6.1 SCENARIO PLANNING AND DEVELOPING AN ADAPTIVE WATER STRATEGY

GOAL

Colorado's Water Plan considers a range of possible future conditions. Through public engagement and sound science, the plan develops a practical, adaptive, and balanced path forward for meeting Colorado's future water needs.

The purpose of scenario planning is to develop strategies to meet Colorado's future water needs that are based on the best available science as well as input from stakeholders. Section 6.1 broadly describes what is required to meet our state's future needs over the next 10 to 15 years and prepare for a broad range of possible futures. Scenario planning also provides the opportunity to consider Colorado's water values and build portfolios of solutions. The state needs conservation, reuse, completion of planned projects, and development of alternative agricultural transfers in the near term. At the same time, Colorado must prepare for the possibility of further agricultural transfers, an additional TMD as Chapter 8 describes, and even higher levels of conservation to meet future M&I needs—while concurrently implementing environmental and recreational projects and continuing to support agriculture.[1]

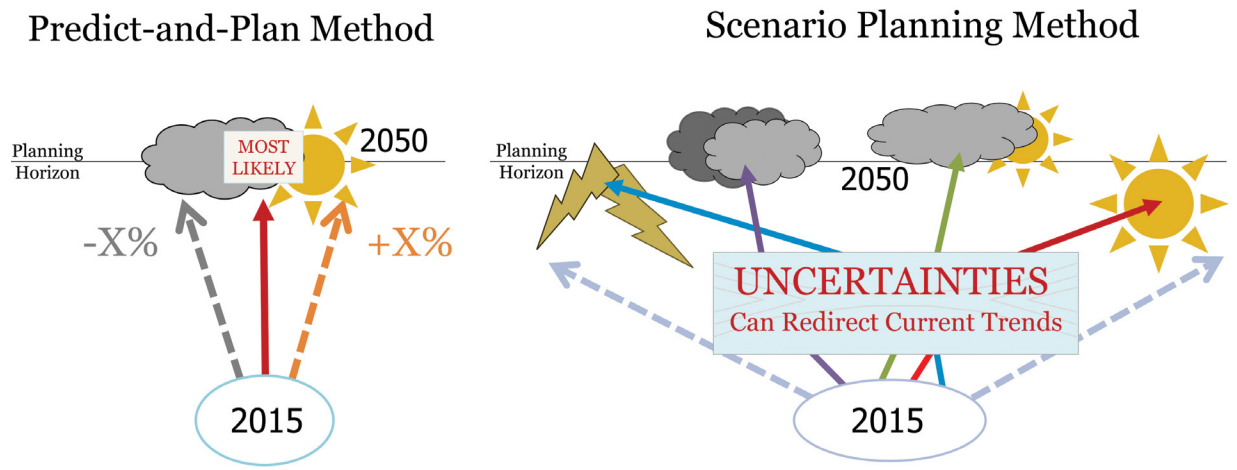
Rather than trying to predict the future by looking at the past, scenario planning allows us to identify and account for key uncertainties.

The elements of Colorado's adaptive strategy arose from significant technical work and the early and ongoing engagement of stakeholders. In developing Colorado's Water Plan, the CWCB, basin roundtables, and the IBCC adopted the scenario planning process to initiate a conversation among stakeholders about planning for uncertainties and emerging water resource challenges.[2] These groups worked together to explore how to meet the increasing water needs of Colorado's growing communities while balancing water interests.[3] Of particular concern, Colorado must contend with the significant and growing municipal water needs by 2050.[4] Scenario planning helps answer questions about how much water Colorado may need in the future, how much water may be available to meet our state's future needs, and what sources of water supply future generations will support. Subsequent sections in Chapter 6, as well as Chapter 8, provide details about ways in which Colorado can employ the scenario planning approach to more specifically respond to an uncertain future.

Scenario Planning: *Planning for Multiple Futures*

Given the uncertainties of future water supply and demand, the CWCB adopted a planning approach that many major water providers across the West use: scenario planning.[5] The use of scenario planning assumes that the future is unknown and provides flexibility in responding to various future conditions.[6] Rather than trying to predict the future by looking at the past, scenario planning allows the CWCB and stakeholders to identify and account for key uncertainties operating within the planning period (Figure 6.1-1).

FIGURE 6.1-1 THE TRADITIONAL "PREDICT-AND-PLAN" APPROACH COMPARED TO THE SCENARIO-PLANNING APPROACH

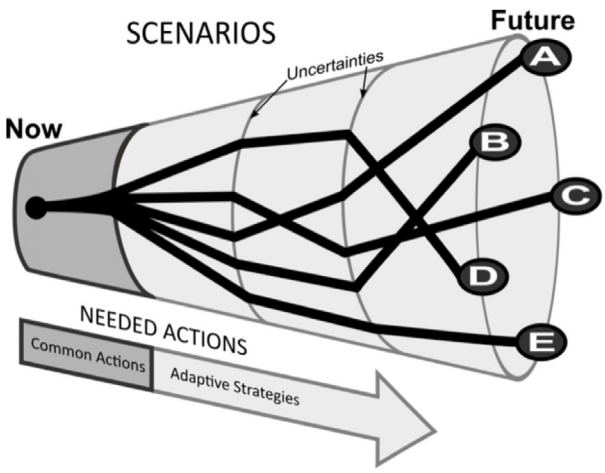


Adapted from Global Business Network, 2012 & Marra, 2013[7]

