedgwick
Town of Snowmass Village
Town of Springfield
Town of Telluride
Town of Vilas
Town of Walden Public Works
Town of Walsh
Town of Wellington Public Work
Town of Windsor
Town of Yampa
Tree Haus Metropolitan District
Triview Metropolitan District
Trowel Ditch
Twenty Mile Coal Company
Twin Lakes Reservoir & Canal Co
UMETCO Minerals Corp.
Uncompahgre Valley Water Users
Uncompahgre Valley Water Users Association
Upper Arkansas Water Conservancy District
Upper Gunnison River Water Conservancy District
Upper South Platte Water Conservancy District
Upper Yampa Water Conservancy District
US Bureau of Land Management
US Bureau of Reclamation
US Bureau of Reclamation/western
US Fish & Wildlife Service
US Fish & Wildlife, Arapaho NW
US Forest Service
USA for BIA/Ute Tribe
USFS - Rocky Mountain Region

USFS/ Rio Grande
Ute Mtn. Farm & Ranch Enterprise
Ute Water Conservancy District
Various Other Ditch Companies
Villages At Castle Rock Metropolitan District
Vougha Reservoir Association
Walden Reservoir Co
Walker Ditch
Wapiti Canyon Ranch
Ward Canal Co
Wattenberg Ranches
Waunita Hot Springs Ranch
Webber Reservoir and Ditch Company
Weimer Ranch
Welch Ditch
West Divide Water Conservancy District
West Fort Collins Water District
West Plains Energy (Aquila, In.)
Westcreek Lakes Water District
Western Mutual Ditch Co.
Western Sugar
Westlands
Westside Canal
Westside Canal
Wheat Ridge Water District
White River Nahcolite Minerals
White River Soil Conservation
Whitewater Bldg. Materials Cor.
Widefield Water & Sanitation
Williams Irrigation Ditch
Willow Brook Metropolitan Dist
Willow Creek Ditch
Wolf Land Co.
Wolfer Ditch Corporation
Woodchuck Ditch
Woolery Ditch
Xcel Energy
Yellow-Jacket Water Conservancy District

The Colorado Water Conservation Board (CWCB) makes numerous services available to Colorado water users and part of the assessment aimed to determine which users utilize the services in order to maximize assistance provided. Respondents were first asked whether or not they were aware of a particular CWCB service and then asked to rate its attractiveness in relation to the respondent's water entity. Respondents were then asked whether their entities had used the service and those who had, were asked to rate the service using a 5-point scale, where 1 is not attractive and 5 is very attractive.

The two most recognized CWCB services by respondents involved funding. Loans for infrastructure improvements and grants for feasibility studies were by far the most prominent services. Sixty-seven percent of respondents indicated awareness of the availability of loans for infrastructure improvements and almost half rated it an attractive service for their entity. As the most used service (one in four respondents had used loans for infrastructure improvements), nearly 80% rated the service 4-5. More than half of the respondents also were aware of the grants for feasibility studies, with 46% rating it attractive or extremely attractive. The grants were the second most used service of the assessment, with 14% claiming they had utilized them, and 77% of its users rating it a 4-5.

Assistance with dam safety was also a prominent service among the respondents. Over half said they are aware of the service and one in three finds it attractive for their entity. Only 11% of respondents had used CWCB assistance with dam safety, but of those, almost 80% rated the service 4-5.

The service respondents rated the most attractive was assistance with interpretation of water law. Surprisingly, this service had one of the lowest awareness ratings as only 29% of respondents know that CWCB offers this assistance.

CWCB services and their associated ratings, which were consistent across Divisions & Segments, are listed below.

Table C-1: Ratings of CWCB Services

	Awareness %	Attractive % 4-5	Attractive Mean	Used %	Satisfaction Rating % 4-5	Satisfaction Rating Mean
Loans for infrastructure improvements	67	46	3.3	25	77	4.0
Grants for feasibility studies	52	46	3.3	14	77	4.1
Assistance w /biological opinions & wildlife/habitat assessments	32	20	2.6	3	39	3.4
Assistance w/ compact issues	37	27	2.6	5	64	3.8
Assistance w/ dam safety	53	31	2.6	11	79	4.0
Assistance w/ drought planning	44	40	3.1	4	60	3.6
Assist w/ flood studies & evaluations	47	29	2.7	10	64	3.9
Assist w/ interpretation of water law	29	48	3.3	6	52	3.8
Assist w/ instream flow protection programs	48	35	2.8	7	56	3.7
Assist w/ maintaining natural lake levels	23	20	2.3	1	50	3.3
Assist w/ project feasibility studies	49	39	3.1	11	80	4.0
Assist w/ river & ecosystem restoration	36	25	2.6	3	76	4.1
Assist w/ stream & lake hydrology & hydraulics	35	24	2.6	4	66	4.0
Assist w/ water conservation planning	59	38	3.1	6	57	3.7
Assist w/ water systems sampling & monitoring	29	29	2.7	5	76	4.2

