SECTION 5
INSIGHTS, TOOLS, AND RECOMMENDATIONS

In addition to the core analysis of this report, the Technical Update incorporates a set of topic-specific evaluations (insights), supporting tools, and recommendations. These efforts aim to provide insights, assistance and direction to basin roundtables as they update their BIPs and consider solutions for addressing future gaps. Technical memoranda on each of the insights and existing tools are included in Volume 2 (see Appendix A for a full list). An overview of each of these topics is provided in the following subsections and as summarized below:

Insights: Section 5.1 provides a summary of high-level and conceptual analyses on the following focused topics related to implications of supply/demand gaps and key points to consider when developing potential solutions to solving future gaps. Basin roundtables may choose to expand on these analyses if necessary or desirable when updating their BIPs. The analyses focused on the following water-related areas:

- Public values regarding water issues in Colorado
- Overview and case study descriptions of Alternative Transfer Methods (ATM)
- Overview of water reuse mechanism
- Storage opportunities in Colorado
- Economic impacts of failing to solve future projected supply/demand gaps

Tools: Section 5.2 highlights several tools for basin roundtables to use when updating their BIPs. During the Technical Update, the consistency of data across all the existing BIPs was reviewed. The results of this review pointed to a strong need to improve the completeness and uniformity of information on all water supply projects/strategies and related costs. The tools developed in the Technical Update build on prior efforts in the following areas:

- Costing Tool
- E&R Flow Tool
- E&R database
- Projects database

Recommendations: Section 5.3 outlines several recommendations that primarily focus on how to use, enhance, and integrate findings from the Technical Update into the BIP updates. Recommendations stem from multiple stakeholder interactions and divide into five major update areas:

- BIP
- Project
- Technical
- Outreach
- Strategic

5.1 INSIGHTS

5.1.1 Public Perception Insights

In 2012 and 2013, a survey entitled, *Public Opinions, Attitudes and Awareness Regarding Water in Colorado*, was conducted on behalf of the CWCB. In addition, other survey research was documented relevant to understanding social values in the context of the Technical Update planning scenarios and water supply challenges that Colorado will face. Findings from the survey are documented in the technical memorandum, *Observations Regarding Public Perceptions on Water* (included in Volume 2, Section 12) and summarized below.

- Coloradans have varied levels of knowledge regarding water use in the state. Only one in three residents recognizes that agriculture is the largest water user in Colorado. In 2012 and 2013, a large majority of the state's residents were paying more attention to water issues and their own water use than they had in the past. In part, this was likely due to 2012's dry summer conditions. Repeated surveys in other locations found that water awareness rises during droughts and diminishes after the drought recedes.
- Among eight potential water-related concerns, Coloradans identified protecting home water quality, having enough water for Colorado's farms and ranches, and having enough water for Colorado's cities and towns as the most important issues. These were the top three issues in each region of the state, although the ranking order of the issues varied by region.
- Coloradans most frequently described conservation as their preferred approach to addressing Colorado's water issues, followed by prioritizing environmental needs and building new water supply projects. Conservation was the most frequently recommended strategy in every region, and support for prioritizing environmental needs was consistent across Colorado's regions. Support for developing new water supply projects was more varied.
- Coloradans perceive home water service to be affordable compared to other home services, and they are willing to pay more to address Colorado's water issues. On average, Coloradans are willing to pay between $5 and $10 more per month to address water-related concerns. At $5 per month per household, this willingness to pay would correspond to statewide annual financial support of about $125 million.

5.1.2 ATM Insights

Overview

The Technical Update shows that under multiple planning scenarios a growing population, healthy economy, and climate change will lead to increasing municipal and industrial water demands and subsequently intensify pressure to permanently transfer agricultural water rights. In particular, the South Platte and Arkansas basins face significant reductions in irrigated agricultural land due to increasing demand. Other drivers of permanent reductions in irrigated acreage include urbanization, inadequate augmentation water supplies, declining aquifers, and compact compliance.

Across the state, water stakeholders want to minimize permanent reductions in irrigated agricultural land and support a variety of alternative options, such as water banking and interruptible water supply agreements. Colorado's Water Plan sets a goal of achieving 50,000 acre-feet of water transfers through voluntary ATMs by 2030. The Water Plan also sets a goal that ATMs compete with, if not out-perform, traditional transactions in the water market. Through the long-standing ATM Grant Program and other initiatives, the CWCB continues to facilitate the development and implementation of ATM projects across the state

The technical memorandum, *Review of Successful Alternative Transfer Method Programs and Future Implementation* (included in Volume 2, Section 11) reviews select ATM projects that have been successfully implemented and highlights key characteristics of each ATM that provide insight into how future ATMs might also be successfully structured. Additionally, the study provides perspectives on agricultural to municipal transfers, and includes recommendations for monitoring metrics to track the effectiveness of future ATM programs.

ATM projects provide several general benefits when compared to permanent, buy-and-dry water transfers. For municipalities, ATMs may provide a reliable source of dry-year water supplies and can be more cost effective than permanent transfers and other traditional new supply sources. By maintaining some farm operations as part of the ATM program, rural economies that depend on agricultural activities can be sustained, and agricultural users can have access to new income streams for purchasing new equipment and investing in infrastructure improvements or other operational needs. ATMs can also be useful in preserving ecosystem services associated with working agricultural lands, such as open space and wildlife habitat. Additionally, ATMs can be applied to address multiple water supply challenges, including municipal and industrial needs, compact compliance, groundwater management, and non-consumptive needs.

