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## DITCH AND RESERVOIR COMPANY RECOMMENDATIONS FOR COLORADO’S WATER PLAN

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## 1. INTRODUCTION

From the input gathered by many qualified people and entities throughout the state of Colorado, the Statewide Water Supply Initiative efforts, the Basin and Technical Roundtables, and the Interbasin Compact Committee, it is clear that much deliberation and critical thought has gone into the collection of good ideas and practices. There appears to be a consensus on many issues, including a respect for the agricultural heritage and the conservation of productive capacity of Colorado's farmers and ranchers. DARCA and its members value the long and hard work, including enormous volunteer effort that has gone into the recommendations and findings of Colorado's Water Plan (CWP).<sup>1</sup>

DARCA has been conducting its own outreach to DARCA members, ditch and reservoir companies, and their farmer/rancher base across Colorado. Building on DARCA's standing committee on the CWP and through its outreach workshops, it respectfully submits these recommendation and comments - ones that are state wide and not necessarily basin specific.

Collecting and synthesizing a huge amount of information into a state water plan has promoted critical thinking towards effective solutions. The social process of collecting information, increasing mutual understanding among different interests, compiling engineering and legal interpretations, and drafting the plan, have been the natural and critical first steps in developing consensus on some fundamental values. As the next step, an analytical modeling approach is necessary so that this process of critical thinking develops into fully examined and well-reasoned sets of solutions. New discovery results from such modeling using processes that may challenge settled beliefs and open doors to previously unidentified solutions.

Now that the Basin Implementation Plans (BIPs), the Identified Plans and Procedures (IPPs), and recommendations have been consolidated into the basis of the plan, a formal and scientific analysis can help determine the optimal courses of action. Many options are on the table, and the Colorado water community needs to determine what combinations of alternatives will move the state to the desired goals in the easiest, quickest, least costly, and most efficient manner.

There is a need for standardization of the methodology and terminology among basins so that apples can be compared with apples. The physical, demographic, and political dimensions of water in Colorado are complex, requiring complex decision making approaches. Water professionals across Colorado are innovative, use the latest technologies, and approach problems in a scientific, fact driven process. It will be advantageous if the CWP adopts a parallel modeling approach to help in the discovery of the optimal decisions. DARCA recommends that an ad hoc, trial by error, or political process of decision making may not prove to be the best way to achieve our common goals, now that they are clearly appreciated, as the stakes are too high for bad decisions. In short, the CWP can now incorporate a process approach, one that is objective, and one that does more than the identification of projects.

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<sup>1</sup> DARCA, a 501(c)(6), is dedicated to serving Colorado's mutual ditch and reservoir companies, irrigation districts, and private water rights holders by being a resource for networking, information exchange, and advocacy. It is governed by a geographically diverse board of directors from across the state.

Given the importance of Colorado's ditch and reservoir companies, it would be appropriate to provide these entities with a separate "Ditch and Reservoir Company" chapter within the plan.

## **2. DECISION SUPPORT: IMPLEMENTATION OF RECOMMENDATIONS**

A post parallel formal decision making process needs to incorporate uncertainty and risk.<sup>2</sup> The physical attributes of weather and climate, combined with reliable and substantial amounts of data that have been collected over many years, are perfectly suited to modeling a state water plan under uncertainty. The projected gap, a metric of quantity, is again perfectly suited to a mathematical approach. Modeling and decision making with the use of analytical tools is an important technology, as are other ones routinely used in Colorado, (GIS/GPS, automation, telemetry, modeling, forecasting, etc.).<sup>3</sup> A framework for this methodical process of determining the best combinations of actions would need to include goals, decision variables, constraints, and most importantly, usable output. Although the modeling process is technical, the results are entirely practical. For example: 1) what decisions do you make? 2) what projects do you start? 3) what projects have a good likelihood of success? 4) what decisions give you the most bang for the buck? and 5) what courses of action today involve strategic planning for the future and how do you evaluate them today? The process is not imposing a "top-down" solution - but rather a "bottom up" approach - by investigating and analyzing what currently exists in Colorado, within the context of risk. Implementation of decision analysis first involves learning and collecting information which has been accomplished through the CWP process.