Scenario planning relies on several key driving forces in order to build multiple plausible futures (i.e., scenarios), whereas, by contrast, the more traditional "predict-and-plan" approach develops the most probable future. The IBCC and basin roundtables worked in partnership with the CWCB to explore the implications of multiple plausible futures. Given the unpredictability of factors driving Colorado's future, such as climate change, economic and population growth, and social values, the necessity of planning for multiple scenarios in Colorado's future requires a much more comprehensive planning and preparation tool. The IBCC and basin roundtables developed descriptions of several futures Colorado could face, and used those descriptions to identify and evaluate a prospective series of implementable projects and initiatives called "portfolios." One goal of this work was to identify projects and policies that are needed across multiple scenarios. Common actions would therefore apply to multiple futures, and Colorado can plan for and prioritize those first, while still monitoring uncertainties that may redirect recent trends.

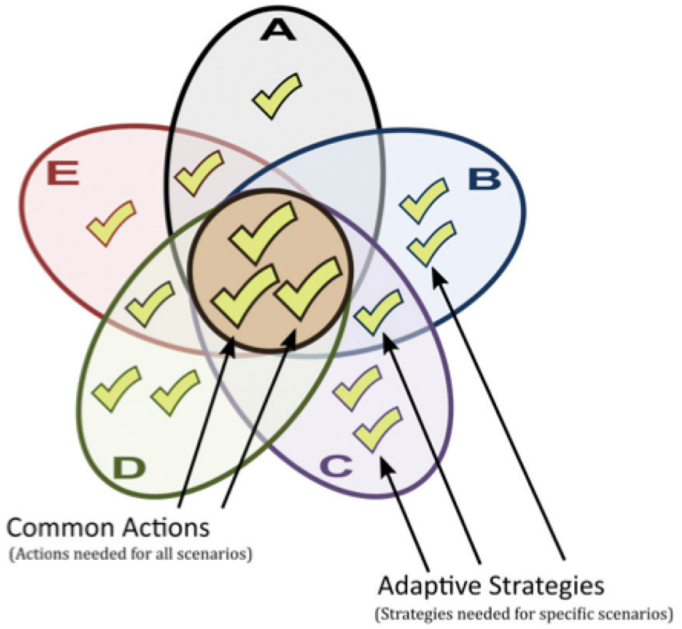
By implementing successive sets of common actions over time, decision makers can be more confident that the policies and investments Colorado makes in the near term will also be viable in the longer term. The near- and long-term actions combine with the scenarios to create a forward looking pathway of actions that both anticipate and prepare for the emerging needs of the future. Figure 6.1-2 conceptualizes ways in which Colorado can align various potential future conditions with near-term actions and long-term adaptive strategies.

FIGURE 6.1-2 SCENARIO PLANNING IDENTIFIES SUCCESSIVE SETS OF COMMON ACTIONS THAT APPLY TO MULTIPLE FUTURES



Adapted from Marra & Thomure, 2009.[8]

FIGURE 6.1-3 COMMON ACTIONS AND ADAPTIVE STRATEGIES IN SCENARIO PLANNING



In the near term, Colorado's way forward involves implementing actions that are common to all or most of the envisioned futures. These common actions have broad applicability, as Figure 6.1-3 shows. The common actions are necessary regardless of which scenario Colorado eventually encounters, and they can be implemented immediately. By contrast, the adaptive strategies are dependent on the specific scenario and will be evaluated based on future information. In the mid-to-long term, the direction forward may narrow and favor a smaller set of possible futures. In that case, the CWCB would work with stakeholders to reevaluate and update the planned actions as well as the strategies. The CWCB would base these updates on the status of predetermined "signposts" or decision points that reveal whether past uncertainties now have more clarity. For water in Colorado, these uncertainties include water needs, water supply, and Colorado's social values. The use of scenarios enables planners to respond and adapt to still-emerging issues and to explore the opportunities and challenges each possible future presents—without reducing options available going forward.[9]

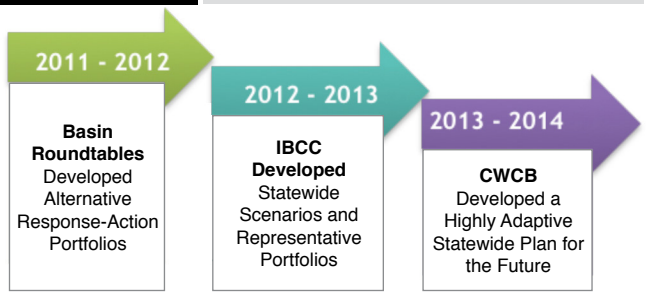
Developing Alternative Water Supply Portfolios

The SWSI 2010 report introduced the "status-quo portfolio"—a set of prospective water-supply actions that would likely be required if current trends continue their trajectories. The status quo is counter to Colorado's water values (as Chapter 1 presents), and leads to the transfer of large quantities of water out of the agricultural sector to satisfy M&I water-supply needs. Such a transfer would result in a substantial loss of agricultural lands and could potentially cause harm to the environment and to Colorado's economy. This plan discusses additional challenges with the status-quo portfolio below. The general statewide consensus is that the status-quo portfolio of actions, and the projected future it assumes, is not desirable for Colorado.[10]

Given these concerns, the CWCB initiated a multi-year, stakeholder plan development process in conjunction with the nine basin roundtables and the IBCC. Each basin roundtable represents the water interests of a specific region within Colorado, and the IBCC facilitates conversations among the basin roundtables and addresses broader, statewide water issues. Figure 6.1-4 on the following page summarizes the plan development process.