Challenges to ATM implementation include balancing the municipal and industrial user's desire for certainty and permanence of long-term supply with the supplier's desire to maintain profitable agriculture, and potentially high infrastructure costs needed to implement a viable water transfer (potentially high infrastructure costs are a barrier to implementing a permanent transfer and are not necessarily unique to ATMs). Furthermore, high transaction and administration costs common to nearly all transfers can discourage some parties from pursuing an ATM arrangement. Several efforts have been made to address these challenges over recent years, including the continued financing of ATM projects through the CWCB's ATM Grant Program and development of more flexible, administrative ATM project approvals through the HB13-1248 Fallowing-Leasing Pilot Program and Agricultural Water Protection Water Right.

ATM Case Study Examples **(can this just be Case Studies throughout? case study and examples seems redundant)**

ATMs in Colorado are predominantly used to transfer water from agriculture to municipal, industrial, or environmental uses on a temporary basis, but several long-term ATM projects have been developed based on the needs of the parties involved. Case study examples of recently implemented ATMs in Colorado were developed to better understand methods used to overcome challenges and past barriers to implementing ATMs, unique issues between the parties involved, overall benefits, and key lessons learned that can apply to future ATM implementation. The case studies selected represent different ATMs, and are shown below:

Agricultural to Municipal and Industrial

- Little Thompson Farm
- Catlin Canal

Agricultural to Environmental

- McKinley Ditch

Compact Compliance

- Grand Valley Water Users Association Conserved Consumptive Use Pilot Program

Hypothetical Agricultural to Municipal Transfer Considerations

A hypothetical example ATM program was considered to provide context into how a coordinated, large-scale rotational fallowing program could be developed to meet a significant portion of the M&I gap. The example describes a large-scale fallowing program and concluded that a significant portion of irrigated acreage would need to be enrolled in the program to yield significant amounts of supply. Additionally, several infrastructure components may be required to implement a large-scale ATM program, including augmentation and operational storage, pipelines and pump stations, and water treatment systems. This infrastructure may be needed even if traditional agricultural transfers were implemented from the same geographical areas.

ATM Implementation and Effectiveness Monitoring

Following recommendations in the Water Plan concerning ATM data compilation, future ATM monitoring metrics were identified to help give insight to the effectiveness and operation of a single ATM, or a large-scale ATM program across a larger geographic area to gauge regional or basinwide trends. Obtaining this data for a wide variety of implemented ATMs (both geographically and for different ATMs) will provide more information to decision makers to evaluate the effectiveness of proposed ATMs, identify trends, and evaluate pricing. ATMs provide an opportunity to meet increasing water demands of a growing population while lessening the impacts to Colorado agricultural communities. Next steps to be considered include:

- Developing better guidance as to what types of projects and processes further Water Plan goals related to maintaining or enhancing agricultural viability while meeting potential new demands and addressing other water resource management issues
- Assessing institutional support of ATMs and evaluating progress made on addressing the primary barriers to ATM development and implementation
- Developing additional pilot projects for the varying ATM programs and engaging in thoughtful monitoring of their effectiveness
- Working with basin roundtables to consider how ATMs can play a role in addressing basin needs and priorities
- Pursuing further the collection of recommended monitoring data for ATMs as they are developed and sharing this information through existing platforms such as CDSS or new platforms such as an ATM data clearinghouse.

5.1.3 Water Reuse Insights

The Colorado Water Plan notes that various forms of water reuse will be an important component of closing future supply-demand gaps for municipalities; it also encourages water providers to build on the successes of the many reuse projects already implemented in Colorado. To advance these concepts, high-level comparisons of various water reuse mechanisms were compared and contrasted

in a fact-sheet style format that summarized hypothetical mass balances of a municipal water system implementing reuse. Benefits, tradeoffs, unintended consequences, treatment requirements, and regulatory considerations pertaining to a particular reuse mechanism were also evaluated. This information was designed to provide guidance on how to define potential municipal reuse projects in future BIP efforts. Evaluated reuse mechanisms included:

- Reuse via. Exchange
- Non-potable reuse
- Indirect potable reuse
- Direct potable reuse
- Graywater reuse

The results of the comparisons are presented in a technical memorandum *Opportunities and Perspectives on Water Reuse* (see Volume 2, Section 13).

Key Findings

In this analysis, particular attention was paid to quantifying and qualifying the impact of a local reuse project on the greater basin and watershed system. The mass balance exercises noted previously identified the following key takeaways to consider when a municipality is evaluating implementation of a particular reuse mechanism:

- *Reuse of Existing Reusable Return Flows:* If a municipality can reuse existing legally reusable return flows, the amount of new supplies needed to meet future demands can be reduced. Indirect, direct, or reuse via exchange methods have the best opportunity to reduce the need for new supplies due to the ability to reuse water year-round. When a municipality begins to reuse return flows that historically have not been reused, a flow reduction to downstream users can result. Coordination between the water provider and downstream water users could help those users plan for this reduction in downstream water availability.
- *Reuse of New Supplies:* If a municipality cannot reuse existing return flows, reusing future, new, legally reusable supplies will reduce the amount of new supplies needed. Reuse of new supplies using indirect, direct, or reuse by exchange methods can be used year-round, which maximizes the benefit of reuse to the municipality and minimizes the amount of new supplies needed.

5.1.4 Storage Opportunity Insights

The CWP states that Colorado must develop additional storage to manage and share conserved water and manage the challenges of a changing climate. It sets a measurable objective of attaining 400,000 acre-feet of innovative water storage by 2050. The technical memorandum, *Opportunities for Increasing Storage* (see Volume 2, Section 10), investigates concepts related to increasing water storage to assist in meeting current and future water supply challenges throughout Colorado.

