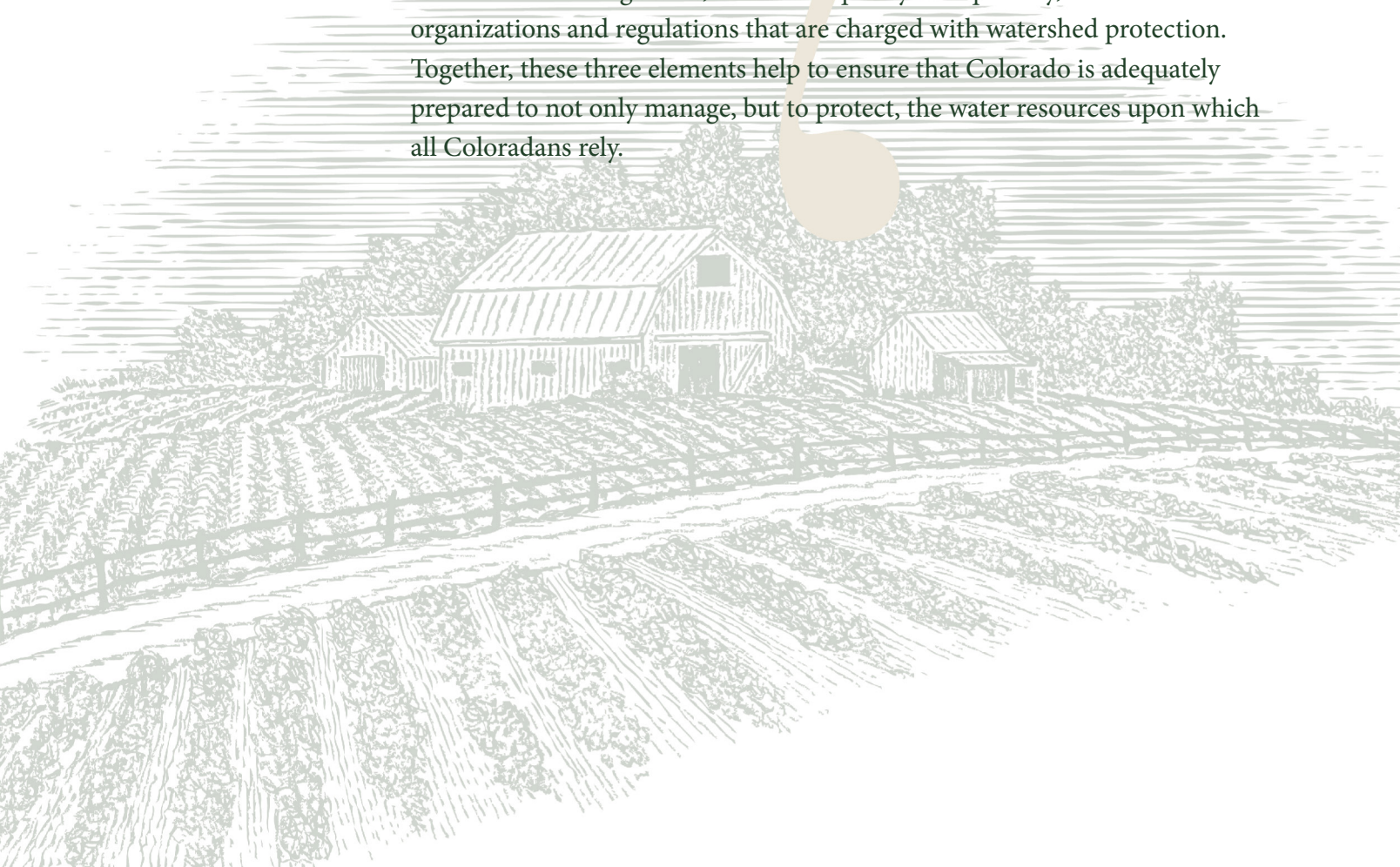
Water Resource Management and Protection

Chapter 7 examines factors beyond supply and demand that affect water availability, such as natural hazards, watershed health, and water quality. Section 7.1 delves further into watershed health, including the effect of natural disasters on watershed health, management strategies, and the critical role watershed health plays in ensuring Colorado's water future. In particular, this section, emphasizes the ways stakeholders can work together through collaboration and information-sharing. Section 7.2 provides an overview of natural hazards, which can result in serious consequences for our state's watersheds, drive up demands for water, and influence water quality. Natural hazards and watershed health influence water quality, which is of utmost importance to water providers, and Colorado's wildlife, which depends on healthy streams. Section 7.3 provides a detailed exploration of watershed management, watershed quality and quantity, and the organizations and regulations that are charged with watershed protection. Together, these three elements help to ensure that Colorado is adequately prepared to not only manage, but to protect, the water resources upon which all Coloradans rely.



Fires can seriously degrade the water quality and capacity of reservoirs for years to come. Flash flooding can carry burnt earth and debris into them. This underscores the need for healthy watersheds and natural disaster preparedness and recovery.
High Park Fire, 2012.

7.1 WATERSHED HEALTH AND MANAGEMENT

GOAL

Colorado's Water Plan promotes watershed health and supports the development of watershed coalitions and watershed master plans that address the needs of a diverse set of local stakeholders.

Introduction

Watersheds connect terrestrial, freshwater, and coastal ecosystems. They also provide ecosystem services, such as carbon sequestration, water supply, filtration, and purification.[1] Colorado watersheds support multi-objective uses for both consumptive and nonconsumptive water supply. Approximately 80 percent of Colorado's population relies on forested watersheds to deliver municipal water supplies.[2] Watershed health management strategies that protect this domestic supply will also protect other uses in the watershed.

Colorado's mountain watersheds have a strong influence on the quality and quantity of water. Watershed geography includes physical aspects, such as climate and geology, and ecological aspects, such as stream biology; but it also examines the relationships between humans, land and water. Healthy watersheds provide ecosystem services that benefit ecological processes, local and state economies, and social stability. Ecosystem services include flow regulation, flood attenuation, water purification, erosion control, dilution and flushing of contaminants, and habitat protection.

This section begins by defining the physical processes that influence watershed health, and then discusses recommended strategies for successful stewardship of watersheds and water supply. It concludes with a summary of the roundtables' watershed health strategies.

Watershed Health Science

A watershed is an area of land in which all water drains to a common point. Watersheds exist at all spatial scales, from the tiniest of tributaries to the largest rivers on earth. John Wesley Powell defined a watershed as "that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community." Headwater areas include forested watersheds, intermountain wetland complexes (parks), and the riparian corridors of stream valleys, and are the natural forebays of Colorado's water supply. As water from snowmelt and rain travels down-gradient to reach rivers, it must move through varying terrain, interacting with the watershed's biology and physical environment. This is the watershed's ecosystem. Water quality and quantity are intimately linked to watershed health.

Broadly defined, watershed health is a measure of ecosystem structure and function. Structure refers to species richness (characterized by abundance and diversity), inorganic and organic resources, and physical attributes (including habitat complexity). Function refers to ecosystem processes such as the hydrologic cycle, nutrient cycling, energy flow, and succession.[3] A critical component of the hydrologic cycle is flow regime. Flow regime defines the magnitude, duration, frequency, rate of change, and

timing of flows in stream systems. Magnitude refers to a river's discharge. Duration describes the period of time during which a river experiences a given discharge. The frequency at which a river experiences a given discharge and the rate at which discharges increase and decrease (i.e. change), also characterizes flow regime. Finally, a watershed's hydrologic function influences the timing of discharges, or seasonality. Figure 7.1-1 represents an annual median-flow hydrograph for a snowmelt-driven stream. This figure describes the different elements of flow regimes. Society has adapted its water supply infrastructure to the flow regime of its watersheds. Changes in ecosystem structure and function have direct and indirect effects on a stream's flow regime.

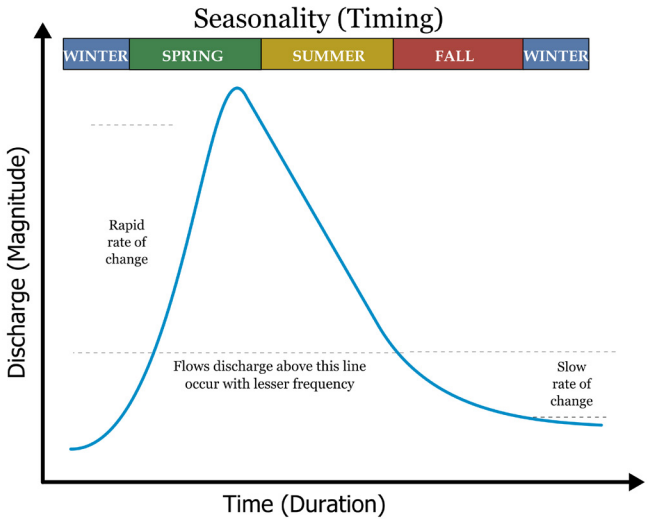
Watersheds support dynamic ecosystems that are subject to natural perturbations, such as fire, flood, and drought.[4] Resilient ecosystems exist in a state of dynamic equilibrium (for example, the flow regime may deviate around a mean while still maintaining its function). These watersheds experience natural disturbances with little effect on function. Often, anthropogenic, or human-induced, activities exacerbate the impacts resulting from fire, flood, and drought. For example, watersheds that have historically been managed to suppress fires have changed ecosystem structure and productivity. This results in fires that burn with greater intensity and leads to soil hydrophobicity, which in turn increases runoff and erosion. When natural ecosystem functions are altered, a watershed may no longer exist in equilibrium. The resultant changes to hydrologic function and water quality may have direct effects on water supply and infrastructure.

Sediment is the most concerning non-point source pollutant our forested lands contribute.[5] An accelerated delivery of sediment in rivers has negative effects on both consumptive and nonconsumptive water uses. Sediment flows into river systems through natural processes that connect land and water. High- to moderate-severity fires, forest roads with failing stormwater management infrastructure, and other processes in which humans or natural causes alter the landscape cause erosion, which increases the volumes of sediment in river systems.

Forests and riparian corridors provide ecosystem services for watersheds that help protect, restore, and sustain water quality and quantity. Healthy, forested watersheds absorb rainfall and snowmelt and allow it to runoff slowly, recharge aquifers, sustain streamflows, and filter pollutants. Healthy forest ecosystems largely protect watersheds because they protect soil, thereby preventing erosion, promoting soil-moisture storage, and allowing groundwater recharge.[6] These services can offset natural hazards by reducing floods, maintaining plant communities, and reducing contaminants. Present-day forest-health concerns are largely attributed to climate change and forest-stand density, ecosystem productivity.[7] Climate change has the potential to affect watershed health by increasing temperatures, altering precipitation patterns, and causing earlier snowmelt. This results in potential increases in stream temperatures, increased pollutant concentrations, reduced quality of aquatic habitats, and loss of wetlands. Conversely, healthy watersheds may increase climate change resiliency and provide natural carbon sequestration.[8]

While forests are vital to overall watershed health, lower elevation rangelands comprise the remaining lands in the watershed. Rangelands, wetlands, and riparian corridors play a substantial role in water storage, transport, sediment control, water quality,