Each of the nine basin roundtables developed one or more statewide water supply portfolios to respond to the projected low, medium, or high future water needs of communities.[11] Each portfolio constitutes a unique combination of possible strategies communities could use to meet a range of projected M&I water needs. The strategies include conservation, reuse, agricultural transfers, development of water projects within each basin, and TMDs. The CWCB developed an interactive tool that quantifies tradeoffs—associated with Colorado's water values—that each portfolio would generate. These tradeoffs include effects on the environment, agriculture, reliability, and cost. This work brought basin roundtables together by showing how one water supply decision has multiple effects across the state. Most of the 34 portfolios the basin roundtables developed reduced these tradeoffs, thereby minimizing negative effects statewide and in each basin. They also presented combinations of solutions that both met a variety of possible future conditions and aligned with Colorado's water values.

FIGURE 6.1-4 SUMMARY OF THE STAKEHOLDER AND PLAN DEVELOPMENT PROCESS



The IBCC subsequently synthesized and reduced the 34 basin roundtable-generated portfolios into a smaller set of 10 "representative" portfolios to address projected low-, mid-, and high-range M&I water demands (as Chapter 5 describes). The basin roundtables determined that the representative portfolios successfully captured the intent and character of the original 34 portfolios.

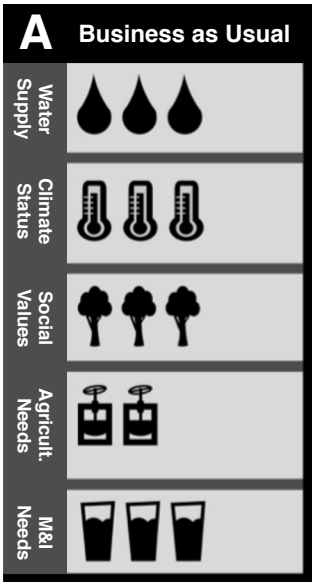
Formulating Plausible Scenarios

Potential changes in future M&I water demand and available water supply were among the most important drivers all of the basin roundtables considered when developing their portfolios. Some of the basin roundtables also considered changing societal values and other drivers outside of the water community's control. The IBCC took these perspectives into account when developing the list of nine high-impact drivers, which it factored-in to the scenario development process. These drivers will greatly influence the direction of Colorado's water future:

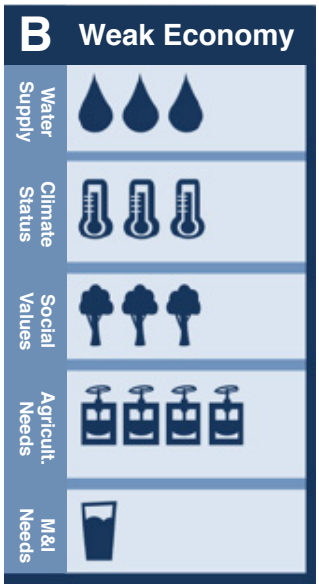
1. Population/Economic Growth
2. Social/Environmental Values
3. Climate Change/Water Supply Availability
4. Urban Land Use/Urban Growth Patterns
5. Energy Economics/Water Demand
6. Level of Regulatory Oversight/Constraint
7. Agricultural Economics/Water Demand
8. M&I Water Demands
9. Availability of Water-Efficient Technologies

Using these drivers, the IBCC developed five scenarios that represent plausible futures. It then matched the scenarios with five of the 10 representative portfolios of solutions that best met the needs each scenario described, and that aligned with Colorado's water values. The scenarios represent how Colorado's water future might look in 2050, even though the actual future at that time will likely contain a mixture of multiple scenarios. The scenario summary also includes a visualization of five of the main drivers. A chart for each scenario shows the relative increase and decrease in levels for each driver compared to current levels. The descriptive scenario names portray the overall essence that each scenario embodies in its respective views of the future.[12] The IBCC describes the scenarios as follows:

A. **Business as Usual:** Recent trends continue into the future. Few unanticipated events occur. The economy goes through regular economic cycles but grows over time. By 2050, Colorado's population is close to 9 million people. Single-family homes dominate, but there is a slow increase of denser developments in large urban areas. Social values and regulations remain the same, but streamflows and water supplies show increased stress. Regulations are not well coordinated and create increasing uncertainty for local planners and water managers. Willingness to pay for social and environmental mitigation of new water development slowly increases. Municipal water conservation efforts slowly increase. Oil-shale development continues to be researched as an option. Large portions of agricultural land around cities are developed by 2050. Transfer of water from agriculture to urban uses continues. Efforts to mitigate the effects of the transfers slowly increase. Agricultural economics continue to be viable, but agricultural water use continues to decline. The climate is similar to the observed conditions of the 20th century.