The modeling approach suited for achieving the best results does not rely on few, generalized, global assumptions or "top down" scenarios, but rather starts from a more micro/decentralized approach, one where the model consists of an aggregation of smaller pieces. This approach is less sensitive to mistakes and misdirection. Naturally, these smaller pieces of input can and should be existing data, conclusions, and the output of other models that water experts have created.

### **2.1 Goals of the State Water Plan**

This parallel model for the CWP can be created to deal with not just one objective but many. Competing interests around the state have their own visions of what lies ahead and what they desire in the coming decades. For illustration purposes, these goals may be: 1) lessening the gap between demand and supply; 2) reducing the amount of new transmountain diversions; 3) minimizing the loss of agricultural land; 4) maximizing the amount of water in ditch company portfolios; and 5) maximizing the prosperity<sup>4</sup> of ditch and reservoir companies. The CWP can be developed to include decisions that minimize risk, taking into account climate change, demographic patterns, identified projects, and including cultural and political considerations; the list is long. These models will give the state the greatest chance of success by maximizing the certainty of achieving a particular goal(s).

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<sup>2</sup> Analytical tools and techniques routinely used in business that can be applied to analyzing the implementation of the CWP are: Monte Carlo simulation, optimization under uncertainty, forecasting under uncertainty, decision trees, and real options.

<sup>3</sup> Examples include: Republican River Basin Groundwater Model, Arkansas River Basin H-I Model, Rio Grande Decision Support System, and other Decision Support Systems

<sup>4</sup> Prosperity of ditch companies can be viewed in a variety of ways including: financial stability, long term viability and sustainability, and the ability to maintain and upgrade ditch systems.

## 2.2 Determining the Decisions to Implement

Many have studied the cognitive power of humans in the decision making process. Humans do have the ability to process all of the alternative solutions to a problem as complex as one presented by the CWP without the use of computer assisted modeling and analytical tools. The CWP and preceding efforts have effectively developed some consensus and have identified many recommendations but now we face the question: which courses of action and in what combinations do you choose when there are millions of possible combinations? Effective modeling efforts are able to account for correlations (positive or negative feedback loops) among decisions alternatives.

Complex projects can and do routinely fail throughout government, the non-profit sector, and the business world. The reasons for unsuccessful outcomes may be a lack of relevancy, effectiveness and efficiency, as well as project management failures, (i.e., implementation, managerial, and organizational failures). For example, almost half of the projects funded by the World Bank do not have successful outcomes.<sup>5</sup> That being said, it is critical that projects and practices for CWP be well implemented, but more importantly, selected with the utmost care.

## 2.3 Determining Limitations and Constraints

Obviously, constraints are always present in the pursuit of achieving goals. As illustration, these could take the form of: 1) amount of funds available for projects; 2) likelihood of having a project adopted or legislation passed; 3) hydrological conditions of a basin; 4) setting a floor for the number of irrigated acres to remain in a particular basin; and 5) amount of new transmountain water allowed for transfer.

## 2.4 Practical Use of Modeling Efforts

Unfortunately, a complicated model is often seen as no more than an academic exercise that has little practical significance. Although a model can be complex and includes many inputs, including those involving uncertainty, the output is invaluable to aid the decision making process. A properly constructed “bottom up” model, put through an optimization routine will give unbiased solutions to policy makers. It will enable decision makers to assess the key drivers and also identify those variables that have little effect. The identification of key drivers or sensitivity analysis is critical for it shows which solutions contribute to the success and which ones contribute to the failure of the model’s goals. Once these drivers are examined, the cost and probability of implementing them are the next steps.