Services of which respondents are most aware:

Loans for infrastructure improvements	67%
Assistance with water conservation planning	59%
Assistance with dam safety	53%
Grants for feasibility studies	52%

Most attractive services (given a rating of 4-5):

Assistance with interpretation of water law*	48%	Mean 3.3
Loans for infrastructure improvements	46%	Mean 3.3
Grants for feasibility studies	46%	Mean 3.3

*It is interesting to note that this service had one of the lowest awareness ratings at only 29%

Most used services:

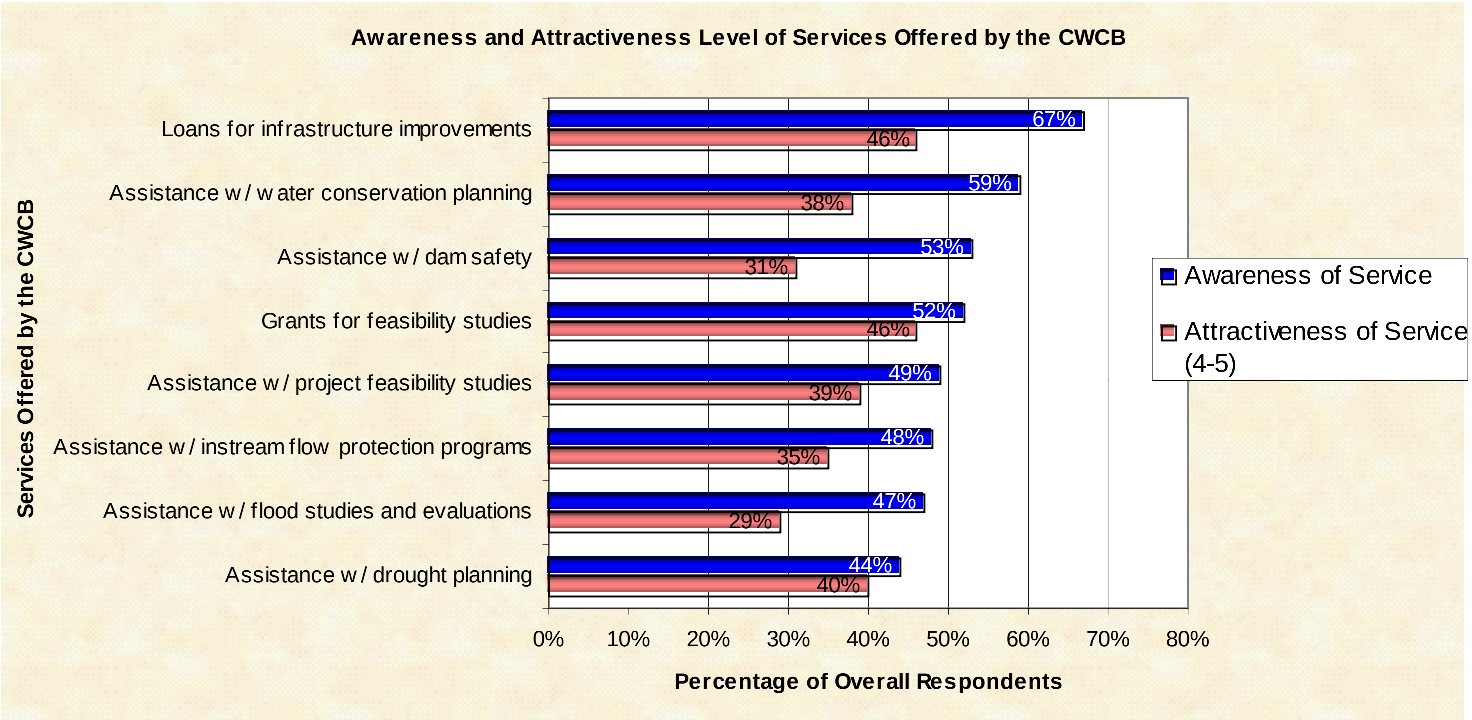
Loans for infrastructure improvements	24%
Grants for feasibility studies	14
Assistance with feasibility studies	11
Assistance with dam safety	11