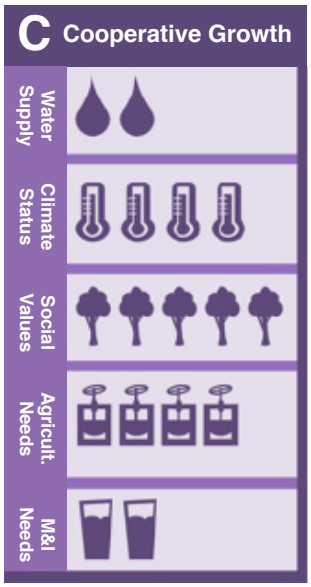


B. **Weak Economy:** The world's economy struggles, and the state's economy is slow to improve. Population growth is lower than currently

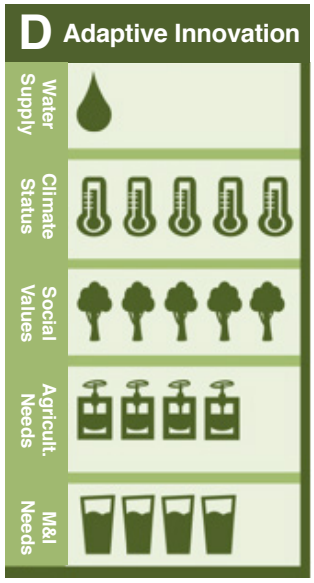


projected, slowing the conversion of agricultural land to housing. The maintenance of infrastructure, including water facilities, becomes difficult to fund. Many sectors of the state's economy, including most water users and water-dependent businesses, begin to struggle financially. There is little change in social values, levels of water conservation, urban land use patterns, and environmental regulations. Regulations are not well coordinated and create increasing uncertainty for local planners and water managers. Willingness to pay for social and environmental mitigation decreases due to economic concerns. Greenhouse gas emissions do not grow as much as currently projected and the climate is similar to the observed conditions of the 20th century.

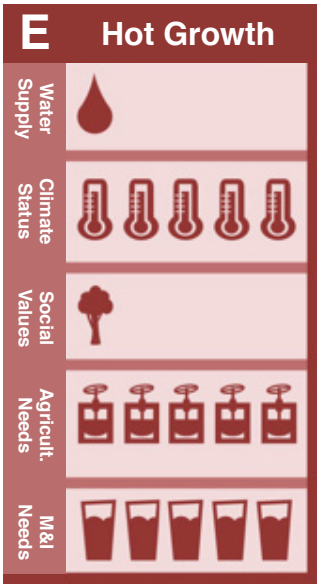
C. **Cooperative Growth:** Environmental stewardship becomes the norm. Broad alliances form to provide for more integrated and efficient planning and development. Population growth is consistent with current forecasts. Mass transportation planning concentrates more development in urban centers and in mountain resort communities, thereby slowing the loss of agricultural land and reducing the strain on natural resources compared to traditional development. Coloradans embrace water and energy conservation. New water-saving technologies emerge. Eco-tourism thrives. Water-development controls are more restrictive and require both high water-use efficiency and environmental and recreational benefits. Environmental regulations are more protective, and include efforts to re-operate water supply projects to reduce effects. Demand for more water-efficient foods reduces water use. There is a moderate warming of the climate, which results in increased water use in all sectors, in turn affecting streamflows and supplies. This dynamic reinforces the social value of widespread water efficiency and increased environmental protection.



D. **Adaptive Innovation:** A much warmer climate causes major environmental problems globally and locally. Social attitudes shift to a shared responsibility to address problems. Technological innovation becomes the dominant solution. Strong investments in research lead to breakthrough efficiencies in the use of natural resources, including water. Renewable and clean energy become dominant. Colorado is a research hub and has a strong economy. The relatively cooler weather in Colorado (due to its higher elevation) and the high-tech job market cause population to grow faster than currently projected. The warmer climate increases demand for irrigation water in agriculture and municipal uses, but innovative technology mitigates the increased demand. The warmer climate reduces global food production, increasing the market for local agriculture and food imports to Colorado. More food is bought locally, increasing local food prices and reducing the loss of agricultural land to urban development. Higher water efficiency helps maintain streamflows, even as water supplies decline. The regulations are well defined and permitting outcomes are predictable and expedited. The environment declines and shifts to becoming habitat for warmer-weather species. Droughts and floods become more extreme. More compact urban development occurs through innovations in mass transit.



E. **Hot Growth:** A vibrant economy fuels population growth and development throughout the state. Regulations are relaxed in favor of flexibility to promote and pursue business development. A much warmer global climate brings more people to Colorado with its relatively cooler climate. Families prefer low-density housing and many seek rural properties, ranchettes, and mountain living. Agricultural and other open lands are rapidly developed. A hotter climate decreases global food production. Worldwide demand for agricultural products rises, greatly increasing food prices. Hot and dry conditions lead to a decline in streamflows and water supplies. The environment degrades and shifts to becoming habitat for species adapted to warmer waters and climate. Droughts and floods become more extreme. Communities struggle unilaterally to provide services needed to accommodate the rapid business and population growth. Fossil fuel is the dominant energy source, and there is large production of oil shale, coal, natural gas, and oil in the state.



The five scenarios above collectively capture a broad range of future supply-and-demand possibilities and uncertainties. Of the five scenarios, "Business as Usual" is the most conventional, while "Adaptive Innovation" and "Hot Growth" are the most difficult to prepare for because of high water demands combined with the effects of climate change. The challenge is not to pick the most likely or attractive future; rather, it is to develop the capacity to prepare Colorado for all of them.

Developing an Adaptive Water Management Plan

In analyzing the portfolios, the IBCC identified common near-term strategies and actions that would provide baseline benefits for all five of the envisioned scenarios. Most of these actions would be necessary no matter what future Colorado faces, and would fully meet low demands, as the "Weak Economy" scenario describes. Some strategies prepare Colorado for future projects and methods that may be needed in one or more futures. These near-term commonalities are called "no-and-low-regret" strategies and actions, since they would most likely be viable no matter how the future might ultimately unfold.