Conditional Storage Water Rights

To evaluate future storage opportunities in Colorado, the State's current water right database was queried for potential reservoir sites with conditional storage rights greater than 5,000 acre-feet. As shown in Figure 5.5.1, there are more than 6.5 million acre-feet (MAF) of conditional storage rights at reservoir sites with greater than 5,000 AF on file with the State of Colorado.

The 6.5 MAF of conditional storage rights (if constructed) would nearly double the existing surface water storage in Colorado and is more than 15 times the CWP's measurable objective of 400,000 AF of additional storage by 2050. It is not likely that the 6.5 MAF of new surface water storage will occur by 2050; however, if only a portion of the conditional storage sites were ultimately determined to be technically and environmentally feasible, those new surface water storage facilities could become a critical component to a balanced approach to meeting projected water resources gaps throughout Colorado.

Other Storage Opportunities

In addition to considering conditional storage rights, other opportunities for new storage and increasing operational storage in existing reservoirs were evaluated as a means to help solve Colorado's projected water supply and demand gaps. Table 5.5.1 summarizes the key considerations for each type of potential storage discussed in Volume 2, Section 10 titled *Opportunities for Increasing Storage*.

Figure 5.1.1 Sum of Conditional Storage Right Volumes in Various River Basins

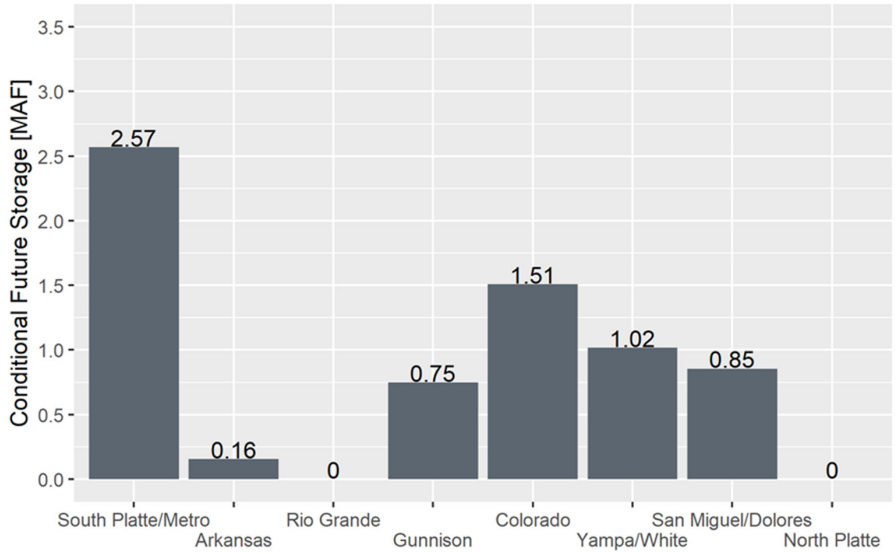


Table 5.1.1 Overview of Water Storage Opportunities

Reallocate Some Flood Storage to Active Storage	• Volume reallocation from flood control to reservoir operations (referred to as the storage delta concept) could be a part of achieving additional storage in existing reservoirs.
	• Further meteorological and hydrologic analysis could be performed on key reservoirs that have dedicated flood storage to identify the most likely opportunities for implementing the storage delta concept in the future.
Remove Sediment	• Further analysis should be completed on key reservoirs (i.e., reservoirs that have been in operation for a long period or are downstream of wildfire areas) to clarify the degree to which sediment removal could achieve additional operational storage volume.
Rehabilitate Fill Restricted Dams	• Further analysis should be completed on key reservoirs with fill restrictions to determine the degree to which dam rehabilitation and removal of fill restrictions could achieve additional operational storage volume.
	• Collaborative partnerships between municipal and agricultural water users should be explored as a way to share in the cost of reservoir rehabilitation in some cases.
Enlarge Dams	• In select cases where water is physically and legally available and the reservoir fits into existing system operations, raising the height of a dam could be a feasible option for achieving additional storage in an existing reservoir.
	• In a dam enlargement situation, significant permitting efforts will be required.
Create New Dam Sites	• Many of the largest of the 6.5 MAF of filed conditional storage water rights greater than 5,000 AF in each basin are decreed for municipal, industrial, and irrigation uses.
	• When considering future storage options, a larger number of smaller reservoirs do not accomplish the same operational objectives as a mix of larger reservoirs due to significant increases in evaporation losses and the loss of the benefits of economies of scale.
Aquifer Storage and Recovery	• Unconfined/Shallow aquifer storage and recovery projects may be best for near-term or seasonal surface water availability retiming due to potential connections to surface water systems that may limit the duration water can feasibly be stored in the unconfined system.
	• Confined/Deep aquifer storage and recovery projects may be most applicable for longer-term water storage and can be used in conjunction with a surface water storage system to better enable capture of surface water peak flows and optimize the sizing of the aquifer storage and recovery system.

5.1.5 Economic Impacts Insights

The technical memorandum *Potential Economic Impacts of Not Meeting Projected Gaps* (see Volume 2, Section 9) provides order-of-magnitude estimates of the economic consequences of failing to meet future supply gaps within Colorado and each of its basins. The study was based on data developed for the medium scenario[14] for 2050 M&I gaps from the previous SWSI effort (SWSI 2010), which anticipated a statewide gap for these uses of approximately 390,000 AF per year by 2050[15], and the projected 2050 shortage in water supplies for irrigated agriculture from the previous SWSI study, which was estimated at more than 1.7 MAF per year[16].