FIGURE 7.1-1 STREAM HYDROGRAPH



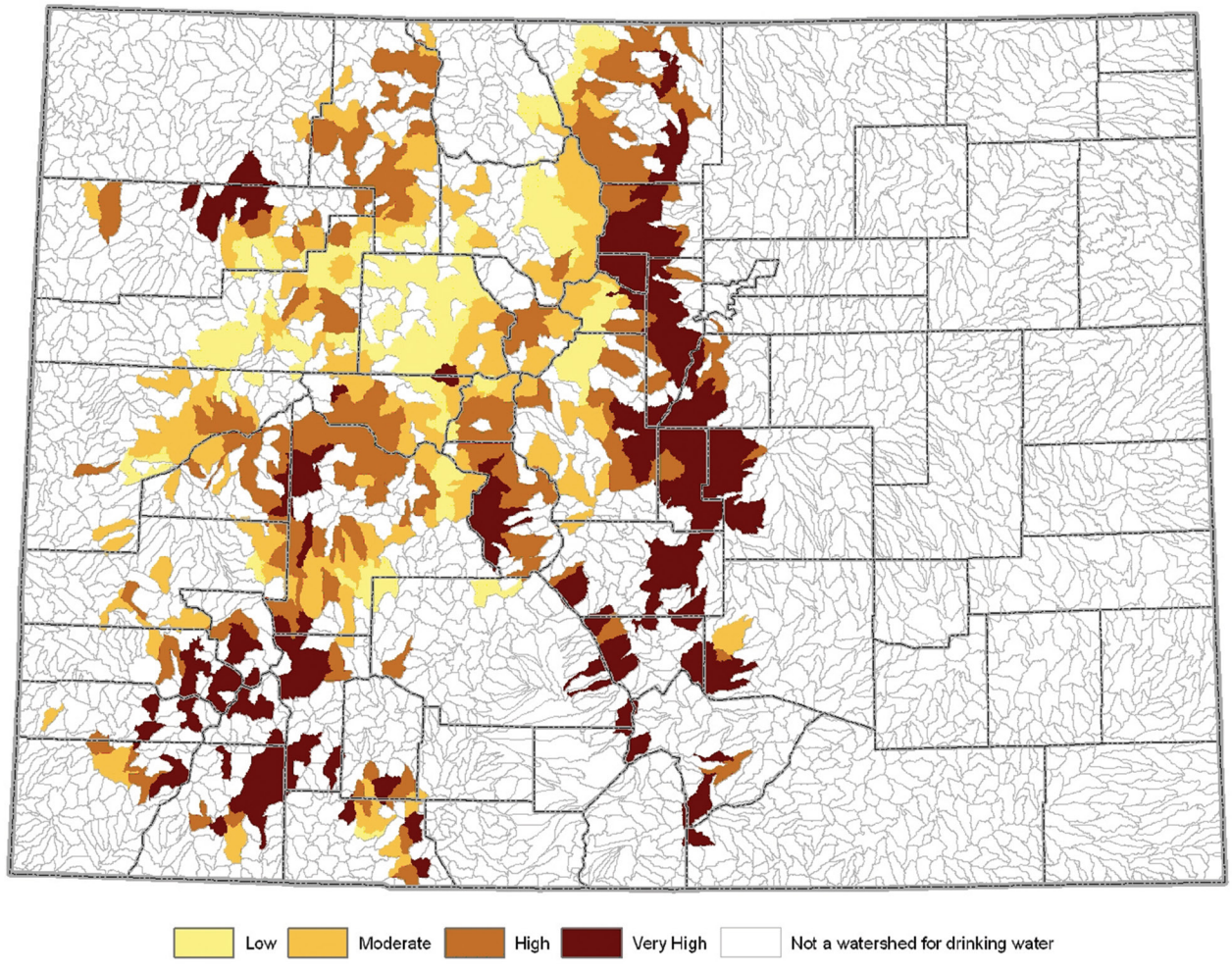
wildlife habitat, and streamflows. The presence of wetland complexes and optimal agricultural practices may favorably influence lower-elevation watershed health.

Watershed Partnerships

Watershed management for healthy ecosystem structure and function can provide a unique opportunity for watershed stakeholders. Successful watershed management necessitates a pragmatic approach that includes coalition-building, data collection, planning, prioritization, implementation, and monitoring. This is a cyclical process, and each phase requires continued efforts. Watersheds span across political boundaries, and watershed health management involves collaboration among many interested entities. Natural resource management may be the driver that catalyzes a need for collaboration, but social, political, and economic interests must be represented as well.

A watershed approach is a flexible framework for managing water-resource quality and quantity within specified drainage areas, or watersheds. This approach includes stakeholder involvement and management

FIGURE 7.1-2 COLORADO STATE FOREST SERVICE RISK OF POST-FIRE EROSION IN WATERSHEDS THAT ARE IMPORTANT SOURCES OF DRINKING WATER



Healthy watersheds are critical not only for wildlife and streams, but also water quality and water infrastructure.

actions supported by sound science and appropriate technology. Coalition-building typically starts when interested parties come together to discuss a watershed health concern. For example, Colorado identifies many watersheds as having a high post-fire erosion risk as well as being a critical watershed for water supply (Figure 7.1-2).[9] This is an example in which concerned stakeholders can engage in collaborative dialogues to address very real watershed health concerns. Coalitions form to address a variety of concerns, including pre- and post-fire mitigation, forest mortality, water quality impairments, potential impacts of abandoned mines, flood mitigation and recovery, aquatic and riparian habitat enhancement, and land-use change. In September 2013, flooding in the Front Range resulted in the formation of 10 new watershed coalitions that developed master plans focusing on stream restoration. Other groups may come together to discuss watershed protection in well functioning ecosystems. Collaboration before a threshold-crossing disturbance takes place sets the stage for faster and more resilient recovery measures.

The State of Colorado recommends that partnerships form an organizational structure consisting of a diverse stakeholder group and a coordinator. The State recommends this structure whether or not the coalition chooses to become incorporated. The coalition should be open to diverse interests within the watershed, as well as to interests the watershed outputs directly affect. Diverse stakeholder input at the beginning stages of coalition-building increases the likelihood that actions to improve watershed health will succeed. Engaged community members are more likely to participate in building political will, developing management options, and supporting project implementation. Stakeholder representation includes all levels of government, special districts, private landowners, businesses, citizens, nonprofits, educators, recreational interests, agricultural interests, grantors, and conservationists. A paid watershed coordinator improves the chances for continued coalition success by servicing all coalition stakeholders equally and by representing the interests of all coalition members. They are the unifying body, the moderator, the facilitator, and the manager. It is helpful for this person to have a background in both nonprofit and governmental work.[10]

Ideally, partnerships work to develop a watershed plan. A watershed plan is a strategy that defines a coalition's mission, goals, and objectives, along with assessment and management information, for a geographically defined watershed. The strategy should include the analyses, actions, participants, and resources related to developing and implementing the plan. It may include or be informed by a streamflow management plan (which Chapter 6.6 defines). The plan may serve as a guide for mitigation of fires and floods, or for the development of new infrastructure. It can also offer a holistic approach for the rehabilitation of stream systems. The watershed plan development process will require a leader with a certain level of technical expertise, and the participation of a variety of stakeholders with diverse skills and knowledge. These

participants will aid in the assemblage and assimilation of watershed information—including geographic information systems data, maps, monitoring reports, risk analysis, and existing assessments.

A holistic watershed planning approach will provide the most technically sound and economically efficient means of addressing watershed health concerns. The involvement of stakeholders strengthens the process. This approach will address all of the beneficial uses of the water that the watershed supplies, the criteria needed to protect the uses, and the strategies required to restore or protect ecosystem processes. This approach also expedites cooperative and integrated water-supply planning, which leads to successful implementation of watershed health management strategies. Examples of partnerships formed to address these issues are detailed below.

Forest Health Partnerships

Fires are a part of Colorado's forest ecosystems. Forest management for fire prevention has proven to exacerbate burn intensity.[11] Many stakeholders have come together to address forest health through fire mitigation strategies. The USFS has partnered with Colorado's municipal water providers, state agencies, and private interests through the Rocky Mountain Protection Partnership. This partnership functions to preserve water quality by mitigating the effects of forest-landscape change that severe fires and pine beetles have caused.[12] It is also a venue to strategize post-fire restoration in critical watersheds on public and private lands. Key municipal water providers include Denver Water, Aurora Water, Colorado Springs Utilities, Northern Water Conservancy District, and the Pueblo Board of Water Works. The National Forest Foundation and the Coalition for the Upper South Platte are nonprofit organizations that play a critical role in the partnership. Federal and state funds are leveraging partner funds to plant trees, treat hazardous fuels, restore riparian and wetland areas, treat invasive species, restore trails, decommission roads, restore stream channels, and engage volunteers.

Federal, state, and local governments and private partners formed the Watershed Wildfire Protection Group in 2007. The group's vision "is to protect Colorado water supplies and critical infrastructure from catastrophic wildfire and other threats by maintaining healthy, resilient watersheds through collaboration, implementation, leveraging, and education." Core members of this group include the CWCB, the Colorado State Forest Service, the USFS, Denver Water, Aurora Water, the Coalition for the Upper South Platte, and J.W. Associates. The group provides education and outreach activities statewide and connects practitioners with funders.

The CWCB recommends that those who are considering the formation of forest-health partnerships read the Forest Land and Resource Management Plan for their national forest, as well as consult the entities above. These partnerships have explored and prioritized strategies to implement pre- and post-fire mitigation projects for the improvement of forest health and protection of critical water supplies. Existing forest health partnerships are adept at leveraging funds and resources from federal, state, and local government agencies as well as from private companies, foundations, and nonprofits. The CWCB has leveraged funds from various grant programs to improve forest health. These include the Colorado Healthy Rivers Fund, the Colorado Watershed Restoration Program, the Fish and Wildlife Resources Fund, and the Water Supply Reserve Account. The success of the Watershed Wildfire Protection Group helps showcase it as an example for other watershed partnerships, as it is exemplary in its efforts to build consensus among diverse stakeholders and implement cost-effective strategies that benefit all interests.

Basin Implementation Plan Strategies

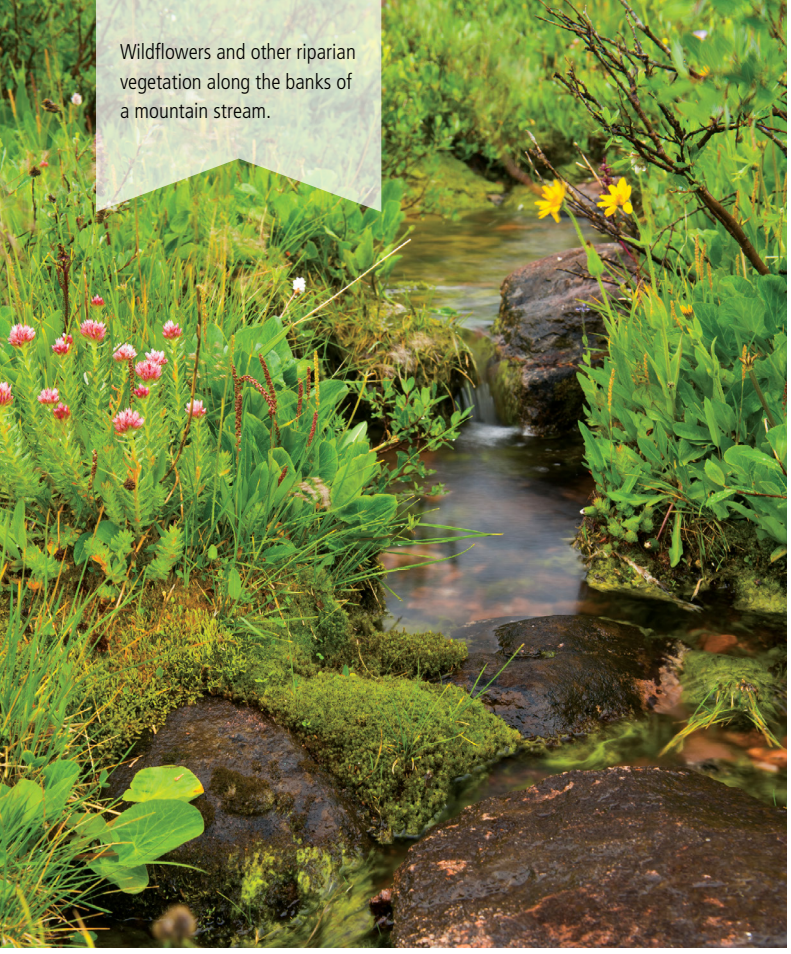
With the roundtables' guidance and CWCB's recommendation, watershed health for individual basins largely focuses on forest-health concerns. Forest health concerns center on wildfire, flooding, and sedimentation. The CWCB asked basins to identify projects and methods that would protect critical water supplies and the environment in the event of a natural disaster at the watershed scale. The CWCB recommended that basins assemble or develop existing watershed assessments. It also recommended that basins begin collaborative discussions on managing forests to benefit water supply. The CWCB encouraged basins with water supplies originating in another basin to work collaboratively.

FIGURE 7.1-3 COALITION STAKEHOLDER FIGURE

> "The Arkansas Basin illustrates a process with a strong emphasis on pre-disaster preparedness through collaborative dialogues with potentially affected parties."