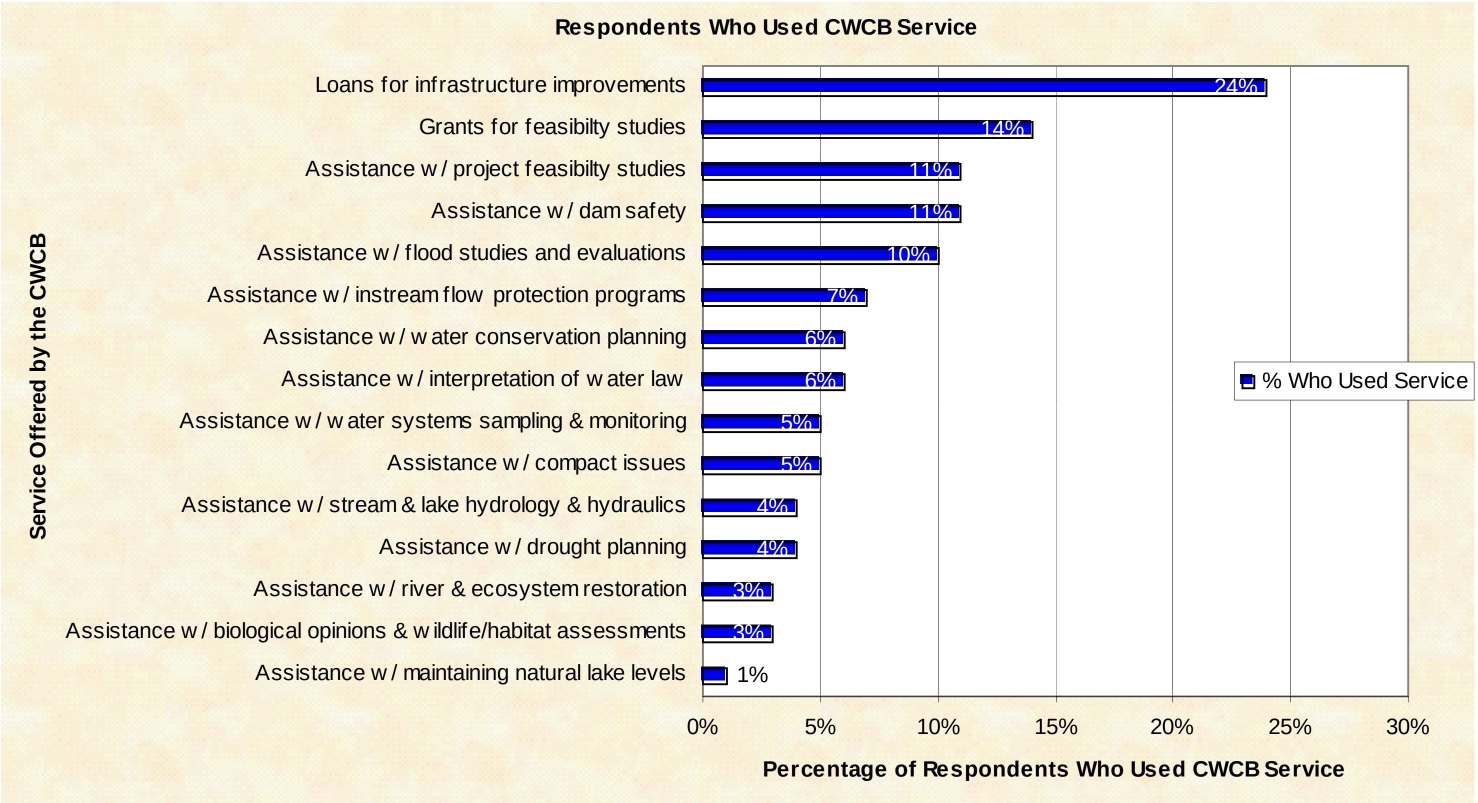
Highest rated services of those who used them (given a 4-5):