The economic analysis conducted for this study was based on a relatively simplified approach consistent with the goal of identifying the general magnitude of the economic consequences of failing to meet future gaps. The analysis focused on the economic implications of projected future gaps for agricultural and M&I uses. There are also significant economic implications for the state and each of its river basins in failing to meet non-consumptive needs for environmental and recreational purposes; however, quantifying the economic implications of shortfalls with respect to non-consumptive needs was beyond the scope of this study.

Three types of economic costs were included:

- Agricultural costs that are already being incurred
- Original costs of a portion of projected future M&I gaps
- Opportunity costs of foregone future economic development

The projected economic impacts of failing to meet the gaps identified in the specific 2010 SWSI demand conditions analyzed in this study provide a number of general insights regarding the importance of Colorado's water planning efforts.

The lack of sufficient supply to meet the full consumptive use requirements for irrigated crops in Colorado already results in an estimated annual loss in potential production value of more than $3 billion and about 28,000 fewer jobs directly and indirectly supported by irrigated agriculture[17]. In many basins, economic impacts on livestock production due to reduced crop and forage output are larger than the economic impacts on the crop producers. Projected gaps in 2050 irrigation water supplies indicate that these reductions in potential agricultural economic activity will continue into the future.

Economic effects of projected M&I gaps depend on the severity of the projected gap in each basin. In areas with smaller M&I gaps relative to projected 2050 demands (less than 10 or 15 percent of projected demand), the primary effects would likely be a substantial reduction in consumer welfare due to greatly reduced water availability for outdoor use and severe effects on the municipal "green industry," involving sectors such as landscape services, nurseries, and car washes. In areas with more severe M&I gaps (greater than 10 or 15 percent of projected future M&I demand), much larger economic impacts are projected due to the opportunity cost of foregone future residential, commercial, and industrial development.

Overall, the potential economic impacts and opportunity costs of the projected gaps in agricultural and M&I water supplies are substantial in every basin in Colorado. From a statewide perspective, failing to meet the gaps identified in the 2010 SWSI demand condition example analyzed in this case study could lead to between 355,000 and 587,000 fewer jobs in Colorado in 2050; $53 to $90 billion fewer dollars in annual economic output; a reduction in gross state product of between $30 and $51 billion per year; $20 to $33 billion in reduced labor income; and $3 to $6 billion fewer dollars in state and local tax revenues. To put these numbers in perspective, the projected economic impacts are equivalent to approximately 9 to 16 percent of current statewide economic output, gross state product, statewide employment, and statewide labor income.

The economic values associated with agricultural water use are substantial but are generally considerably lower than the economic values associated with M&I use. This reality, combined with the flexibility to move water among different uses and locations under Colorado law, implies that there will be continuing economic pressure to shift water from Colorado's farms to its cities and industrial users. Given the importance that the state's residents place on maintaining agriculture in Colorado, as noted in *Observations Regarding Public Perceptions on Water* (Volume 2, Section 12), these economic pressures highlight the need for strategies to mitigate potential future impacts resulting from water transfers that would negatively affect Colorado's agricultural economy. This fact underscores the importance of developing basin-specific water management and supply strategies, and collaborative BIP updates.

5.2 TOOLBOX FOR BASIN ROUNDTABLES

Several tools were developed during the Technical Update that will be useful for basin roundtables during the BIP update process. The tools will be further refined and upgraded in the future as they are used, additional data are gathered, and on-line portals capable of hosting these tools are developed.

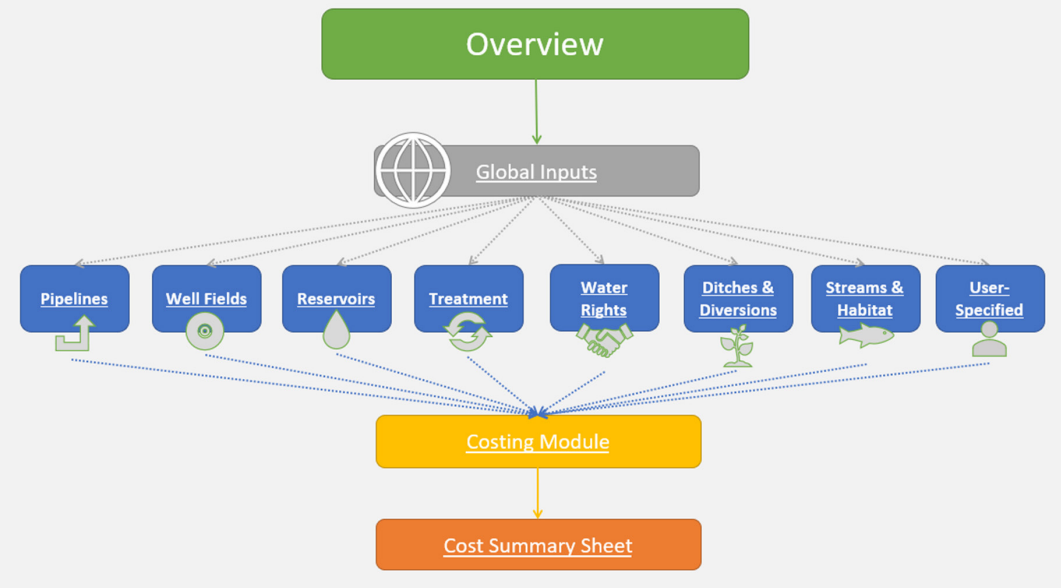
5.2.1 Project Costing Tool

The *Colorado Water Project Cost Estimating Tool* (Cost Estimating Tool) was developed for the Technical Update to provide a common framework for the basin roundtables to develop planning-level project cost estimates. Only 16 percent of the projects and methods listed in previous BIPs included cost estimates. The Cost Estimating Tool provides a baseline cost estimate for use in the planning process and serves as a mechanism to collect useful information for additional planning and tool refinement in future iterations. Its targeted use is for project concepts for which cost estimates have not yet been developed.