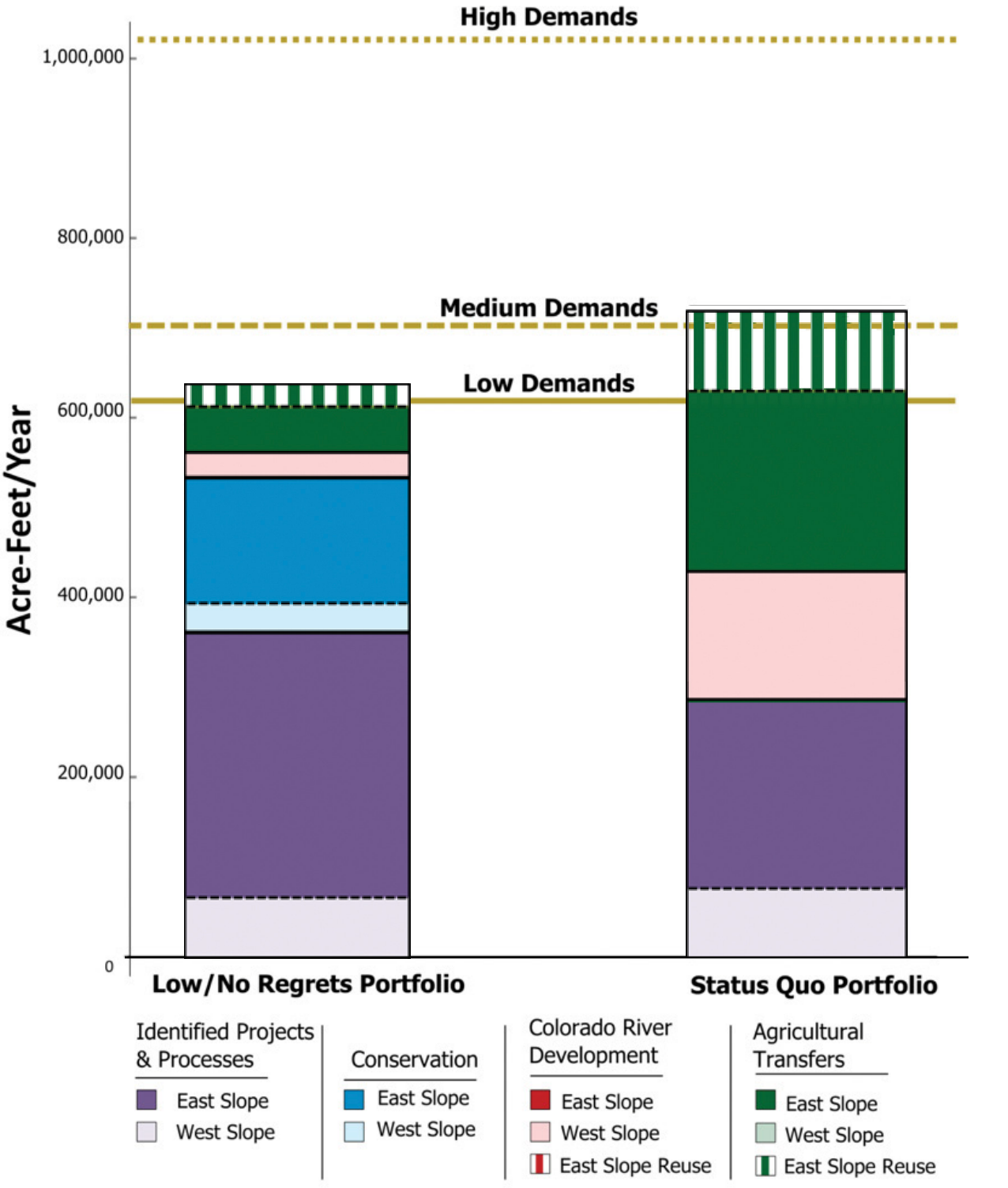
In this context, a "regret" is an action in which Colorado enters a future where there are:

1. Water shortages due to an insufficient number of implemented necessary projects and methods;
2. Significant consequences to Colorado's agriculture, environment, or economy because Colorado's water community did not implement projects and methods consistent with Colorado's water values; or
3. Too many unneeded and costly projects.

By implementing the No-and-Low-Regrets actions sooner rather than later, Colorado will be prepared for any future, without provoking serious tradeoffs. Figure 6.1-5 (page 6-9) illustrates how the No-and-Low Regrets party compares to the status-quo portfolio.

In contrast to the Status-Quo Portfolio, the No-and-Low-Regrets Portfolio reduces potential effects to the environment and agriculture by increasing the success of planned projects and levels of water conservation. The No-and-Low-Regrets Portfolio aligns with Colorado's water values; it avoids the unacceptable consequences resulting from the continued drying-up of Colorado's irrigated agriculture and the use of more Colorado River water. Nevertheless, the No-and-Low-Regrets Portfolio only meets the low-demand scenario (as Figure 6.1-5 shows), and additional water supplies or increased conservation will be required if Colorado faces medium or high water demands. In addition, several portfolios address higher demands while continuing to align with Colorado values; this chapter explores these below.