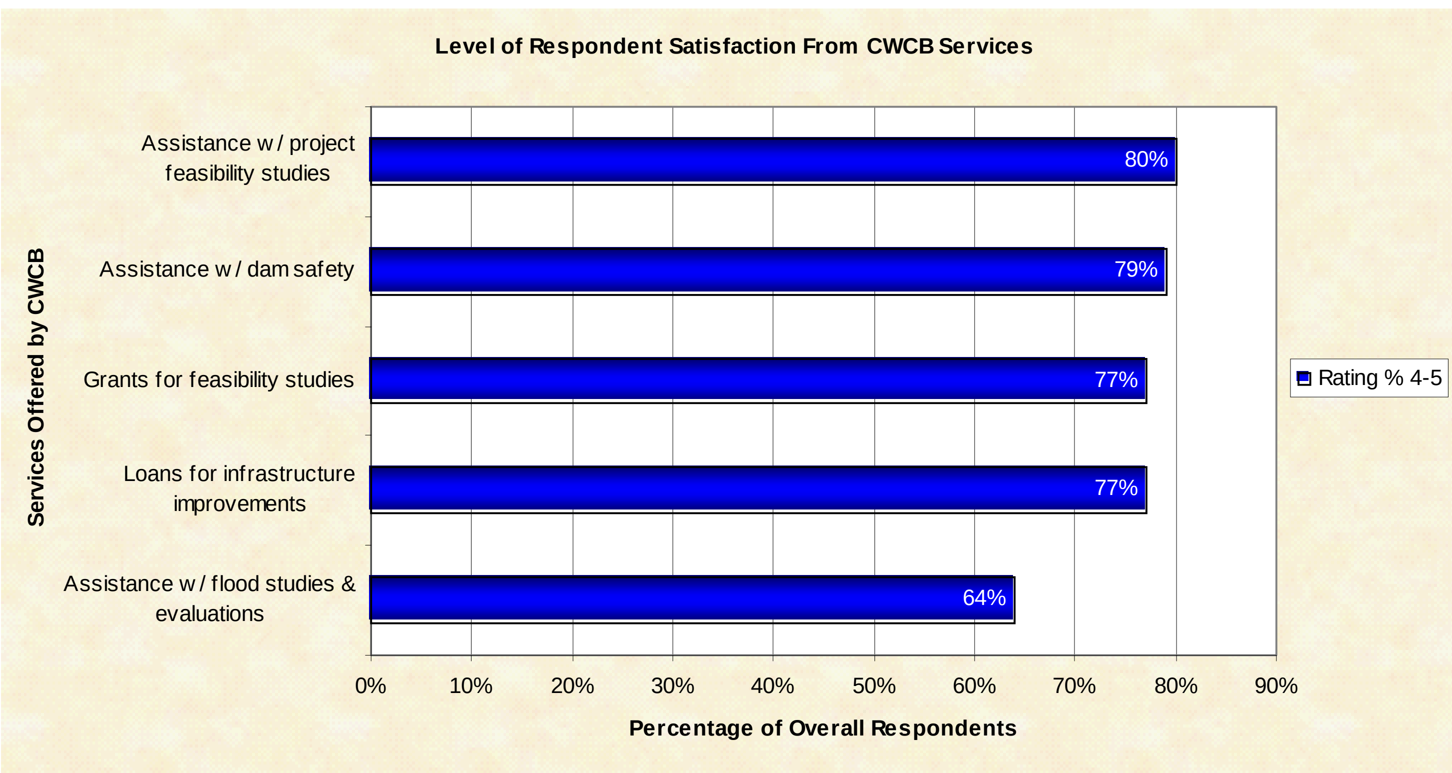
Assistance with project feasibility studies	80%
Assistance with dam safety	79
Loans for infrastructure improvements	77
Grants for feasibility studies	77

Highest rated services of those who used them:

Assistance with water systems sampling & monitoring	Mean 4.2
Grants for feasibility studies	Mean 4.1
Assistance with river & ecosystem restoration	Mean 4.1


Awareness and Attractiveness Level of Services Offered by the CWCB
Services Offered by the CWCB
Loans for infrastructure improvements
Assistance w/ water conservation planning
Assistance w/ dam safety
Grants for feasibility studies
Assistance w/ project feasibility studies
Assistance w/ instream flow protection programs
Assistance w/ flood studies and evaluations
Assistance w/ drought planning
67%
46%
59%
38%
53%
31%
52%
46%
49%
39%
48%
35%
47%
29%
44%
40%
0%
10%
20%
30%
40%
50%
60%
70%
80%
Percentage of Overall Respondents
Awareness of Service
Attractiveness of Service (4-5)


Respondents Who Used CWCB Service
Loans for infrastructure improvements 24%
Grants for feasibilty studies 14%
Assistance w / project feasibilty studies 11%
Assistance w / dam safety 11%
Assistance w / flood studies and evaluations 10%
Assistance w / instream flow protection programs 7%
Assistance w / w ater conservation planning 6%
Assistance w / interpretation of w ater law 6%
Assistance w / w ater systems sampling & monitoring 5%
Assistance w / compact issues 5%
Assistance w / stream & lake hydrology & hydraulics 4%
Assistance w / drought planning 4%
Assistance w / river & ecosystem restoration 3%
Assistance w / biological opinions & w ildlife/habitat assessments 3%
Assistance w / maintaining natural lake levels 1%
0% 5% 10% 15% 20% 25% 30%
Percentage of Respondents Who Used CWCB Service
Service Offered by the CWCB
% Who Used Service


Level of Respondent Satisfaction From CWCB Services
Assistance w / project feasibility studies 80%
Assistance w / dam safety 79%
Grants for feasibility studies 77%
Loans for infrastructure improvements 77%
Assistance w / flood studies & evaluations 64%
0% 10% 20% 30% 40% 50% 60% 70% 80% 90%
Percentage of Overall Respondents
Services Offered by CWCB
Rating % 4-5