Cost Estimating Tool limitations and additional tool functionality recommendations are included in the technical memorandum titled *Colorado Water Project Cost Estimating Tool*, included in Volume 2, Section 5 of the Technical Update.

The Cost Estimating Tool is organized by Project Modules, with each module representing a different type of water supply project. Data from each Project Module is synthesized in the Costing Module and Cost Summary Sheets to develop the overall cost estimate (see Figure 5.2.1).

Figure 5.2.1 Cost Estimating Tool Schematic



Projects Module

The module overview page includes a navigation view of the tool and allows the user to modify global inputs such as project yield, peaking factors, cost indices, and life-cycle and annual costs. Links to each Project Module are also available from the overview page. The Project Modules represent either an entire water project or a component of a large-scale, complex project. The types of projects proposed in BIPs have been pre-loaded into the tool, and users able to customize the parameters associated with their project(s) to reflect a specific design and physical characteristics (see Table 5.2.1). Output from the Project Modules becomes input to the Costing Module.

Table 5.2.1 Project Cost Tool Module Types, Components and Inputs

Project Module	Types	Components	General User Inputs
Pipelines	raw, treated	pipelines, pump stations, storage	project yield and peaking factor, pipeline profile components, pipe size and length, pump type
Well Fields	public supply, aquifer storage and recovery, injection, irrigation wells	wells, booster pumps, pipe network	water table characteristics, project yield and peaking factor, transmission pipeline profile components, number of wells and average production, well depth and capacity, transmission pipe size and length, booster pump capacity
Reservoirs	new reservoir, reservoir expansion, reservoir rehabilitation	reservoir, reservoir rehabilitation, hydropower production	project type, new storage volume, project description, cost of rehabilitation, height of falling water, discharge through hydropower station
Treatment	typical treatment technologies such as direct filtration, conventional, reverse osmosis, etc.	various treatment technologies	average day demand and peaking factor, treatment type
Water Rights	instream flow requirements, recreational in-channel diversion, water supply	cost	total capital cost of water right purchase
Ditches and Diversion	new ditch, ditch rehabilitation	diversion structure, headgate structure, ditch	type of diversion structure, type of headgate structure, maximum diversion discharge/ditch capacity, type of ditch, ditch length
Streams and Habitat	stream restoration, conservation, habitat restoration/species protection, acid mine drainage water treatment	land acquisition, channel improvements, channel structures, channel realignment	stream width range, length of restoration, level of restoration
User-Specified Project	project types not represented by other modules	user-specified	project description, total capital costs, total operations and maintenance costs

Costing Module

The Costing Module brings together information supplied or calculated from the Project Modules to develop planning-level cost estimates. The costs are broken down into construction, project development, and annual costs. Costs are developed based on output from the Project Modules and by applying unit costs or cost curves where available. Unit costs or cost curves are adjustable to account for current market conditions using readily available indices. Other costs are based on industry standard or researched percent values of a direct cost. Values can be adjusted by the user as needed.

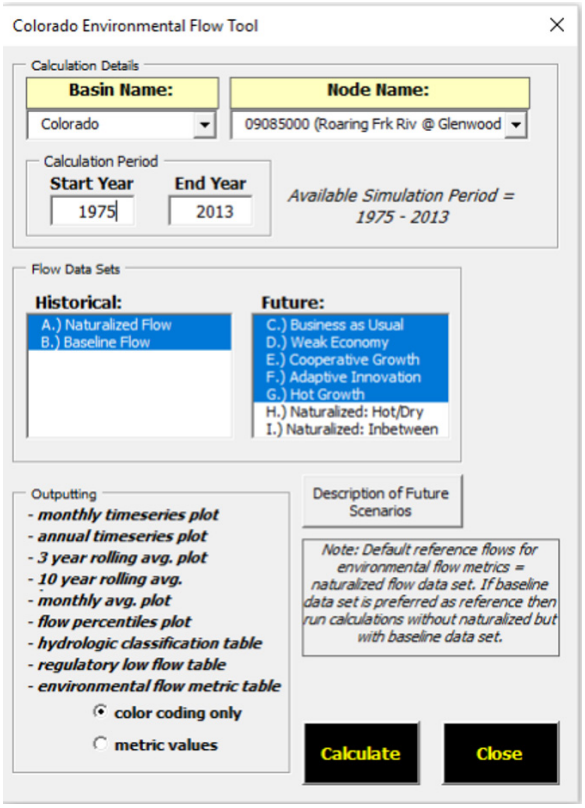
The Costing Module provides a final cost summary sheet that includes a summary outline of project costs by type, present-worth calculations, and a normalized cost that can be used for project comparison.

5.2.2 E&R Flow Tool

The Technical Update included the development of a Flow Tool designed to assess flow conditions in each basin. The Flow Tool was designed to serve as a resource to help basin roundtables refine, categorize, and prioritize their portfolio of E&R projects and methods through an improved understanding of flow needs and potential flow impairments, both existing and projected. The Flow Tool uses hydrologic data from CDSS, additional modeled hydrologic data for various planning scenarios, and established flow-ecology relationships to assess risks to flows and E&R attribute categories at pre-selected gages across the state.