FIGURE 6.1-5 NO-AND-LOW-REGRETS PORTFOLIO VERSUS THE STATUS-QUO PORTFOLIO



Below are descriptions of the recommended No-and-Low-Regrets actions, along with the adaptive strategies that will prepare Colorado for other potential futures:

- **Minimize the transfer of statewide agricultural acres and implement agricultural sharing projects:** Limit traditional permanent dry-up of agricultural lands by supporting lower-impact alternatives for more than 300,000 people (requiring 50,000 acre-feet of water) in the near future. Simultaneously, track the reliability of these alternatives, and plan and preserve the option of additional agricultural transfers should a future scenario necessitate this action. Section 6.4 describes these opportunities.
- **Plan and preserve future options for developing unappropriated waters:** Develop additional water supplies from unappropriated water on the western slope for local use to serve a minimum of 200,000 people (requiring 35,000 acre-feet of water), and to support their associated jobs in the near future. At the same time, plan for and preserve the option of an additional TMD, should a future scenario necessitate such a project through the conceptual framework parameters Chapter 8 describes.
- **Establish low to medium conservation strategies:** Implement strategies to meet low to medium levels of conservation, and apply at least half of these savings to meet future M&I needs in order to support approximately 1 million people (requiring 170,000 acre-feet of water) and their jobs in the near future. At the same time, track the reliability of these conservation savings, and plan for ways to achieve additional conservation savings, should a future scenario necessitate this action. Section 6.3 describes several avenues for accomplishing this.
- **Implement projects and methods that support environmental and recreational uses:** Implement local projects, especially those that support imperiled species and recreational areas that are important to local economies. Section 6.6 describes these projects and methods.
- **Strive for high success rates for projects and methods that are already planned:** Work to support the projects that are already planned, as these already have a project proponent and are often smaller and less controversial than many of the other project options. Statewide, these projects may provide enough water for more than 2 million people (requiring 350,000 acre-feet of water) and their associated jobs in the near future. Continue to track the success rate of these projects and their ability to meet future community water needs. Section 6.5 further describes these projects and methods.
- **Assess and implement storage projects and other infrastructure:** Implement storage and other infrastructure to maximize flexibility and reliability. Focus on options that support multiple needs for communities, agriculture, and the environment. Section 6.5 further discusses storage.
- **Implement water reuse strategies:** Implement strategies that encourage increased use of recycled water, as Section 6.3 describes.

As indicated in SWSI, "Colorado faces a shortage of water for meeting the state's consumptive and nonconsumptive water needs. In order to meet Colorado's water management objectives, a mix of local water projects and processes, conservation, reuse, agricultural transfers, and the development of new water supplies should be pursued concurrently."[13] The No-and-Low-Regrets actions bring together the need to advance each of these which, together, are known as the "four legs of the stool."

The No-and-Low-Regrets Portfolio only satisfies the M&I water supply needs of the "Weak Economy" scenario, and would only be possible if the portfolio were successfully implemented in the near term. If medium or high water demands had to be met as the other scenarios envisioned, additional portfolio actions would be required in the mid and long term.

Colorado must be prepared for a range of possible futures, which may be dry or wet. Drought photo courtesy of USGS.

Building on the earlier work of the basin roundtables and the IBCC, the CWCB developed a scenario-based adaptive water strategy. While the No-and-Low-Regrets Portfolio is necessary no matter what future Colorado may face, the adaptive framework recognizes that the future hinges upon how much the primary drivers—M&I water demand, waters-supply availability, and social values—change over time. These drivers could tip the still-evolving future toward one scenario or another. The tipping points serve as water management decision points, or "signposts," that can lead toward the need to implement a certain portfolio of solutions. By developing an adaptive water management framework, managers and decision makers will be more aware of approaching signposts and can anticipate the need to make timely water management decisions.

An explanation of the primary drivers follows:

- Future changes in *M&I water demands* may trend "lower" or "higher" relative to the mid-level water demand forecasts previous SWSI efforts used. The State may anticipate such changes by tracking indicators of economic activity and demographic growth, as well as other secondary factors.
- Water *supply availability* may similarly trend "lower" or "higher" depending on climate change, watershed hydrology, and legal constraints associated with Colorado's interstate compacts, water law, and environmental regulations. The State will assess water supply availability as trending lower or higher over time as compared to earlier versions of the SWSI.

- The third primary driver, *social values,* is a measure of statewide public sentiment; it may trend toward a more "green" orientation or it may shift toward greater "resource utilization." "Green" values will likely favor more dense, low-impact urban development, greater reliance on water reuse and energy efficiency, greater protection of environmental and recreational resources, and preservation of local agriculture and open space. Values associated with more intensive resource utilization will gravitate toward full use of existing natural sources as well as the development of new sources to satisfy M&I water demands.

This scenario-based framework allows for incremental implementation of future portfolio response actions beyond the No-and-Low-Regrets actions recommended in the near term (Figure 6.1-6). Pre positioned portfolio actions—such as increased levels of conservation, agricultural transfers, or TMDs—can be implemented at specified key signposts. This will allow decision makers to adaptively respond in real time to changes in critical drivers that cannot be predicted with certainty. Critical drivers include water demands, water supply, and social values.[14]

Table 6.1-1, on page 6-13, illustrates the relationships between the three primary drivers, scenarios, and portfolios of solutions. The five portfolios that match the scenarios best meet both future conditions and Colorado's water values.

The No-and-Low-Regrets actions will not be easy to accomplish. Nevertheless, if Colorado does not implement these in the next 15 years, the effects will be severe. The water supply gap will be greater than any basin roundtable has envisioned, and the solutions will dry up more agriculture and cause further harm to the environment. If Colorado faces high demands and does not fully implement the No-and-Low-Regrets actions, the state will have to implement projects and methods beyond anything the basin roundtables have planned and prepared for in the portfolio development process.