All of the basin roundtables identify wildfire as a watershed-health concern. This includes recovery from existing fires and identification of pre-fire mitigation strategies. The Arkansas Basin illustrates a process with a strong emphasis on pre-disaster preparedness through collaborative dialogues with potentially affected parties. Figure 7.1-3 outlines the Watershed Health and Emergency Event Life Cycle and the role of stakeholders.[13]

The Rio Grande Basin contributed to the Arkansas Basin's watershed health planning process and closely aligns with that of the Arkansas Basin's approach to watershed health. The primary goal of the basin is to "protect, preserve and/or restore the sustainability of the Rio Grande Basin watershed by focusing on the watershed health and ecosystem function." The basin developed a collaborative watershed coalition during the 2013 West Fork Fire, and discovered the benefits of such a group for restoration and protection of forested watersheds. The coalition known as the Rio Grande Watershed Emergency Action Coordination Team (known as RWEACT) has modeled post-fire hydrology, improved its ability to forecast storms, identified flood potential, and developed post-wildfire flood-risk analysis maps. The basin's watershed health



Wildflowers and other riparian vegetation along the banks of a mountain stream.

actions emphasize forest management and stakeholder coordination. Methods to improve forest health include forest thinning and prescribed burning. In addition, the Rio Grande Basin included soil health for agricultural lands as a key action in its plan.[14]

> "The basin [Rio Grande] developed a collaborative watershed coalition during the 2013 West Fork Fire, and discovered the benefits of such a group for restoration and protection of forested watersheds."

The South Platte and Metro Basins also participated in the Arkansas Basin's watershed-health planning process. They propose a collaborative dialogue that focuses on post-fire mitigation across watershed (basin) boundaries. Deliverables resulting from this process will include the development of forest-health manuals at a statewide level. The basin watershed-health section in this plan also discusses insect infestations, but concludes that insects have little direct influence on water quality and quantity.[15]

The Southwest Basin has a history of collaborative watershed groups focused on watershed-health topics. This includes forest health and resiliency planning for the San Juan and Piedra watersheds; water quality monitoring and action on the Animas River; watershed health assessments for the Mancos, Dolores, and San Miguel watersheds; and development of Source Water Protection Plans for 23 public water suppliers. A Source Water Protection Plan inventories potential sources of drinking-water contamination in a defined watershed. These efforts have fostered dialogue and action that can help protect critical water supplies from fire risk, contaminants, and other hazards.[16]

> "The South Platte and Metro Basins also participated in the Arkansas Basin's watershed-health planning process."

The Yampa, White, and Green Basin states that more than one-third of its jobs are dependent on water quality, which is influenced by watershed health. They acknowledge that communities in the basin are susceptible to water quality issues that severe wildfires cause. The basin references a Critical Community Watershed Wildfire Protection Plan entitled, "Upper Yampa Phase I Watershed Assessment: Prioritization of Watershed Base Hazards to Water Supply." The plan frequently recommends watershed-wildfire planning for watersheds that are critical to water supply, and provides composite hazard rankings for wildfire hazards, flooding/debris flow-risk, and soil erodibility. These data are combined with Source Water Assessment and Protection data to prioritize critical watersheds.[17] Presently, the Watershed Wildfire Protection Plan prioritizes forest-health treatments for watersheds that are critical to drinking water supply; however, the basins could apply these treatments to any prioritized water use.[18]

> "The Yampa, White, and Green Basin states that more than one-third of its jobs are dependent on water quality, which is influenced by watershed health."

The Gunnison Basin is addressing forest-health concerns by partnering with the Colorado State and USFS to manage forests, insects, and wildfire. The basin also expects to conduct education and outreach associated with this effort. It did not participate in the Arkansas Basin's watershed-health planning process, but does plan to reference produced materials for future watershed-health projects. That said, several local watershed groups are working in the Gunnison Basin to address general watershed health and specific water quality challenges. These groups have developed comprehensive watershed plans.[19]

"The Gunnison Basin is addressing forest-health concerns by partnering with the Colorado State and USFS to manage forests, insects, and wildfire."

A goal of the North Platte Basin is to enhance forest health and management efforts for wildfire protection and beetle-kill effects on watershed health. To reach this goal, the basin has funded a major study that monitors forest beetle-kill, wildfire potential, and effects on water quality and quantity. It also looks at management alternatives in the post-beetle kill forest environment. The study is nearing completion, and the basin intends to review, disseminate, and implement recommendations the study identifies.[20]

"A goal of the North Platte Basin is to enhance forest health and management efforts for wildfire protection and beetle-kill effects on watershed health. To reach this goal, the basin has funded a major study that monitors forest beetle-kill, wildfire potential, and effects on water quality and quantity."

The Colorado Basin identifies 14 collaborative watershed groups that are actively engaged in improving watershed health. Primary watershed-health concerns in the basin include wildfire risk and the evolving forest landscape; both have the potential to impair water supply. The basin supports watershed wildfire assessments, and there are currently 18 Community Wildfire Protection Plans within the basin.[21]

ACTIONS

To better understand and promote watershed health, it is important to support the development of watershed coalitions and watershed master plans that address needs from a diverse set of local stakeholders. The parties responsible for implementing action plans should be watershed coalitions and forest partnerships. Water-supply stakeholders should participate in the development of effective watershed coalitions. The Watershed Wildfire Protection Group, other watershed groups with a state- or region-wide geographic scope, and state agencies focusing on watershed health should manage coordination across watershed divides. State agencies include CPW, the CDPHE, and the CWCB.

Actions include:

1. Identify existing watershed coalitions and existing watershed plans and assessments, including source-water protection plans.
2. Encourage and support capacity in many areas that currently do not have watershed groups or other groups that work with a broad set of local stakeholders
3. Assist stakeholders in existing watershed groups to identify tools and resources that address gaps and build capacity in existing plans.
4. Identify public and private funding sources that together can support watershed- and forest-health projects.
5. Identify watersheds that are critical to water supply.
6. Work toward a long-term goal of developing watershed master plans for watersheds critical to consumptive and nonconsumptive water supply.
7. Prioritize and implement projects identified in master planning.
8. Monitor projects to ensure that objectives are met and maintained.
9. Conduct adaptive management as necessary.
10. Coordinate statewide watershed-coalition and partnership plans, projects, monitoring, and adaptive management strategies.
11. Watershed management plans may include potential impacts to the environment, public water supplies, and agricultural production from abandoned mines, and a strategy for addressing these impacts. CDPHE and DRMS are potential partners in developing a prioritized list of mines which could impact streams.

7.2 NATURAL DISASTER MANAGEMENT

GOAL

Colorado's Water Plan promotes water resource resilience from natural disasters through strategic preparedness and response.

Natural disasters are potentially devastating natural events that may have detrimental effects on the state and its economy. In Colorado, we are prone to droughts, floods, earthquakes, tornados, and wildfires. Since the turn of the current century, Colorado has experienced many record-breaking natural disasters. These have included our most intense single-year drought in 2002; our most expensive wildfire, the Waldo Canyon Fire of 2012; our most destructive wildfire, the Black Forest Fire of 2013; our most expensive winter storm in 2003; and our most expensive summer storm in 2009. In fact, 54 percent of all homeowner insurance claims between 2009.[22] and 2013 were a result of catastrophe, more than double the rate for the previous 12 years.[23] Natural disasters do not only affect people and property; they may also have serious negative effects on our water systems and on the amount of water that is available for meeting the needs of Coloradans. Additionally, climate change has the potential to influence the frequency and severity of these events in the future.

The Effects of Climate Change on Natural Disasters

In 9 out of every 10 years, a portion of the state experiences some level of drought conditions.[24] As Chapter 4 discusses, droughts and floods that make our water availability so variable may also bring devastating economic and natural consequences to Colorado. The State has invested heavily in developing both structural and nonstructural flood mitigation activities, and leads the nation in innovative drought preparedness planning. Although we cannot avoid or prevent natural disasters, investments in planning and preparedness can help reduce adverse effects.

Given that water influences nearly all sectors of Colorado's economy, and that too little or too much water can have a substantial effect on the environment and the economy, it is important to understand how climate change may affect the frequency, duration, and intensity of natural disasters. The CWCB has conducted several studies to examine the ways in which climate change will affect water resources. These studies include Climate Change in Colorado, The Colorado River Water Availability Study, The Joint Front Range Climate Change Vulnerability Study, the Colorado Drought Mitigation and Response Plan, and the Colorado River Basin Water Supply and Demand Study.[25]

The most likely effect of future climate change on water supplies is a shift in the timing of runoff. Projections indicate that runoff timing will shift one to three weeks earlier by mid-century due to increased temperatures.[26] This shift may affect water rights holders that are only permitted to withdraw their allocation during specific timeframes, and those with limited storage. It is also likely to result in decreased late-summer streamflow due to both increased temperatures, and the projection that precipitation will generally increase in the winter months and decrease in the summer months.[27] At the same time, increased population and higher crop irrigation requirements will put additional pressure on a changing water supply.[28]

Although precipitation trends are far less clear than temperature trends, some studies have examined what floods and droughts might look like under an altered climate. Colorado's paleoclimate record shows droughts that are longer-lasting and more

intense than those experienced in the 20th and early 21st centuries.[29] That said, there is much variability across the state. For instance, in the Yampa/White River Basin, the hydrologic paleo record shows that streamflows are variable enough to capture all but the wettest projected flows under various climate change conditions. Conversely, in the Arkansas River Basin, paleo flows accurately represent only one of the climate projections, and none of the driest.[30] These records reinforce that the past may not be a good predictor of the future.

When one directly examines flood and drought extremes under projected future climate conditions, substantial variability exists across the state. On the Colorado River at Cameo, the average intensity for droughts was somewhat greater than the historical intensity (-24 percent versus -19 percent), while the intensity of surplus, or flood spells, was considerably lower than the historical surplus (27 percent versus 46 percent). When one takes into account climate projections, future projected drought intensities for the same-length event range from -19 percent to -32 percent, while surplus intensities range from 17 percent to 38 percent. The frequency of such events depends on which climate projections one uses.[31]

The frequency and intensity of wildfire may also change under a warmer climate, and will continue to affect watersheds and ecosystems. While it is understood that variability in Colorado's climate will continue long into the future and will include wildfires, drought, and floods, the influence of climate change on these events is less certain. The use of scenario planning enables the State to modify and adapt planning processes as new information becomes available, which will increase flexibility and resiliency in planning.

SEAN CRONIN

SOUTH PLATTE RIVER BASIN

Sean is the Executive Director for the St. Vrain and Left Hand Water Conservancy District in Longmont and was involved in the flood recovery efforts during the 2013 floods that ravaged northeast Colorado. He also chaired the South Platte Basin Roundtable during the creation of the South Platte Basin Implementation Plan and Colorado's Water Plan.

I believe Colorado's future depends on the same vision, drive, and selflessness possessed by past water leaders. I am confident that today's water professionals have those same qualities to "pay it forward" to the next generation. I believe this because Colorado's Water Plan has evolved the water community and enabled it to better appreciate diverse perspectives, openly discuss once-taboo topics, and gather some of the most visionary, driven, selfless, and passionate professionals our state has to offer. I view Colorado's Water Plan as the ultimate in paying...