The Flow Tool was constructed in Microsoft Excel by combining components of the Historical Streamflow Analysis Tool and the Watershed Flow Evaluation Tool. The platform provides a familiar and portable working space for the tool user, and offers standard spreadsheet pre- and post-processing capabilities. User inputs specific to the application of the tool are provided via a user-friendly input form (Figure 5.2.2).

Table 5.2.2 Example Input Window from Flow Tool



The flow tool provides the following outputs:

- Monthly and annual time series plots
- Three and ten year rolling average time series plots
- Plot of monthly means
- Monthly flow percentile plots
- A tabular summary of annual hydrologic classifications
- A tabular summary of statistical low flow
- A tabular summary of the calculated environmental flow metrics

The environmental flows table is generated using the flow-ecology relationships described in Section 2. Numeric output is presented as percent departure from reference flows. Reference flows can be specified as either the naturalized flow dataset (default) or the baseline flow dataset. The table is also color coded based on risk category (from low risk to very high risk). Risk categories are pre-defined by subject matter experts according to percent departure threshold values (compared to reference condition). Risk category thresholds differ for each metric. Flow Tool outputs for all 54 nodes across each of the nine basins are available for review and consideration by basin roundtables. Flow statistics under future planning scenarios can be compared to the timing and magnitude of historical peak and low flows. Risk categories identified through analysis of the environmental flow metrics are also available for review and can inform planning discussion in each basin.

The Flow Tool is easy to use and designed for a range of potential end users; however, adding new stream nodes to the tool is not currently an option available to the user and would require additional programming by the tool developers. While the Flow Tool is intended to provide data for use in planning E&R projects and methods, it is not prescriptive.

The Flow Tool does not:

- Designate any gap values
- Provide the basis for any regulatory actions
- Identify areas where ecological change may be associated with factors other than streamflow
- Provide results as detailed or as accurate as a site-specific analysis

The Flow Tool is intended to be a high-level planning tool that:

- Uses the foundations of the HSAT and Watershed Flow Evaluation Tool to scale to a statewide platform
- Post-processes CDSS projections to provide summaries of changes in monthly flow regime at pre-selected locations under different planning horizons
- Identifies potential risks to E&R attribute categories through flow-ecology calculation projections
- Serves as a complementary tool to CDSS to refine, categorize, and prioritize projects
- Provides guidance during Stream Management Plan development and BIP development

5.2.3 E&R Database

The Nonconsumptive Needs Assessment Database (NCNAdb) was developed in 2010 to help manage nonconsumptive data received by basin roundtables and other stakeholders. The database included information related to nonconsumptive attributes, projects, and protections. A significant focus of the Technical Update has been enhancing the NCNAdb (now referred to as the E&Rdb). The E&Rdb includes an enhanced technical foundation, a more engaging and meaningful user interface, and better integration into the Colorado water planning process.

The E&Rdb is a Microsoft Access database formatted in Microsoft Access 2010 file format. The database contains several tables, queries, and modules. The database uses industry standards such as indexes, keys, referential integrity, normalization, and naming standards for tables and fields.

The core data tables in the E&Rdb are described in Table 5.2.2. A more in-depth data dictionary is provided in the E&Rdb TM included in Volume 2 and is available within the database (tblDataDictionary).

Table 5.2.2 Core Data Tables in the E&Rdb

Table	Description
tblBasin	Contains basin information
tblContact	Contact information such as name, address, phone
tblContactProject	Intermediate table relates contacts to projects
tblDatabaseLog	Used to document modifications to database
tblDataDictionary	Contains all tables/fields and respective attributes within the database
tblProject	Projects
tblProjectProtection	Protections assigned to projects and their attributes
tblSegment	Stream segments
tblSegmentAttributeClass	Attribute classifications for attributes along a given stream segment
tblSegmentProject	List of projects that are related to stream segments, and the length of the segment
tblSegmentIDXRef	Contains cross-reference identification between COMID and GNISID
tblSegmentReach	List of Reaches by COMID

The database contains several tools to help browse, search, and extract data; a project data entry form contains the projects and related information. Predefined reports can be used to view and export data. Querying the database requires experience using Microsoft Access, a solid understanding of the question that is translated to a query, and familiarity with the database design to retrieve the information appropriately. The database includes a Microsoft Excel template that can be used to add or update projects and attributes associated with projects.

5.2.4 Project Database

SWSI 2010 and the BIPs led to the initial development and subsequent revision of project datasets for each basin roundtable. These datasets reflect potential projects and processes identified by stakeholders in each basin that may be developed to meet future water supply needs. Project data across basins are inconsistent in content and format due to the complexity of studies, variation by basin, and number of entities involved. Through the Technical Update, project data were reviewed and formatted to increase the usefulness of data products that can be created and to enhance the consistency of analyses using the data.

Project Dataset Content Standards

After a review of each basin roundtable's project dataset, the principal recommendation for developing a standard project dataset for the Technical Update effort was for the datasets to exist in a Microsoft Excel file (e.g., flat file) format and implement standard dataset fields.

Project Dataset Products

Ultimately, two primary data products were developed through this effort: a consistent standard table reflecting the statewide project dataset and mapping products displaying the project datasets. The original project datasets were inconsistent across each basin, and many of the basins did not provide information that could be represented using standard fields. Original project datasets were converted to the standard project format by interpreting the meaning of project data fields in individual basin's datasets and by using engineering judgement. As reflected in Table 5.2.3, several basins did not have data for all standard fields. In these cases, fields were left blank in the standard project dataset.