FIGURE 6.1-6 COLORADO'S SCENARIOS AND THEIR MATCHING PORTFOLIOS

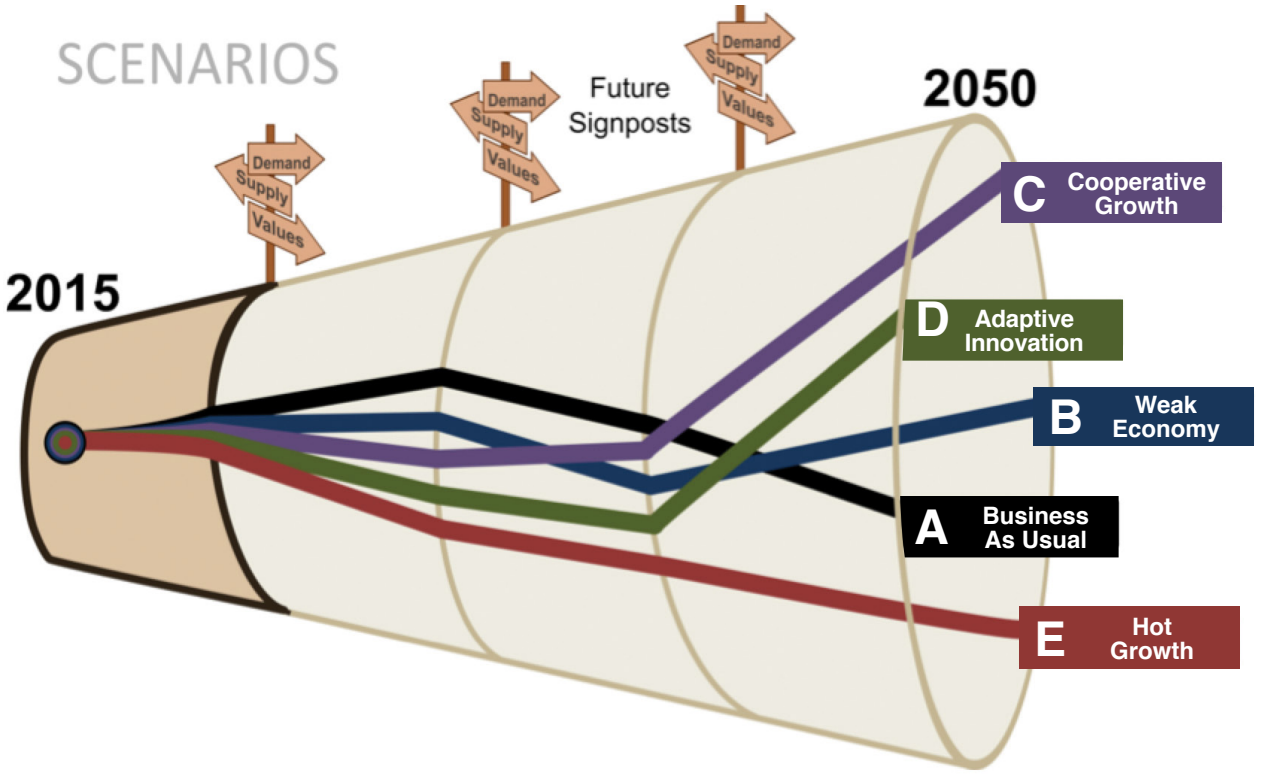
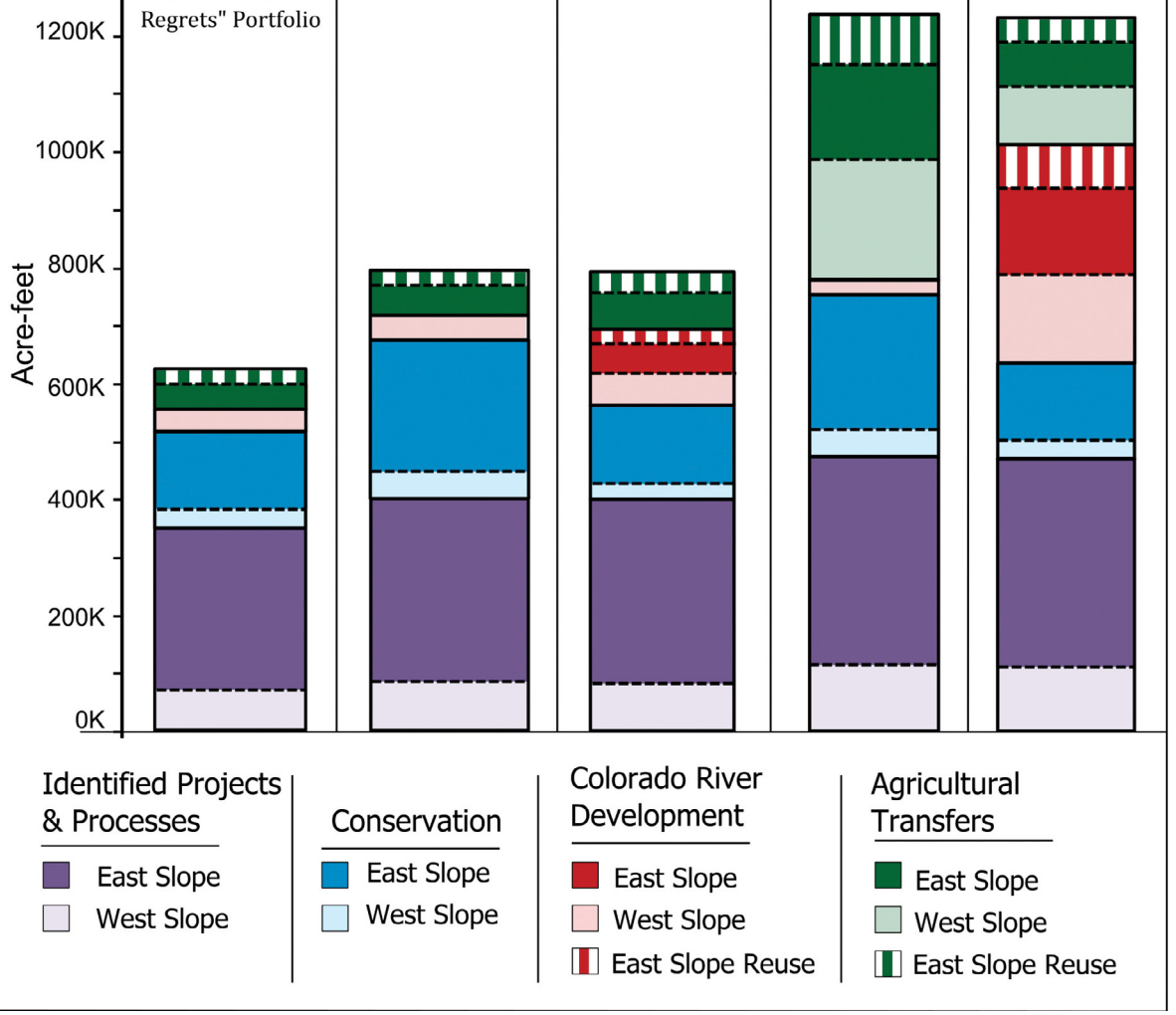