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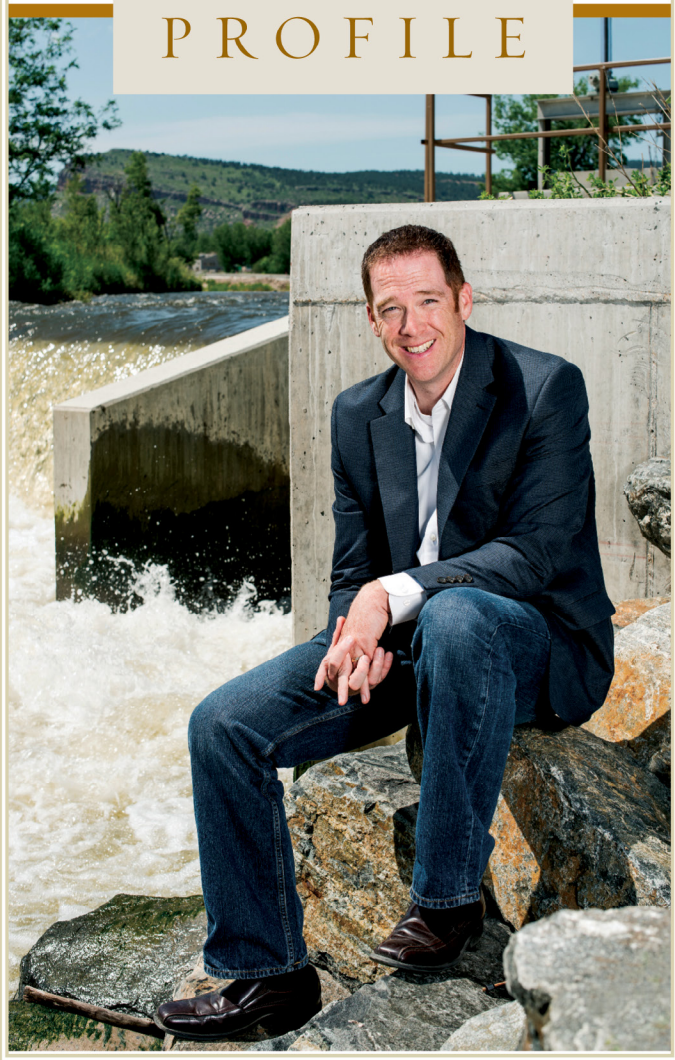
PROFILE



Historic floods in 2013 damaged several portions of Highway 36 between Estes Park and Lyons.

Preparedness and Response

Looking back at Colorado's recent history, the last few years have demonstrated the extreme variability Colorado faces. The year 2011 was historically wet, 2012 was historically dry, and 2013 was both historically dry and wet. This variability presents immense challenges to water supply management and planning in Colorado.

The State gathered stories about the flood of 2013 illustrating water infrastructure and diversion structures that were damaged, facilities that were severely disconnected from stream and river channels, streams and rivers that substantially changed course, homes and businesses that were damaged or washed away, watersheds that were affected by fire followed by flood, and thousands of agricultural acres that became at risk of damage. The State and other agencies across Colorado responded expediently with grant and loan resources. This level of response teaches two things:

1. Coloradans know how to face and recover from disasters. People came together to support their neighbors, and thousands of unknown heroes made a huge difference in the lives of their neighbors and communities.
2. Even when people come together to face catastrophe, having a plan and sufficient resources in place ahead of time makes both the immediate response and the long recovery effort easier and less costly. In fact, studies have shown that for every one dollar of investment in natural hazard mitigation, society saves four dollars in response costs.[32]

Following the 2013 floods, the United States Department of Housing and Urban Development approved Colorado's Community Development Block Grant – Disaster Recovery to include the Watershed Resilience Pilot Program. The CWCB and the DOLA jointly developed this innovative holistic program to provide watershed restoration, risk mitigation, and community and economic development using a collaborative, coalition-of-partners approach. The program identifies an immediate need to focus on capacity-building, comprehensive watershed planning, and project implementation to address long-term catalytic watershed system improvements. The program will support capacity-building; additional watershed master planning and conceptual design activities (including modeling and mapping); planning for multi-objective uses such as green infrastructure, greenways, recreation, transportation, and recreation; and funding for the implementation of projects that result from cooperative planning efforts. This pilot program will receive an allocation of $25 million. The U.S. Department of Housing and Urban Development has never-before approved a watershed resilience pilot program.

The 2013 floods did result in an opportunity to implement various resiliency projects during the recovery period, which may continue in the event of future floods within the state. As an example, the 2013 flood resulted in unprecedented levels of damage to water supply infrastructure, creating the need to quickly rebuild in order to restore water management capabilities. The CWCB, CPW, and other partners encouraged water providers to consider multiple-objective designs when repairing diversion structures and other damaged infrastructure. These multiple-objective designs encourage processes that can enhance fish passage, recreational uses, and movement of sediment. Many rebuilt structures incorporated these design elements. Nevertheless, as the 2013 flood recovery demonstrated, current levels of funding and the need for quick rebuilding often hampered well-intentioned efforts to incorporate these new features. New or enhanced funding sources for these activities must continue to grow in order to be readily available and implemented into this infrastructure at key times.

Agencies successfully implemented other processes during the recovery from the 2013 floods. For example, the CWCB and the Colorado Department of Transportation (CDOT) have begun a very successful partnership to incorporate design principles for stream restoration and highway-rebuilding into a complementary, holistic process. The process has resulted in more-resilient stream and highway corridors and has saved money during the construction process. The State must continue this model in road and stream alignments, especially in the steep-canyon environments.

Damaged streams resulting from the 2013 floods highlighted the need for updated floodplain mapping that more accurately reflects post-flood conditions. A re-study of the hydrology of the flood-affected areas indicated that in many of the damaged watersheds, the regulatory flood hydrology that had been in place for as long as 40 years understated the flood risk. Senate Bill 15-245 put into place State-funded mapping processes that will accurately reflect this higher level of risk. Nevertheless, this process underscored the point that updated, statewide studies based on modern methods are necessary to ensure that the State adequately convey flood risk to landowners, and that important land-use decisions will rely on accurate information.

As Section 6.1 describes, the future is uncertain. While Section 6.1 describes the types of projects and methods the State generally needs for scenario planning and adaptive strategies for average conditions, this section focuses on variability from year to year. In any given year, Colorado must be prepared to respond adequately to the extremes of flood, drought, and fire. To support local communities and prepare for disasters that affect our water supply, the State's many agencies and programs work to both prepare for and respond to extreme events, and will continue these efforts into the future.

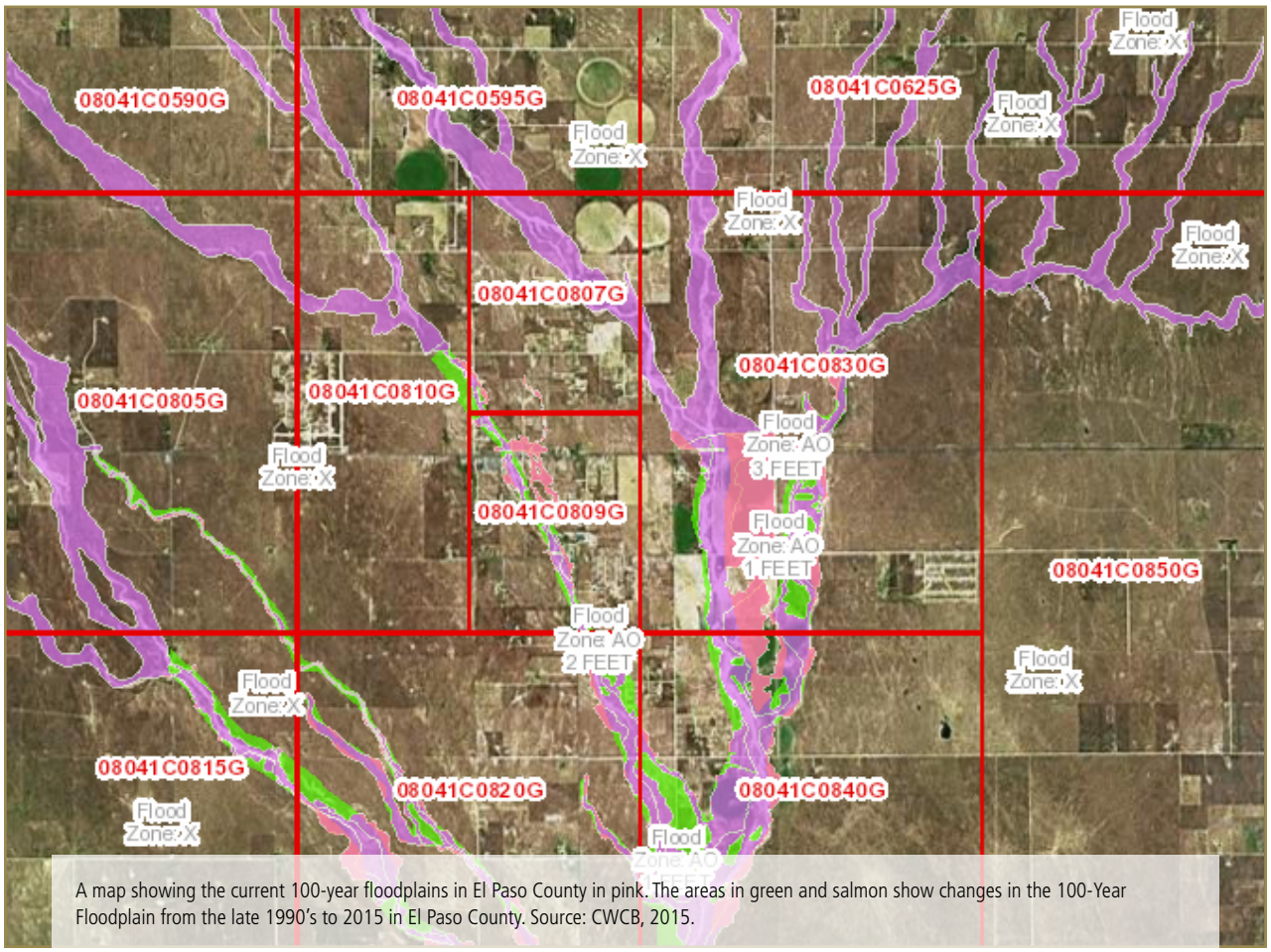
Colorado communities have a responsibility under the State's floodplain management standards— floodplain rules and regulations that meet or exceed the Federal Emergency Management Agency (FEMA) minimum requirements—to foster community resiliency and to develop wisely in light of flood events. The CWCB works with the Colorado Office of Emergency Management and FEMA to provide technical and financial support for these activities. In recent years, Colorado has improved its flood regulations by increasing freeboard requirements for homes and businesses, with additional protection for critical infrastructure such as hospitals, fire stations, and nursing homes. Colorado's Flood Hazard Mitigation Plan also helps the State and local communities better prepare for these events.[33]

The Colorado Drought Mitigation and Response Plan outlines the monitoring, mitigation, and response actions necessary to adequately prepare Colorado for drought.[34] The Water Availability Task Force brings together state, local, and federal agencies to monitor conditions on a monthly basis. Once an event occurs, the State activates the Drought Task Force, bringing together a multitude of state agencies to collaboratively address issues that arise.

The State projects that droughts will increase in frequency and severity. At the local level, the development of drought management plans can help communities prepare for those future conditions.[35] Furthermore, planning and preparedness before the onset of an event can reduce both physical and economic drought-related effects. The CWCB has developed many tools and resources to aid in this process and has made them accessible through the Drought Planning Toolbox.[36] Additionally, through the Water Efficiency Grant Fund, the CWCB is able to provide grant funding for up to 80 percent of the cost of both developing a plan and implementing proposed measures. Currently, mid-sized communities including the Town of Firestone, Pagosa Water and Sanitation District, and the Town of Erie have sought the CWCB's funding for plan development and approval. Larger providers, such as Denver Water and the City of Aurora, have current drought management plans, but have not sought State assistance or approval. If the number of communities that have active drought management plans in place increases, Colorado's overall resilience to drought will increase.

Technical and financial support is also available for healthy watersheds, which can help reduce the risk of catastrophic fires and buffer against the effects of other natural disasters. Section 7.1 further describes this. State agencies work closely with local and federal agencies on fire mitigation, response, and recovery. Because many watersheds are located on federal lands, intergovernmental collaboration is vital for protecting those resources. Additionally, Colorado is a headwaters state, and our downstream neighbors have a vested interest in maintaining healthy watersheds that contribute to their water quantity and quality. Building on these relationships may also contribute to better long-term protection of the resource.

Although Colorado has greatly prepared for the eventualities of floods, drought, and wildfires, these events rarely unfold exactly as predicted. That is why flexibility is critical in fostering effective and



A map showing the current 100-year floodplains in El Paso County in pink. The areas in green and salmon show changes in the 100-Year Floodplain from the late 1990's to 2015 in El Paso County. Source: CWCB, 2015.

efficient response to natural disasters. To that end, Colorado regularly updates its flood, drought, and wildfire plans. These plans comprise part of the State's Natural Hazard Mitigation Plan, which both the Colorado governor and FEMA approve. The updates incorporate lessons learned, new policies, and updated program information and, together with the working partnerships, will enable Colorado to respond better to future natural disasters. Existing technical tools, such as Colorado's Flood Threat Bulletin, are useful for helping state agencies and affected communities prepare for substantial precipitation events. Future enhancements to these and other tools may provide even further benefits.