DARCA has reviewed the *DRAFT 5.1: Scenario Planning and Developing an Adaptive Water Strategy* and believes that the process of formulating plausible scenarios has been useful. Now, scenarios and drivers need to be identified from the output of a model, ones that are determined after a carefully constructed analysis of Colorado’s water system is complete. Likewise, portfolios can be identified with great specificity. In short, scenarios are developed and drivers identified as a result of the modeling process, not as conclusions drawn before the model is constructed and run.

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<sup>5</sup> Lavagnon, A.I., D. Amadou, and D. Thuillier (2012), “Critical Success Factors for World Bank Projects: An Empirical Investigation,” *International Journal of Project Management*, 30, 105-116.

DARCA is advocating for a transparent and open source modeling approach involving many individuals and entities from around the state. Such a modeling effort would likely predict a complicated, yet useful, range of solutions. Clearly communicating these predictions will be difficult, but will be aided by a transparent modeling process that allows end users to engage inputs, methods, and results at different levels. A truly transparent process will provide information on input uncertainty and how understanding this uncertainty affects predictions and can ultimately reduce future risks. This is consistent with methods applied in other CWCB work. Some examples include: Colorado River Water Availability Study, Colorado's Water Supply Future Portfolio and Trade-Off Tool, and Colorado's Risk MAP Program.<sup>6</sup> Downscaled climate model products from the National Center for Atmospheric Research (NCAR) would be especially valuable as inputs to a CWP model.

### **3. BENEFITS PROVIDED BY DITCH AND RESERVOIR COMPANIES**

There is a need to recognize the contribution of ditch and reservoir companies to the culture and environmental qualities of Colorado. These delivery systems include the diversion structures, the canals, the laterals, the reservoirs, the farms and ranches they serve, and the return flows. Ditch companies provide benefits to society, both directly and indirectly. Ditch companies, and their linked agricultural economies, support many rural cities and towns, providing them with a cultural backbone. Farms and ranches produce food and fiber, support more than just the farm and ranch owners, but a range of employees, seasonal workers and associated businesses. Ditch companies are good stewards of the environment and their systems provide benefits in the form of riparian corridors for flora and fauna, wetlands, and reservoirs that lead to more livable communities and tourism dollars. Irrigation may also provide water for late season return flows that extend recreational and irrigation seasons while supporting additional environmental flow needs. The amenity, recreational and quality of life benefits provided by ditches are even higher in urbanizing areas, where they provide highly valued landscape features which are loved by millions.<sup>7</sup>

Many of the benefits are hard to quantify, such as the joy and spiritual values from contact with natural places – and almost all of the water-related natural places in Colorado relate to ditches and reservoirs, now often more than a century old. But there has been great progress in ecosystem, amenity, recreational and other benefit valuations, including those in water quality that result from riparian and wetland areas sustained by ditches and irrigation (such as denitrification, sediment capture, and flood reduction). There is now a scientifically and legally sound basis for incorporating asset and stream of benefit values into decision-making about resource allocations and conservation.

#### **3.1 Ditch and Reservoir Companies and Agricultural Preservation**

Agricultural preservation and ditch and reservoir company prosperity go hand in hand, for these companies are one of the primary drivers of Colorado agriculture. Colorado, first a destination for miners seeking

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<sup>6</sup> The Rand Corporation has developed a proof-of concept analysis: Robust Water Management Strategies for California Water Plan Update 2013.

[http://www.rand.org/content/dam/rand/pubs/research\\_reports/RR100/RR182/RAND\\_RR182.sum.pdf](http://www.rand.org/content/dam/rand/pubs/research_reports/RR100/RR182/RAND_RR182.sum.pdf)

<sup>7</sup> An example is the increased real estate values associated with open space and riparian areas created and sustained by ditches and irrigation.

gold and silver, was built on ranching and farming helping to create the exceptional quality of life that most of us enjoy here today. A local and secure source of food requires that ditch companies retain their water delivery integrity and adequate land base. DARCA is strongly in support of defending Colorado's food system, not only by protecting individual water rights and historic uses through the existing prior appropriation system, but by providing adequate incentives and opportunities to help agriculture become more profitable.