Table 5.2.3 Standard Project Data Fields and Presence of Fields in Final Basin Project Datasets

Data Field/Column	Arkansas	Colorado	Gunnison	North Platte	Rio Grande	South Platte / Metro	Southwest	Yampa-White-Green
Project_ID	X	X	X	X	X	X	X	X
Project_Name	X	X	X	X	X	X	X	X
Project_Description	X		X	X			X	X
Project_Keywords								
Status	X	X	X				X	
Lead_Proponent	X	X	X		X	X	X	X
Lead_Contact	X		X	X		X	X	
Municipal_Ind_Need	X	X	X	X	X	X	X	X
Agricultural_Need	X	X	X	X	X		X	X
Envr_Rec_Need	X	X	X	X	X		X	X
Admin_Need					X			
Latitude	X	X	X	X	X	X	X	X
Longitude	X	X	X	X	X	X	X	X
County	X	X	X	X	X	X	X	X
Lat_Long_Flag								
Water_District	X	X	X	X	X	X	X	X
Estimated_Yield	X	X	X			X		
Yield_Units	X	X	X			X		
Estimated_Capacity	X					X		
Capacity_Units	X					X		
Estimated_Cost	X	X	X		X	X		

Uses of Projects Dataset

The availability of required data fields will support several future uses of project datasets:

- **Filtered Lists.** It will be possible to create customized datasets, maps, spreadsheet files, and other formats for use in analysis and visualizations.
- **Maps.** The addition of general location coordinate data for each project allows for all projects to be easily located on maps. A user interested in a particular basin or region can then quickly determine the projects in that area and find more information.

5.3 BIP UPDATES

Recommendations from the Technical Update have been distilled into five "next step" categories: 1) BIP Updates, 2) Project Updates, 3) Technical Updates, 4) Strategic Updates, and 5) Outreach Updates. These recommendations, detailed below, will be used to guide upcoming discussion with Colorado's nine basin roundtables, including future phases of work to update BIPs and the Water Plan.

Each action item is accompanied by a brief background description that provides insight into the history of stakeholder processes and conversations that led to the recommended action. This includes, but is not limited to, input from roundtables; public education, participation and outreach workgroups (known as PEPO); the Interbasin Compact Committee; and the 2018-2019 Implementation Working Group.

The following list of recommendations is intended to provide basin roundtables flexibility in the update process, tailoring approaches to best suit roundtable goals. These recommendations provide a framework for some level of standardization across the BIP updates. This iterative process is meant to support statewide water supply planning, cross-basin dialogue, project funding, enhanced future supply analyses, revised goals, and updated project lists. Integrating Technical Update findings with the BIPs, project lists, and the Colorado Water Plan update ensures state water planning will continue to be informed by the best available data.

5.3.1 BIP Updates

A. Evaluate the scope of BIP updates to integrate Technical Update findings

Basin roundtables will work with the CWCB and their membership to identify how to best update their BIPs. In the first BIP process, the CWCB created a guidance document that each roundtable tailored to suit its own needs. Each roundtable then hired separate contractors to assist with its first plan development. To lighten the level of effort required to update these plans, the CWCB, roundtables, and the IWG reviewed the benefit of hiring a central contractor (selected by the CWCB and roundtable chairs) to support each roundtable and coordinate a path forward. Local expert contractors (selected by each roundtable) will play an important role in supporting the roundtables and the general contractor. A first order of business will be coordinating on the full scope of the BIP update, including an evaluation of core needs (e.g., reviewing project lists) and any additional analysis that may be beneficial to each roundtable.

B. Integrate relevant studies and local plans into BIP updates

Basin roundtables will evaluate which plans and studies should inform and be referenced in their BIPs. As noted by the IWG, several local, regional, and statewide studies are available since the initial BIPs (2015) that may provide important context to basin planning. Examples include stream management plans, conservation plans, forest health studies, climate studies, city/master plans, and resilience plans.

C. Identify opportunities for enhanced data inputs that improve modeling output

Basin roundtables will identify if additional data inputs can support enhanced analysis. In all modeling studies, future projections are only as good as the data that inform the model. In the Technical Update, basin-specific data were limited in certain areas and could likely be refined. For example, municipal irrigated acreage data were not something to which the state had access, which limited the ability to model outdoor municipal water use analysis in more detail; however, municipal providers may have this information, and sharing it could be used to refine the model. Other opportunities exist across municipal, environmental, and agricultural reporting where the Technical Update could likely be enhanced in future iterations with the basin roundtable's help to refine model input data.

5.3.2 Project Updates

A. Enhance planned project data

Basin roundtables will enhance and maintain project data with the help of the contracting team as part of the BIP update. The Technical Update review of basin project lists (previously known as identified projects and processes, or IPPs) recommends 20 data fields to be associated with every project (e.g., project name, location, yield, proponent and cost). The Implementation Working Group reviewed the attribute list and added fields such as water rights and permitting status. While much of the data are not captured in existing project lists, the CWCB is working to develop a project database to assist with consistent data collection and input. This not only helps better support water supply planning needs, but also supports roundtable funding and the refinement of funding needs identified in the Water Plan.

B. Improve project costs in Water Plan

Basin roundtables will update project costs to help confirm Water Plan funding needs. The Water Plan identifies how project cost estimates will be improved upon in the BIP update process. Currently, less than 50 percent of the projects in any BIP have associated costs. To assist in this next step, the Technical Update scope included developing a costing tool to help evaluate project costs. As Water Plan funding is an increasing focus, it is critical to have more accurate cost information to better support how funds would be spent.