TABLE 6.1-1 SCENARIOS AND THEIR MATCHING PORTFOLIOS

		Scenarios				
		B Weak Economy	C Cooperative Growth	A Business as Usual	D Adaptive Innovation	E Hot Growth
Scenario Drivers	Water Demand	Lower	Lower	Higher	Higher	Higher
	Water Supply	Higher	Lower	Higher	Lower	Lower
	Social Values	No Change	"Green"	No Change	"Green"	"Resource Utilization"
Portfolio of Solutions		"Low Demand Conservation" / "No-and-Low Regrets" Portfolio	"Mid Demand Conservation" Portfolio	"Mid Demand Mixed" Portfolio	"High Demand Conservation" Portfolio	"High Demand Mixed" Portfolio



Depending on the scenario, this could be an even larger TMD, draconian conservation measures, or even greater amounts of agricultural dry-up—and these approaches would not be consistent with Colorado's water values. It is imperative that Colorado implement the No-and-Low-Regrets actions.

Section 6.2 assesses whether or not the BIPs would be able to meet the No-and-Low-Regrets actions. Sections 6.3 through 6.6 and Chapter 8 explore in detail how Colorado, at a minimum, can implement the No-and-Low-Regrets actions through the BIPs and other stakeholder projects and methods; the State would accomplish this by obtaining financial support, pursuing education efforts, forming partnerships, and pursuing legislative solutions.

If successfully implemented, this adaptive water strategy will provide a roadmap to a still-evolving future. Given the whims inherent in predicting future conditions, the plan must be a living document. As new critical drivers arise, or as decision points change over time, the CWCB in partnership with stakeholders, will need to assess and revise the scenarios and associated response-action portfolios in subsequent updates to the SWSI.

ACTIONS

The following actions will continue to support scenario planning and Colorado's adaptive strategies:

1. **Support the implementation of the No-and-Low-Regrets strategy:** The CWCB, in partnership with other state agencies, will commit state financial, technical, and regulatory resources to the near-term implementation of prioritized water management projects as specified in the No-and-Low-Regrets actions. As part of this work, and in partnership with the basin roundtables, the CWCB will evaluate progress toward achieving the No-and-Low-Regrets actions.
2. **Monitor drivers:** To determine which scenario Colorado will most likely face, the CWCB will work with partners, such as the Climate Change Technical Advisory Group, to monitor the critical drivers of water supply, demand, and the level of "green" versus "full-resource use" values through future SWSI updates and other technical work. As part of this work the CWCB will work with stakeholder groups to update the scenarios and adaptive strategies.
3. **Promote use of scenario planning and adaptive strategies:** The CWCB and the basin roundtables will continue to use and promote scenario planning and the use of adaptive strategies to respond to, mitigate, and prepare for climate change. In partnership with project proponents, the CWCB will also encourage and facilitate the adoption of adaptive strategies for municipal, industrial, agricultural, environmental, and recreational needs as Colorado moves into the future.
4. **Support Colorado's Decision Support Systems (CDSS):** The CWCB and the DWR will continue to develop and support the CDSS to encourage data-driven planning and decision making.
5. **Support innovative and collaborative science:** The CWCB will continue to work with local, state, and federal partners to build coalitions to purchase, deploy, maintain, and operate new equipment and new science necessary for 21st-century water management. Concepts and technologies such as watershed-based gap-filling radars for continuous weather coverage, radiometers for improved profiles of the atmosphere and modeling support, and improved high -resolution atmospheric and hydrological modeling specific to Colorado, lead to accurate quantification of the snowpack and runoff, regardless of the scenario.