### 3.2 Creating Baselines for Ditch and Reservoir Companies

Ditch and reservoir companies own the rights to the majority of water in Colorado. Although the state administers these water rights and the Division of Water Resources' Hydrobase contains an abundance of water rights and diversion data, there is not a good database of ditch companies, their service areas, and practices. With better knowledge of these ditch companies, baselines can be created to be used as a reference point in determining trends and future changes to the amount of water carried, water use, changes in the service area, amount of water tied to the ground, and financial viability of ditch companies. Ditch companies come in all shapes and sizes throughout the different basins, and a broad brush approach in characterizing these companies is not always appropriate. DARCA is always willing to assist in the state's effort of providing ditch company data for Colorado's Water Plan.

### 3.3 Compensating Ditch and Reservoir Companies

Ditch companies have been providing substantial benefits to society, both directly and indirectly. Despite this, the recipients of these benefits are usually not required to provide direct compensation for these positive externalities.

Mechanisms for compensating ditch companies need to be explored, both monetary and non-monetary approaches. Many of DARCA's recommendations to the CWP can be considered as micro-subsidies or non-monetary compensation that can help ditch companies prosper.

## 4. DITCH AND RESERVOIR COMPANY PLANNING

Just as the CWP is attempting to accomplish on a state level, better planning capabilities for ditch and reservoir companies could make it easier for those companies to adapt to changing social and environmental pressures. Unfortunately, Colorado's ditch and reservoir companies are not well positioned to adequately protect their interests with the continuing and substantial pressure for their water resources. Urbanization issues, municipalities seeking ditch company water for urban use, and the increasing cost of doing business in today's regulatory and legal environment, have vastly complicated the matter of running ditch companies in Colorado.

Many ditch companies have not been operated in a manner that approaches the optimal use of their resource base. DARCA believes that many ditch company struggles can be traced to a shortage of resources for adequately dealing with problems, pressures, and opportunities. Additionally, there may be inherent characteristics of some company structures that seriously hinder effective planning strategies including limited resources for better decision making. Few ditch companies have in-house staff such as lawyers, engineers, and planners to help navigate today's complex world. With less clarity in their options,

many companies are risk-averse to the point of not willing to explore and embrace opportunities that may be extremely lucrative for their companies.

Ditch companies deal adequately with short term concerns but internal planning rarely incorporates the long term. The directors of ditch companies, shareholders themselves, place primary emphasis on the continuation of water delivery on a seasonal basis. Perhaps, shareholders of the ditch companies may view the ditch only as an entity that allows access to their water right and not as a business entity that needs to prosper in the coming years. DARCA is advocating that planning activities in the medium and long term be strengthened. Funds need to be set aside to help ditch companies plan for their futures; some ditch companies are cognizant of their needs but need additional resources.<sup>8</sup> Grants like these would address the CWP's stated objectives of avoiding the dry up of agricultural lands and keeping ag resilient in the face of increasing drought and climatic variability.

## **5. ALTERNATIVE TRANSFER MECHANISMS**

DARCA is in full support of alternative transfer mechanisms (ATM) as substitutes to buy and dry sales. Although, these ATMs, may only delay an inevitable separation of water from the land, nevertheless they need full support. The separation of the water from the land leads to negative effects for ditch companies, rural economies, food security, the environment, and historical and cultural identities. DARCA supports the ability of water right holders to transfer and sell their water rights, but believes ATMs can be financially attractive to ditch companies and their farmer and rancher base. However, respect for existing water rights' holders needs to be preserved.

ATMs may provide greater value and options in the future for farmers and ranchers, especially considering the uncertainty of climate change in Colorado. They also offer farmers another potential source of revenue without completely curtailing an on-going farming operation.