ACTIONS

1. Where appropriate, the State of Colorado will continue to support and expand drought, flood, and wildfire-preparedness and response programs.
2. The State of Colorado will actively encourage local communities to develop drought preparedness plans by providing tools and resources for development and implementation.
3. The CWCB and the Colorado Recovery and Resiliency Office will implement the actions identified in the Colorado Resiliency Framework to build communities that are more resilient to natural disasters.
4. The CWCB and CDPHE will work with utilities, federal agencies, and others to proactively identify and address regulatory barriers to climate preparedness and adaptation

7.3 WATER QUALITY

GOAL

Colorado's Water Plan promotes waters that fully support their classified uses by 2050 through strategies designed to meet Colorado's current and future consumptive, recreational, and environmental water needs. These strategies incorporate the protection and restoration of water quality as a key objective.

Coloradans have a strong connection to water. The State and water managers need to protect quality of water, and in some cases, restore quality to support Colorado's heritage, communities, and way of life, now and into the future. Executive Order D 2013-005 recognizes this by stating, "Colorado's water quantity and quality questions can no longer be thought of separately. Each impacts the other and our state water policy should address them conjunctively." The executive order also lists "a strong environment that includes healthy watersheds, rivers and streams and wildlife" as one of three core Colorado values. In addition, recent public survey results highlight the value Coloradans place on safe, clean water. This survey indicates that Coloradans believe the quality of both surface and groundwater is very important as a source of drinking water. Coloradans also believe the quality of water in streams and lakes is very important to support recreational uses. The survey shows that public health, followed by wildlife and fish habitat, are the most compelling reasons to improve water quality.[37, 38]

As Colorado plans for its water future, it will be critical to better integrate water quality and quantity planning and management activities. To ensure that Coloradans continue to have access to safe and clean water, the State must prioritize opportunities to address existing water quality effects and minimize future effects. Creating a balance between increasing quantity demands and water quality protection and restoration requires on-going dialogue with all Coloradans and collaboration at all levels of government. Colorado's Water Plan offers a framework for moving forward with the quality and quantity conversations.

The following information is a starting point for an ongoing conversation. To create a foundation for understanding this complex subject, the conversation describes how quality and quantity are related. It also identifies an integration goal geared to improve relationships in support of protecting and restoring water quality. The conversation describes current water quality management as a context for identifying ways to improve coordination, and makes recommendations for moving forward with initiatives that meet the integration goal. The water quality foundation for this conversation is included in Colorado legislation, and the Water Quality Control Commission (WQCC) and the Water Quality Control Division (WQCD) established goals to meet the intent of this legislation.

Water Quality and Quantity Relationships

State and associated federal statutes, as well as local, state and federal regulations, protect water quality in Colorado. The WQCC adopts regulations, guidance, and policies required by the federal Clean Water Act (CWA), the federal Safe Drinking Water Act, and the Colorado Water Quality Control Act. The CDPHE Water Quality Control Division is the primary agency that implements these regulations, guidance, and policies. This water quality management structure is different from that which is in place for water-quantity management. Understanding the existing relationships between these distinct management frameworks, and looking for opportunities to improve coordination and integration, are important for protecting the state's water resources.

Water Quality and Quantity Connections

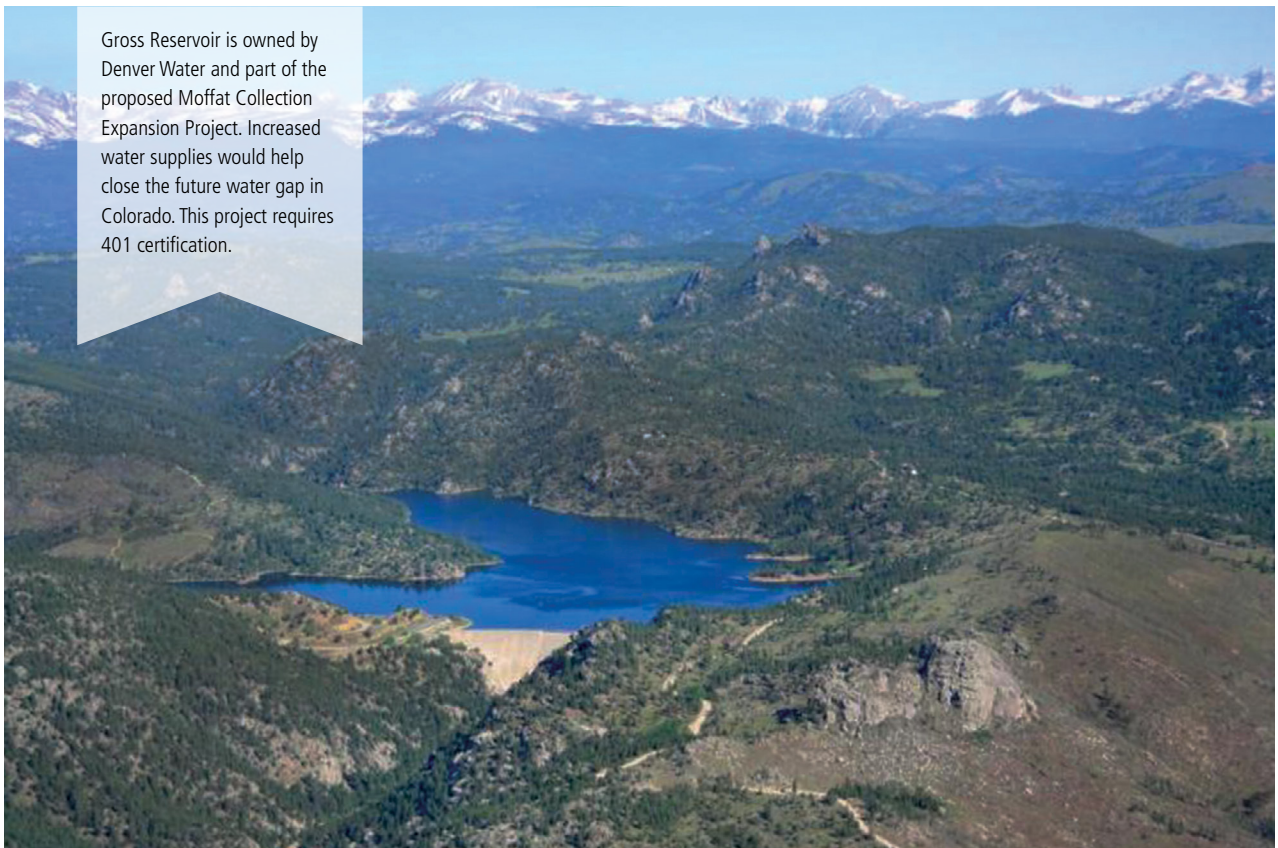
Managing water quantity may cause a change in water quality. When entities divert water to farms or cities, store it for future use or flood control, or manage it as return-flows to address downstream water rights, water quality can change. For example:

- Recreational fishing is a way of life in Colorado and is important to local and state economies. Deep reservoirs tend to thermally stratify in summer, when cold water settles to the bottom. Many reservoirs release water downstream from the bottom, where the stratified water is very cold. In some places, cold-water releases from the bottom of reservoirs have affected downstream native fish and aquatic life. Most of Colorado's Gold Medal Fisheries, which CPW manages, are located downstream of

Black Lake No. 1 and No. 2. The lakes were enlarged so that stream flows could be maintained during snowmaking season.

dams. Other surface-water structures, such as diversions to canals and off-stream reservoirs, can also affect water quality and fisheries. Such modifications can result in low streamflows and cause low oxygen concentrations, high water temperatures, and higher concentrations of pollutants. In Colorado, the State is exploring solutions during project planning to address these types of water quality effects that surface-water modifications can cause.

- One option for addressing future municipal-water supply needs is the use of alternative agricultural transfers, such as rotational fallowing and interruptible supply options. High concentration of salts and other pollutants from this source water, however, may require advanced water-treatment technologies, such as reverse osmosis, to make the water usable for communities. The waste product from reverse osmosis has very high salt levels and cannot be discharged into the stream. Other disposal options for the waste product are limited. If a municipal provider has higher-quality source water to blend with lower-quality sources, this issue can be avoided. For example, Aurora Water recently completed the Prairie Waters Project in which both natural and constructed treatment allow potable water reuse—without requiring new CWA permits.
- The implementation and maintenance of drinking water and wastewater treatment in a semi-arid environment is a challenge today, and will continue to be in the future. Treatment infrastructure is critical to protecting public health and the environment. The capacity of the stream to accept wastewater pollutants without a negative effect on quality depends on the amount of water flowing in the stream. Water diversions upstream can result in fluctuating stream levels, and therefore affect water quality. Changes in treatment processes that are necessary to meet new, more stringent discharge limits, or upgrades to aging infrastructure, can increase operational costs for wastewater treatment facilities. However, protecting water quality through wastewater treatment and other measures can result in cost savings for downstream drinking water treatment facilities, because such protection results in higher-quality source water that could require less treatment in the future.
- The CWCB is responsible for the appropriation, acquisition, protection, and monitoring of instream flow and natural lake level water rights in order to preserve and improve the natural environment to a reasonable degree. The CWCB



Gross Reservoir is owned by Denver Water and part of the proposed Moffat Collection Expansion Project. Increased water supplies would help close the future water gap in Colorado. This project requires 401 certification.

exclusively established these water rights for nonconsumptive, in-channel, or in-lake water uses to support minimum flows between specific points on a stream, or minimum levels in natural lakes. The State's water right priority system administers the rights. While Colorado law explicitly prohibits the WQCC and the WQCD from taking any action that requires minimum instream flows, the program has provided tangible water quality benefits specifically for aquatic life classified uses across the state.

Cause-and-effect connections related to water quality and quantity are integral to the State's ability to make sound water management decisions. The State considers these connections during decision-making processes that are dependent on statutory, regulatory and management relationships related to water quality and quantity.

Statutory and Regulatory Relationships

The State manages water quality and quantity separately based on different constitutional, statutory, and regulatory provisions. That said, state and federal statutes that protect instream water quality recognize the importance of protecting water rights while providing the authority to impose water-pollution controls. The federal statute that protects drinking water quality also recognizes integration with water quantity by including source-water protections that reduce treatment costs.

Many state and federal water quality-specific regulations intersect with quantity management. Establishing water quality standards and ensuring that entities attain these standards as required in state and associated federal water quality regulations is connected to the amount of water available in streams. State regulations also recognize water quality by addressing the quality of substitute water supplies used in exchanges and in substitute water supply plans. Regulations governing reuse also support integration between water quality and quantity management.

One of the primary examples of the regulatory quality and quantity relationship is the WQCD's water quality certification of federal permits and licenses under Section 401 of the CWA. WQCC Regulation No. 82 implements this certification, known as 401 certification. Section 401 of the CWA directs states to certify that activities needing federal permits and licenses, including many water development projects, must comply with the applicable provisions of the State's water quality use classifications, standards, and designation program during both construction and operation over time. WQCC Regulation No. 82 gives the WQCD three certification options for federal permits or licenses. These include the ability to certify, conditionally certify through identified mitigation measures, or deny certification. WQCD certification signifies that when the proposed project implements the federal permit or license, the project will comply with applicable surface and groundwater standards regulations, classifications, and all other applicable water quality requirements for the affected waters. For example, if a project requires a CWA Section 404 individual permit from the Army Corps of Engineers, it also requires a WQCD 401 water quality certification. Section 9.4 discusses the 401 water quality certification in more detail.

The WQCC's adoption of site-specific standards and designations is another example of a quantity-and-quality regulatory relationship. Site-specific standards and designations may reflect a lower level of water quality than would have been present before exercised water rights resulted in a hydrologic modification such as a dam, diversion, or return flows.