C. Assess how to best use project tiers

Basin roundtables will work collectively to help inform simplified and standardized project tiers. To be strategic with limited resources, some level of prioritization is necessary. Three of the eight BIPs already utilize some form of project ranking or tier system. At a minimum, missing data can serve as a de facto tiering system in which projects with clearly listed project proponents, costs, and other data are ranked over those without these data points; however, this needs to be reviewed more carefully as it may not be feasible to have all the data listed based on where a project is in the planning cycle.

To assist with this effort, the IWG reviewed a draft "Project Tier Matrix" that will need to be evaluated further during the BIP updates. The IWG determined that both proof-of-concept and shovel-ready (immediately implementable) projects are equally important to fund. The IWG also saw value in a placeholder category for Projects that may be more conceptual in their current phase but might be fleshed out in the future. This is especially true if the project lists are used establish future funding needs. Similarly, the IWG noted that a tier system should not generate competition in funding between basin roundtables.

5.3.3 Technical Updates

A. Review modeling assumptions + consider refinement

Basin roundtables will review beneficial localized and statewide modeling changes as needed. Every model is based on a set of assumptions. The TAG process reviewed, evaluated, and agreed on baseline model assumptions. However, a number of decision points on additional/refined assumptions arose in later stages of modeling. If roundtables decide additional modeling is desired for their BIP update, roundtables will work with the central contractor to ensure their modeling questions are in-line with baseline model assumptions (to support an "apples-to-apples" analysis). Modeling assumptions cannot be changed in ways that could potentially be used to address sensitive legal issues (local or statewide), conflict with policy, or create divisions across the basins.

B. Consider modeling projects

Basin roundtables will evaluate modeling needs and if/how they choose to model projects. Roundtables may choose to model their own unique variables as appropriate (such as projects). Unlike SWSI 2010, the Technical Update did not include any specific projects (e.g. water savings from planned projects) in the analysis, largely due to insufficient project data. The opportunity remains for roundtables to model their own unique projects to explore offsets to the Technical Update supply gaps. Any modeling would carefully consider potential implications of modeling discrete projects that could conflict with ongoing planning or permitting efforts (or any caveats outlined by the Attorney General's Office).

C. Review sub-basin modeling needs

Basin roundtables will review need and trade-offs of summarizing more granular subbasin data. Each of the original BIPs divided their basins into tributary regions differently, resulting in regional data and planning at different scales; however, it was unclear if each roundtable found their BIP sub-basin breakouts to be helpful, if they would have done them differently, or if they would potentially need them at all. Additionally, modeling at granular scales is intensive, costly, and complex. The CWCB chose to report modeling findings at the basin level only. If higher resolution data are desirable, regional delineations would require roundtable input.

5.3.4 Strategic Updates

A. Continue to focus on adaptive management strategies through scenario planning

Basin roundtables will evaluate how they can be nimble amidst changing conditions. Adaptive management has been a key component of roundtable and IBCC discussions for many years. This discussion directly informed the adoption of using a scenario planning approach to account for key drivers and uncertainties within the planning horizon (2050). How basin projects and plans can be tested against these variant futures (the five scenarios) or could be shifted to respond to future changes is something that needs to be considered. Projects and basin roundtable planning should be reviewed for impact and responsiveness. This is at the heart of the No-and-Low Regrets Action Plan that comprise not only core strategies in the Water Plan but also received 100 percent consensus by the IBCC and CWCB board. These core strategies aim to establish a set of plans having the highest benefit with the least unintended consequences, regardless of the future condition.

B. Develop signposts with CWCB support

Basin roundtables will work with the CWCB to identify and establish signposts as appropriate. Using signposts, or check-in points, is fundamental to scenario planning. There may be triggers or key indicators that help determine if specific actions are needed and/or there should be a set frequency for review to help determine growth trajectories. A signpost may also be seen as the frequency by which the state and/or basin roundtables look for and review key indicators. Roundtables and the CWCB need to collaborate on the best approach for establishing clear signposts that help provide the necessary review and analysis of current conditions.

C. Evaluate climate extremes for greater integration

Basin roundtables should identify how to best integrate climate change into planning. Climate change factors are incorporated into three of the five scenarios. Beyond temperature, other issues with climate extremes and greater variability are a major concern for acute and chronic impacts. For example, earlier runoff can affect agricultural operations in early and late season. Additionally, the scale of climate extremes, like major floods, may not be reflected in all the current modeling (e.g., the floods of 2013). Issues such as flood, forest fires, invasive species, and drought need to be considered in future planning. Evaluating and planning for climate impacts and extreme weather events with adaptive and resilient management strategies should be a focus that helps with planning for any potential future.

5.3.5 Outreach Updates

A. Enhance water plan goals, messaging and stakeholder engagement

Basin roundtables will work to engage new audiences in water planning and outreach. The Water Plan set education and outreach goals through 2020, which are all on track to be met. Roundtables will review and enhance their Education Action Plans while considering the Statewide Education Action Plan, which is still under development by Water Education Colorado, to further improve coordination and continue the effort to reach beyond the traditional roundtable audience. Each roundtables Education Action Plan will be coordinated with the BIP updates in support of the greater Water Plan goals. The CWCB will need to work across these groups to identify what new outreach goals will need to be established in future plans.

B. Rebrand around the Water Plan for consistency

Basin roundtables will support rebranding that integrates BIPs around the Water Plan. The Technical Update, Basin Implementation Plans, and Water Plan update are all intertwined. Each effort builds on the last and, as such, the collective process informs the comprehensive Water Plan update. Basin roundtables will need to help evaluate creative ways to communicate this comprehensive message using new and innovative strategies. This may include improved data visualization, surveys, statewide events, water-related contests, campaigns, or other means of engaging with and focusing on the Water Plan.