The WQCC is solely responsible for the adoption of water quality standards and classifications; however, local government regulations can also have a water quality and -quantity connection. For example, the State gives local governments permit authority over certain matters under the Areas and Activities of State Interest Act. Under the act, local governments can adopt regulations that address the effect of municipal and industrial water projects. These regulations, referred to as 1041 regulations, often require mitigation of water quality effects from water projects. Associations of local governments also prepare Regional Water Quality Management Plans that establish water quality goals and recommendations for regional water quality management. Typically, local 1041 regulations require new water projects to comply with these plans.

Water Management Relationships

Statutes and regulations define roles and responsibilities that many entities share, creating a complex system for overseeing Colorado's water resources. At the state level alone, many entities are involved with protecting water quality, which requires coordination and integration to ensure that they appropriate manage water resources.

The Colorado Water Quality Control Act defines water quality roles and responsibilities for the WQCC and the WQCD. The Act also identifies several additional water quality implementing agencies, including:

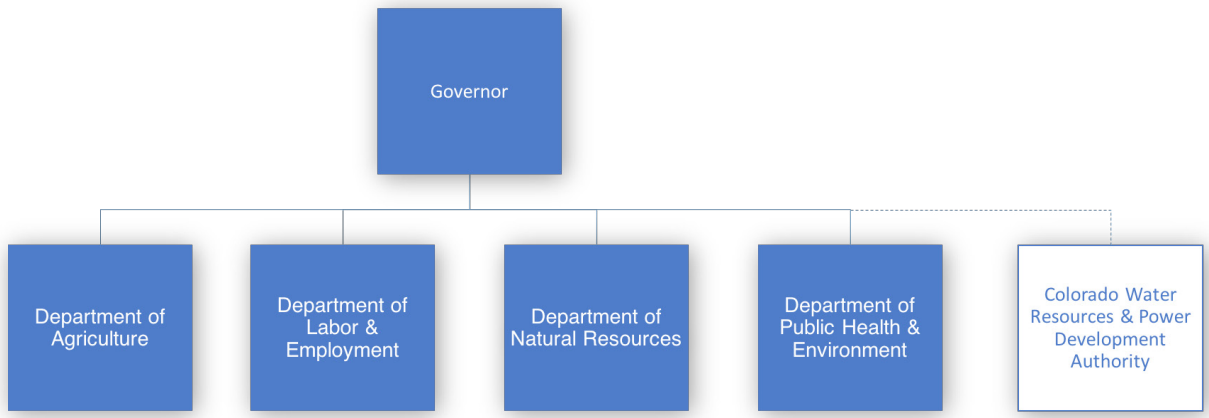
- Division of Reclamation, Mining and Safety
- DWR
- Oil and Gas Conservation Commission
- CDPHE Hazardous Materials and Waste Management Division
- Division of Oil and Public Safety at the Department of Labor and Employment

These agencies have initial responsibility for implementing groundwater quality classifications and standards the WQCC adopts. A Memorandum of Agreement defines these implementing relationships. The WQCC can intervene in the event that it determines an implementing agency is not assuring compliance with water quality classifications and standards.

The DNR plays a critical role in managing water quantity in the state. The DWR within the DNR is responsible for water administration, while the CWCB, another DNR division, sets water policy, completes water planning, and reviews state wildlife-mitigation plans. The DNR's CPW develops state wildlife-mitigation plans, which address fish and wildlife resources that the construction, operation, or maintenance of water diversion, delivery, or storage facilities affect.

The Colorado Water Quality Control Act requires the WQCC and the WQCD to consult with the CWCB before making any decisions or adopting any rules or policies that have the potential to cause material injury to water rights. The CWCB receives copies of all WQCC rulemaking hearing notices, and all notices include a provision requesting information from the public regarding potential effects on water rights.

FIGURE 7.3-1 COLORADO STATE AGENCIES AND QUASI-GOVERNMENTAL ORGANIZATIONS WITH QUANTITY AND QUALITY RESPONSIBILITIES



Water Quality- and Quantity-Integration Goal

Executive Order D 2013-005 states, "Colorado's water quantity and quality questions can no longer be thought of separately. Each impacts the other and our state water policy should address them conjunctively." To this end, it is important to establish a goal related to quantity and quality integration between now and 2050. To develop this goal, the CWCB reviewed many documents, including the CWA, the federal Safe Drinking Water Act, the U.S. EPA's strategic plan, Colorado's Water Quality Control Act, the WQCD's strategic goals, the WQCC's strategic water quality goals, and the BIPs. These laws, goals, and plans focus on broader actions than quality and quantity integration, yet they provide important insight for developing a quality- and quantity-integration goal as part of Colorado's Water Plan.

It is important to establish a goal related to quantity and quality integration between now and 2050.

The CWA sets a national goal "to restore and maintain the chemical, physical, and biological integrity of the nation's waters," with interim goals that all waters be fishable and swimmable where possible. The federal Safe Drinking Water Act authorizes the EPA to set national health-based standards for drinking water in order to protect against both naturally occurring and man-made contaminants in drinking water. The EPA and water systems work together to make sure states meet these standards. The EPA's current strategic plan has a goal regarding protecting America's waters to "protect and restore waters to ensure that drinking water is safe and sustainably managed, and that aquatic ecosystems sustain fish, plants, wildlife, and other biota, as well as economic, recreational, and subsistence activities."

The legislative declaration of the Colorado Water Quality Control Act includes the following goals:

- Achieve the maximum practical degree of water quality in the waters of the state.
- Provide that no pollutant be released into any state waters without first receiving treatment or other corrective action necessary to reasonably protect the legitimate and beneficial uses of such waters; to provide for the prevention, abatement, and control of new or existing water pollution; and to cooperate with other states and the federal government in carrying out these objectives.

In addition, there are several Colorado Water Quality Control Act provisions related to water quantity and water rights:

- A primary goal of the Water Quality Control Act is to protect, maintain, and improve the quality of state waters for beneficial uses, including domestic, wildlife, and aquatic life; and agricultural, industrial, and recreational uses.
- Dischargers of pollutants may be required to meet a high degree of treatment to protect water rights.
- The WQCC and the WQCD must consult with the CWCB before making any decisions or adopting any rules or policies that have the potential to cause material injury to water rights.
- Nothing in the state act is to be construed or applied to cause or result in material injury to water rights.
- The WQCC and WQCD shall not require an instream flow for any purpose.

The WQCD's mission is to protect and restore water quality for Colorado's public health and the environment. The WQCD's strategic plan states that it will achieve its mission by pursing the following goals:

- Prevent waterborne disease and reduce chronic public-health risks from drinking water through improved implementation of the federal Safe Drinking Water Act and Colorado's drinking water statutes and regulations.
- Protect all designated uses by attaining water quality standards through improved implementation of the CWA and the Colorado Water Quality Control Act and associated regulations.
- Restore impaired water quality to attainable standards through improved implementation of the CWA and the Colorado Water Quality Control Act and associated regulations.

Finally, the WQCC's strategic water quality goal: By 2050, Colorado's waters will fully support their classified uses, which may include drinking water, agriculture, recreation, aquatic life, and wetlands.

The State will require better integration of water quality and quantity in order to address the WQCC's overall goal for water quality. Based on review of the laws, goals, and plans summarized above, the WQCC developed a quality- and quantity-integration goal:

> Recognizing the inter-relationships between quality and quantity, strategies designed to meet Colorado's current and future consumptive, recreational, and environmental water needs will incorporate, as a key objective, the protection and restoration of water quality.

The following steps further refine and advance this goal:

- The State encourages the basin roundtables to actively incorporate water quality into decision-making processes for consumptive, recreational, and environmental projects. To help facilitate this effort, the WQCD will provide basin-scale water quality information to the basin roundtables for their use in updating their future BIPs. The WQCD originally developed this information as part of the Statewide Water Quality Management Plan.
- Project proponents must understand the nexus between water quality and quantity, and must work to avoid or mitigate water quality effects of a project through the implementation of best management practices, whether associated with 401 water quality certifications or otherwise. The WQCD will support this effort by developing guidance on the 401 water quality certification process and identifying best management practices.
- The WQCD, in concert with other stakeholders, including watershed groups and those with point and nonpoint discharges, will continue to employ available programs to maintain, and in some cases, improve water quality at a basin-scale. The WQCD will document progress over time in the WQCD's Integrated Report and WQCD's Statewide Water quality Management Plan. The WQCD typically updates the Integrated Report every two years and uses it to track progress on the quality portion of the integration goal over time.
- The CWCB will use information from the WQCD's Integrated Report in its scenario-planning efforts when evaluating the status of future *signposts* (see Chapter 6.1). By tracking this information through time, water quality and quantity managers will know whether efforts to integrate water quantity and quality are successful, and can make course corrections as part of adaptive management plan efforts.

A hiker takes a break to drink some crisp mountain water.

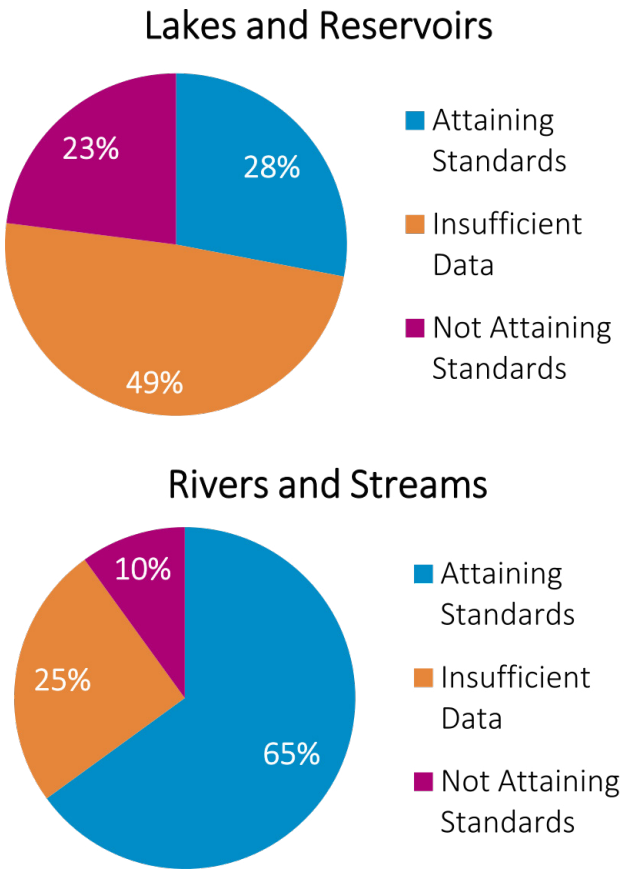
Current Water Quality Conditions

As state water managers and stakeholders produce plans for meeting consumptive, recreational, and environmental needs in ways that recognize the many interactions of statute, regulation, and management activities, it will be important to understand current water quality conditions in the state. Understanding current water quality conditions is also fundamental for ensuring compliance with water quality regulations as they pertain to water-supply planning and implementation activities.

The ability to evaluate the status of surface-water quality in Colorado requires an understanding of the classified uses for waterbodies throughout the state. A classified use is a specific type of use for an identified waterbody and can include domestic water supply, agriculture, recreation, aquatic life, and wetlands. With an aim to protect these waterbody-specific uses, the WQCC assigns classified uses to stream and lake segments and adopts water quality standards for many different pollutants.

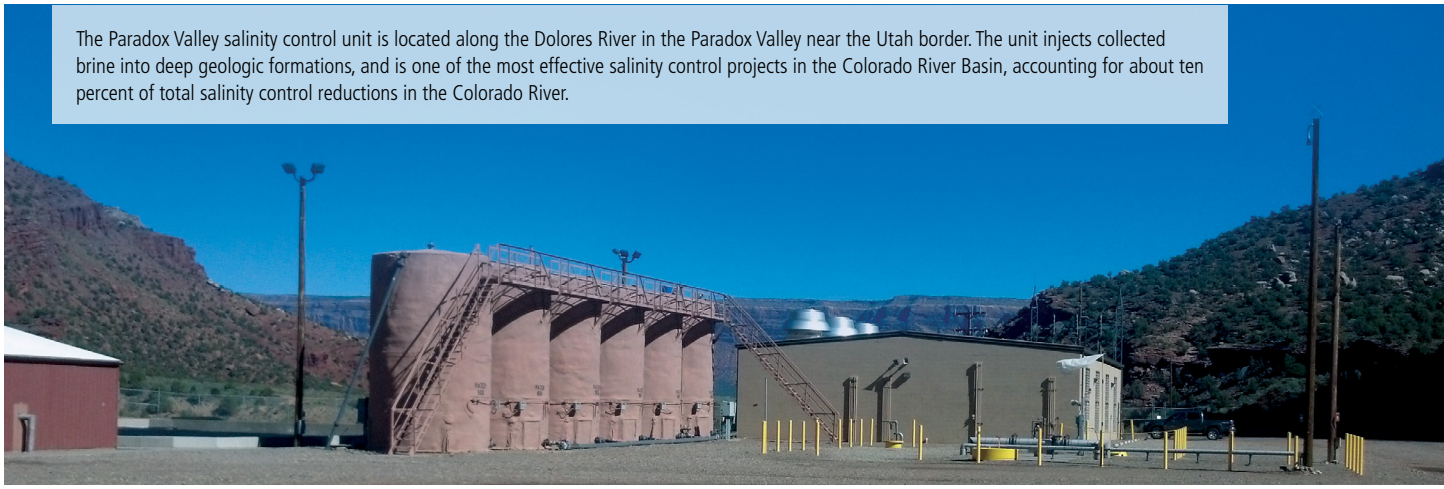
The state also must have an antidegradation policy as part of its water quality standards. Antidegradation protects the value of high-quality surface waters. Colorado's antidegradation policy establishes that, at a minimum, the State and water managers must maintain existing classified uses for all surface waters, and the water quality necessary to protect those uses; these waters are *use-protected waters.* The antidegradation policy also provides extra levels of protection for two other types of waters the commission designates. *Outstanding waters* receive the highest level of protection and require that quality must be maintained at current levels (with no degradation). *Reviewable waters* are high-quality waters that receive an intermediate level of protection. The rules for antidegradation review require a public process. This must occur before the natural capacity of a waterbody to dilute and absorb pollutants and prevent harmful effects is completely allocated to a project or permit under which a new or increased impact is proposed. The State allows use of such capacity if the review shows that it would accommodate important economic or social development for the area in which the waters are located.

FIGURE 7.3-2 CURRENT WATER QUALITY CONDITIONS[39]



Standards are the basis for evaluating the status of water quality for each waterbody. When available data show that a waterbody is not meeting water quality standards, state regulation identifies the waterbody as impaired. A biennial report to the EPA (Integrated Water Quality Monitoring and Assessment Report, or Integrated Report) must identify these impaired waterbodies, as well as other information about water quality in the state.

For waters that attain water quality standards, the challenge is to maintain the existing good water quality in order to protect classified uses, such as drinking water supplies, robust fisheries, and recreational opportunities.



The Paradox Valley salinity control unit is located along the Dolores River in the Paradox Valley near the Utah border. The unit injects collected brine into deep geologic formations, and is one of the most effective salinity control projects in the Colorado River Basin, accounting for about ten percent of total salinity control reductions in the Colorado River.

The most common causes of river and stream impairments in waters that are not meeting water quality standards are selenium, pathogens such as E. coli, and iron. In lakes and reservoirs, the most common causes of impairment are selenium, mercury, and dissolved oxygen saturation. Waters that do not attain water quality standards affect the ability of water users to use water for domestic water supply, agriculture, aquatic life, and recreation.

As shown on previous page, Figure 7.3-2 presents statewide information and is based on available water quality data. Different regions or basins within the state have varying water quality conditions and may have unique water quality challenges. Water quality impairments may also exist in streams or lakes that have either little or no available data, or that the Integrated Report process has not yet assessed.

Future Water Quality Conditions

Over the next 35 years, many changes will occur that have the potential to affect both regional and statewide water quality. Understanding these changes is important as the State, water managers and stakeholders develop plans for addressing the municipal and industrial supply gap and for meeting recreational and environmental needs.

Water-quantity decisions will affect future water quality conditions, but changing water quality regulations will also influence these decisions. Currently, several additional proposed regulations are designed to further protect and restore water quality. Examples of proposed regulations include increased nutrient controls, more stringent arsenic standards, and a revised selenium standard. There is also renewed emphasis on implementing actions that will produce measureable, positive changes in water quality. Recognizing the possibilities associated with potential change, both water- quantity and -quality managers must seek opportunities to protect and enhance water quality in the future.

Other factors affecting future water quality conditions are also important to consider. As the economy and population grow and land uses change, water-quantity demands will increase and additional stressors on water quality will come into play. Future land-use decisions are a substantial factor, as increased urbanization and associated stormwater runoff, higher volumes of discharged municipal wastewater, and industrial discharges—including those from the

energy sector—can affect water quality. As additional diversions deplete streams, existing concentrations of pollutants will increase, and water treatment and wastewater-treatment processes that rely on those streams will become more difficult and expensive. New issues may also arise from emerging contaminants or from interactions among different constituents. These potential effects could be negative; however, there may also be opportunities for positive change. These variables reinforce the critical nature of informed and integrated water-resource management decisions.

Climate change further compounds the potential for positive or negative effects on water quality in the future. Predicted effects of a changing climate on water quality include:[40]

- Potential streamflow volume will decrease in the Rockies and interior southwest, and increase in the east and southeast coasts.
- Higher peak streamflow will increase erosion and sediment transport, and loads of nitrogen and phosphorus are also likely to increase in many watersheds.
- Many watersheds are likely to experience substantial changes in the timing of streamflow and pollutant delivery. In particular, there will be a tendency to shift from snowmelt-dominated spring runoff systems to rain-dominated systems with greater winter runoff.
- Nutrient and sediment loads will change, as they are generally correlated with changes in hydrology.
- Warming air temperature will cause stream and lake temperatures to rise, which can harm aquatic organisms—such as trout—that live in cold-water habitats. Additionally, warmer water can increase the range of non-native fish species, permitting them to move into previously cold-water streams. The population of native fish species often decreases as non-native fish prey on and compete with them for food.

Planning for water quality changes based on these potential fundamental system-shifts is challenging, and highlights the need to make measurable progress on the water quality and -quantity integration goal.

Water Quality Management

The WQCD and WQCC currently make water quality decisions in the context of a management system based on statutes, regulations, and implementation processes. This system defines boundaries needed to protect and restore water quality, and also offers opportunities for flexible, integrated approaches for meeting consumptive, recreational, and environmental needs. The existing water quality management system is a starting point for finding opportunities and maximizing them to facilitate improved, integrated water-resource management decisions.

Section 2.4 and in Section 7.3 discuss the statutory and regulatory framework for water quality. The framework establishes the requirements for protecting and restoring water quality in the state, and processes at the state and local level implement the framework. The chapters also discuss classified uses and the water quality standards established to protect those uses. Both are critical to protecting and restoring water quality in the state; with public input, WQCC processes establish those uses and standards.

Water quality management processes also include monitoring, data assessment, and reporting. Monitoring and data assessment are essential to identifying and characterizing water quality problems, revising water quality standards, and developing and evaluating the results of control programs. Many statewide partners aid in completing the monitoring. The WQCD uses its own data and partners' data in evaluating the status of statewide and basin-scale water quality with respect to meeting water quality standards. Information about attainment of water quality standards is available in the Integrated Report discussed in 7.3.2. WQCC Regulation No. 93, Colorado's Section 303(d) List of Impaired Waters and Monitoring and Evaluation List also identify the information. The WQCC has used public processes to adopt both of these.

When streams and lakes do not meet water quality standards, WQCD produces a restoration plan called a Total Maximum Daily Load (TMDL). The TMDL defines how much of the pollutant causing the

impairment is allowed in the stream or lake while still ensuring high water quality standards. The allowable amount of the pollutant is then divided among all the different sources of the pollutant—including both point and nonpoint sources. A point source is a sewage treatment plant or industrial facility discharge. Nonpoint sources are diffuse sources of pollution, such as runoff from agricultural fields or abandoned mines.

As the WQCD produces the restoration plan, public notice process provides the opportunity for gathering input. Once the EPA approves the TMDL, the TMDL becomes the basis for implementing necessary actions to bring the stream or lake back into attainment. As an alternative to implementing controls to meet existing water quality standards, TMDLs can result in a re-evaluation of standards and sometimes a re-evaluation of classifications. A TMDL implementation plan can define implementation actions in a locally driven watershed plan or in a locally driven, regional water quality management plan (208 plan). Watershed plans and 208 plans identify stressors to water quality and address other water quality improvement and protection activities necessary to meet local and regional goals. The WQCD works with local partners and local plans to implement priority projects in order to restore and maintain water quality at a watershed or regional scale.

The WQCD also actively engages in promoting and supporting source-water protection planning across Colorado through the Source Water Assessment and Protection (SWAP) Program. The program is designed to define drinking water supply areas and identify potential water quality and contaminant risks to drinking water systems. The SWAP program, in collaboration with the Colorado Rural Water Association, provides technical and financial support to encourage voluntary local planning efforts and the implementation of best management practices to minimize source-water quality effects. This effort is a collaborative stakeholder process that contributes to protecting and restoring water quality in the state.

The WQCD uses information from all of these local plans to support its own planning efforts. For example, the WQCD produces a Statewide Water Quality Management Plan for approval by the WQCC. The Statewide Water Quality Management Plan compiles water quality information in support of implementation activities at a statewide and basin-wide scale. This compilation, in addition to the Integrated Report, WQCC policies, and other WQCD documents, supports the WQCD's strategic planning—while promoting progress toward national water quality goals and providing specific metrics for measuring that progress.

The purpose of these plans, which exist at different scales with the support of numerous partners, is to define and prioritize actions for the improvement, restoration, and protection of water quality. The WQCD uses several implementation tools, including Section 401 water quality certifications (which Section 9.3 discusses), permits that allow discharges to streams and lakes (provided they meet certain limits or control measures), and funding support for partners. The federal CWA prohibits the discharge of pollutants from a point source to surface water without a permit. Because the State has developed a program that meets the requirements of the federal CWA, the WQCD, rather than the EPA, administers the primary discharge permit program in Colorado. The permits the WQCD issues to point sources specify the limits or controls required to meet Colorado's water quality standards.

Implementation tools often require the development of strategies or best management practices that, when completed, result in the improvement, restoration, and protection of water quality. Strategies also address consumptive and nonconsumptive needs. Sections 6.3 through 6.6 summarize these strategies. Examples of strategies that have a quality and quantity nexus include, but are not limited to:

- CDPHE regulates non-potable water reuse and graywater use. Section 6.3 further describes these strategies.
- Storage, including reservoirs and aquifer storage and recovery can impact the amount of water available in streams, which may impact water quality.
- Source-water protection best management practices, such as proper storage and disposal of pesticides and proper management of septic systems can improve the quality of drinking water supplies.
- Stormwater best management practices, including retention and detention, can improve the quality and quantity of the supply, and water management practices could incorporate these practices. Colorado has not typically considered stormwater to be a source of supply, but may explore this in the future.
- Nonpoint-source best management practices will be critical to improving water quality for recreational, environmental, and consumptive needs in the future. Examples of nonpoint-source best management practices include mine tailings removal, riparian buffer creation, wetlands construction, and habitat restoration.
- Green infrastructure is taking place at a national level and Colorado is exploring application of this concept. The focus of the green infrastructure concept is to weave natural processes into the built environment, which can provide stormwater management, flood mitigation, air quality management, and riparian zone restoration.
- Water quality trading is based on the fact that sources in a watershed can face very different costs and regulatory requirements when under the control of the same pollutant. Trading programs allow facilities that are facing higher pollution-control costs to meet their regulatory obligations by purchasing environmentally equivalent (or superior) pollution reductions from another source at a lower cost, thus achieving the same water quality improvement at a lower overall cost.

Chapter 9 discusses funding and financing in detail; however, the WQCD provides various financial assistance opportunities to aid with efforts geared to protect public health and the environment. The WQCD administers the following financial assistance programs:

- State revolving funds provide low-interest loans to government entities for drinking water and water quality improvement projects.
- The Water Quality Improvement Fund provides grant funds for water quality improvement projects using civil penalties from water quality violations. State House Bill 11-1026 amended the statute to authorize grants for stormwater management training and best-practices training to prevent or reduce the pollution of state waters.
- Source-water protection grants provide funding for pilot planning projects as well as development and implementation projects.
- The small-system training and technical assistance set-aside provides grant funding to assist with the costs of planning and design for small drinking-water systems serving fewer than 10,000 people.
- State statutes 25-8-703 and 25-1.5-201 authorize funding, when the legislature appropriates it, for small-community domestic wastewater and drinking water projects. These programs provide grants to municipalities for costs associated with planning, design, and construction of drinking water and wastewater treatment plants.

- Through a competitive process, the WQCD distributes nonpoint-source grant funds to local project sponsors to implement projects that restore impaired waters, prevent future impairments, or raise public awareness.

In addition, the CWCB administers the Water Supply Reserve Account as another financial tool. This tool provides grants to assist Colorado water users in addressing their critical water-supply issues and interests. The funds help eligible entities complete water activities, which may include competitive grants for:

- Technical assistance regarding permitting, feasibility studies, and environmental compliance.
- Studies or analysis of structural, nonstructural, consumptive, and nonconsumptive water needs, projects, or activities.
- Implementation of structural and nonstructural water projects or activities.

Water Quality and BIPs

The various basin roundtables have addressed water quality in the BIPs in two major ways: Through quality-related basin goals and measurable outcomes, and through identification of projects and methods with a water quality nexus. In many basins across the state, public water systems, municipal governments, and communities have developed source-water protection plans with specific water quality protection strategies. Many basins also have watershed plans in place that identify priority actions necessary to both protect and restore water quality. Basin roundtables should consider these prevention, protection, and restoration strategies and actions during the project development and prioritization stage. The WQCD can provide information about in-progress or completed protection and watershed plans.

Every basin roundtable has addressed water quality in goals and measurable outcomes. Several basins have addressed water quality issues in the context of greater watershed health, while others look to established water quality standards as a potential measureable outcome. The Rio Grande Basin Roundtable established the following goal: "Make progress toward meeting applicable water quality standards throughout the basin."[41] This approach demonstrates ways in which the basin may use the planning process to work closer with the CDPHE and make progress toward meeting established standards.

In its goals, the Yampa/White/Green Basin Roundtable references water quality as it relates to uses within the basin: "Maintain and consider the existing natural range of water quality that is necessary for current and anticipated water uses."[42] Recognizing the importance of both quality and quantity, this water quality-centric goal follows the strong BIP theme of protecting existing uses within the basin and providing for future development. This type of goal seeks to establish how water quality fits within the basin's vision of its future.

Basin roundtables have also addressed water quality issues through identification of projects and methods that have a water quality nexus. For example, the South Platte/Metro BIP identifies 18 projects with a connection to water quality, ranging from assessment of wildfire restoration, to sediment mitigation projects, to mine remediation.[43] These projects seek to leverage implementation to address water quality issues at the source.

The Gunnison Basin has identified currently ongoing projects and methods that address water quality issues. These include several programs related to Colorado River water quality, such as the Gunnison Basin Selenium Management Plan, and projects funded through the Colorado River Basin Salinity Control Forum.[44] Additional localized projects for improving municipal infrastructure also have benefits for water quality.

Through these goals, outcomes, and identified projects and methods, the basins seek to address water quality concerns at a more local level. Future roundtable efforts will prioritize projects and methods according to basin goals, and this incorporation of quality concerns into the goals-and-outcomes framework will benefit water quality overall.

ACTIONS

The WQCD worked with the Colorado Water Quality Forum and the WQCC to develop recommendations. As the CWCB updates the Colorado's Water Plan in the future, these recommendations will serve as a starting point for implementation efforts focused on:

A. Integrated water quality and -quantity management.

B. Policy considerations.

C. Financial considerations.

D. Stakeholder and public outreach.

In addition, the State will assign these recommendations to a responsible party and prioritize them for implementation over time.

Water for agricultural use needs to be free from contamination. Depicted here are siphon tubes on the Sakata farm in Brighton.

A. Integrated Water Quality and -Quantity Management Actions

Recommendations to promote increased integration of water quality and -quantity management include:

1. Evaluate the water quality effects associated with the proposed solutions and scenarios the BIPs and Colorado's Water Plan (Sections 6.3 through 6.6) have presented. Identification of those effects will help define the scope of strategies that entities need to explore to protect and restore water quality. The State will share information about these effects among all involved parties.

2. In cooperation with basin roundtables, the CWCB, and others, define opportunities for projects or processes that restore and enhance existing water quality conditions, with an aim of addressing potential water quality effects resulting from water-quantity solution implementation. An initial step will be to assist the basin roundtables in developing water quality goals, objectives, and measurable outcomes based on current water quality information; each basin will be able to use this information when updating its BIP. This collaboration supports the basin roundtables in identifying projects and methods that integrate water quality and -quantity management to protect and restore water quality.

3. Define green-infrastructure approaches for the arid West, and explore ways in which entities can use green infrastructure to address Colorado's consumptive and nonconsumptive gaps. For example, green infrastructure in the arid West can go beyond stormwater management activities and low-impact development methods by including landscape-scale land-use planning that identifies where activities should occur in order to meet dynamic goals, including protecting and restoring water quality. Green-building and stormwater management groups have developed information that provides a starting point for developing and maintaining a library of green-infrastructure options.

4. Evaluate new water-supply projects and the potential for multiple benefits, including water quality protection and enhancement. Strive to ensure that project plans incorporate all water quality benefits.
5. Examine ways to design and operate new or existing supply projects to advance water quality objectives. Actively pursue incorporation of these design and operation considerations into proposed projects.
6. Identify the role of reuse by developing a library of reuse examples, such as direct potable reuse, indirect potable reuse, non-potable reuse, graywater use, and the associated water quality issues for each type of reuse. Ensure that any initiative that desires to use these resources addresses the issues. Section 6.3 further discusses reuse and identified actions.
7. Promote the use of aquifer storage and recovery, since water quality effects associated with this storage strategy are minimal.
8. Explore the role of stormwater management from both a quality and a quantity perspective in order to determine whether stormwater is a viable additional source of supply to address consumptive needs.
9. Address nonpoint sources through ongoing management activities, which play an important role in protecting and restoring water quality for the benefit of future water uses. These activities should include cataloguing and evaluating local-government land-use planning tools that minimize nonpoint-source pollution associated with development. Entities should also explore a comprehensive approach to nonpoint-source management, including water- quality trading.
10. Identify the risks of climate change as they relate to integrated water quality and water-quantity management. Develop specific recommendations for addressing these risks.
11. Explore how entities can most efficiently and cost-effectively integrate the CWA requirements and Safe Drinking Water Act requirements. Develop specific implementation recommendations.

B. Policy Considerations

Policy considerations related to quality and quantity integration include:

1. Continue to engage in creative, solution-oriented actions, such as implementing site-specific standards, temporary modifications, discharger-specific variances, pollutant trading, and conditional 401 water quality certifications. Use all available means to improve water quality and protect the high-quality waters that are considered better-than-necessary for supporting classified uses. Maintain ongoing, non-regulatory programs, including nonpoint-source management and source-water protection planning. These solution-oriented actions will also be necessary for addressing the effects of climate change.
2. As entities continue to maximize wastewater reuse in Colorado, establish a more complete understanding of the concept of "net environmental benefit." This concept demonstrates that the ecological value of using effluent to support riparian and aquatic habitats exceeds the ecological benefits of removing the discharge from the waterbody.
3. Review and appropriately modify existing regulations, guidance, and policy documents for new types of wastewater reuse so that revisions will protect public health and the environment, while also providing sufficient flexibility for water suppliers to develop new water-reuse projects across the state.
4. Consider and document the water-rights implications of water quality strategies and the water quality implications of water development strategies as they both pertain to integrated water quality and -quantity management. For example, integrated stormwater management may have effects on downstream flows, and entities would have to understand and address possible water-rights effects before implementing such a strategy.
5. Continue to work with neighboring states to address interstate water quality and quantity-issues to protect Colorado's compact entitlements.
6. Continue statewide monitoring that supports assessment of the quality- and quantity-integration goals and measures.

C. Financial Considerations

Future efforts to integrate water quality and quantity will require funding. Chapters 9 and 10 of Colorado's Water Plan further detail the recommendations outlined below.

1. Continue to fund nonpoint-source pollution management efforts. Identify new funding opportunities and nonpoint-source pollution-control strategies.
2. Identify costs and funding sources forimplementation of green infrastructure and reuse.
3. Pursue state funding of regional watershed-based water quality planning to better integrate current and future water-quantity efforts.
4. Develop and implement State funding mechanisms for future water projects that implement consumptive and nonconsumptive strategies in ways that are consistent with Colorado's Water Plan. Plans should emphasize funding portions of projects that result in a public benefit.
5. Develop and implement State funding mechanisms for the implementation of mitigation activities required either under a state water-court water-rights decision, or under a federal or state water quality protection regulatory action.
6. Develop and implement funding mechanisms for the protection, restoration, or enhancement of water quality values in river or stream reaches.
7. Explore ways to facilitate innovative treatment and engineering solutions through technology transfer and liability management techniques.

D. Stakeholder and Public Outreach

Stakeholder and public outreach is critical to meeting the water quality and -quantity integration goal. Chapter 9.5 of Colorado's Water Plan further details the recommendations outlined below.

1. Use a watershed approach for outreach and community engagement around water quality, ways to protect water quality, and solutions to water quality issues. Colorado's many watershed groups already use this approach to effectively plan for and implement actions that protect and restore water quality. The approach can be used when developing and implementing strategies that integrate water quality and -quantity management.
2. Refine future water quality goals and measurable outcomes by monitoring public attitudes and opinions about water quality as it relates to domestic water supply as well as environmental and recreational uses of water.
3. Develop additional water quality goals and performance measures based on the completed BIPs from the basin roundtables.
4. Conduct joint CWCB and WQCC meetings at least annually to discuss water quality and water quantity integration issues.
5. Consider holding workshops as part of WQCC's annual basin rulemaking process. To gather input and share information related to progress on water quality and quantity integration efforts, workshops should include participation from basin roundtable representatives for the basin that is the subject of the annual rulemaking hearing.
6. As the CWCB updates or implements the water plan in the future, it will participate in the Colorado Water Quality Forum's process and working groups which provide stakeholder input on water quality issues.

Trappers Lake, the headwaters of the White River, in the Flat Tops Wilderness.

A LOOK AT HISTORY

Despite being warned by friendly Native Americans, pioneers in Denver settled along the banks of the South Platteand its tributaries. They suffered the consequences in the Cherry Creek flood of 1864.

source: Colorado Water Conservation Board.

caption: Thomas V. Cech, J William McDonald, Defened and Develop:
A Brief History of the Colorado Water Conservation Board's First 75 Years,
[Denver: Wellstone Press and the Colorado Water Conservation Board, 2012.]

SEAN T. CRONIN, CONTINUED FROM PAGE 7-12

it forward - a gift that is opened when the next generation turns on a tap, fishes a stream, shops at a farmers' market, plays ball in the backyard, or goes downtown for a cold beer.

I live in my adopted home of Colorado with my wife and two children. I remember in 1997 moving to Colorado as entering nirvana -- spectacular weather, world-class recreation opportunities, high employment, and darn tasty beer. My first water job evoked a "water awakening". It suddenly became abundantly clear that this nirvana did not exist by chance. It was instead very deliberately engineered, and all connected by a common thread - water.

Prior to moving to Colorado, I lived in North Carolina where I obtained a degree in environmental science from the University of North Carolina at Charlotte and worked for the North Carolina Cooperative Extension Service. I grew up in Massachusetts on the South Shore of Boston where as a young kid witnessed human-caused degradation of local waterways. Those were defining moments that inspired me to obtain the rank of Eagle Scout and pursue my chosen field of study.

After working in the water industry for over 20 years, what I most enjoy is the opportunity to serve the greater good. A service that started at the Extension where I lead a partnership with farmers and non-profits to implement best management practices to protect water quality; then to a municipality providing a clean, reliable water supply to residents; and most recently with the District assisting property owners and ditch companies with flood recovery efforts. I consider myself fortunate to be part of a community of stewards for this life giving natural resource.

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