ATMs have the potential to significantly decrease current buy and dry practices but at present there have not been many examples of ATM's in practice. DARCA is suggesting ways for more vigorous adoption. There appears to be hesitation to adopt these water transfers both in the agricultural and M&I sectors. Among the reasons for the lack of adoption may be: 1) they can be complicated and parties may opt to undertake an outright sale instead of a ATM agreement due to a lack of understanding or clarity; 2) the high transaction costs involved; 3) M&I interests may prefer more certainty that a purchase of a water right provides; 4) market prices are almost always lacking on what willing participants should expect including full terms of transfers and side deals, outside of a few voluntary disclosures by some cities and the NCWCD market; and 5) physical and engineering constraints may be present that prohibit a transfer of water.

DARCA proposes that more educational efforts be undertaken to promote ATMs. For ATMs to be used in a free market system with willing participants, the various options need to be made clear and understandable. Models of financial impact to the parties need to be developed. More activities like the Following Leasing Pilot Program (HB 13-1248) are important but need to be enhanced and promoted. In particular,

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<sup>8</sup> The state of Wyoming provides grants for preliminary project planning purposes through the Wyoming Water Development Commission.

basin models can provide data on potential injury, return flows, and transferable consumptive use. Investment in the State Engineer's Office to improve data collection in the form of stream gauges, remote sensing, and piezometers may reduce uncertainty and improve system efficiency. Funding for ditch company modernization may also increase opportunities for ATMs and other flexible market structures by addressing current structural and engineering barriers. All of these educational, outreach, data collection, modeling, and infrastructure investment needs may significantly increase adoption of ATMs as an important component of Colorado's water future.

## **6. CLIMATE CHANGE**

Climate change has become a known source of shifting variability in the environment; however, despite the research and evidence, there is still a lack of recognition by many decision makers and water rights owners on the impacts that climate change will have on ditch and reservoir companies.<sup>9</sup> For ditch companies, the effects of climate change are seen in changes of the historical patterns of water availability, both in timing and quantity. With the increasing risks of climate change, ditch companies, and the agricultural community, need to devise adaptations and plans for an uncertain future. Using more storage, improved diversion and conveyance infrastructure, different crops and growing practices, and the better use of water are a few examples of planned adaptations.

With limited knowledge of climate change, and future regional and local effects remaining hard to forecast, progressive strategies may be perceived as unnecessary or unfeasible. Regardless of the realized effects and their severity, climate change is best observed through long-term data analysis. Currently, historical climate data may be limited in location and breadth, and much of the available data, although easily accessible from multiple sources, may be too generalized for site specific applications. Individual ditch companies need to better monitor and begin recording their own data including flow patterns, water availability, temperature, ET data, and annual precipitation. Seeing the effects of climate change through locally collected data that is more granular (daily, weekly, and monthly), requires years of accumulation, but there is great value gained in the collection of this micro data to better adapt for the future. This data will also be critical to analyzing how expected changes in timing and water supply will affect agricultural profitability and resiliency in the future. Regardless of the specific impacts, Colorado should invest in climate adaptation strategies such as a prioritizing high conservation in cities and those agricultural and ditch company practices listed here to help preserve Colorado's agricultural heritage.

## **7. TRANSMOUNTAIN DIVERSIONS**

Trans-mountain diversions (TMD) are beneficial in transporting water to regions that regularly risk scarcity. Although the region receiving water might see a TMD as a valuable addition to their water resources, those on the other end of the pipe may see only long-term in-basin depletion. DARCA acknowledges the value of existing transmountain diversions but believes that all other efforts to close the gap should be attempted before future TMDs are implemented. The financial, recreational, agricultural, and environmental costs for the long term as well as the present, along with an increasing concern for the Colorado

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<sup>9</sup> Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation (Lukas et al. 2014) (<http://cwcb.state.co.us/environment/climate-change/Pages/main.aspx>).

River Basin leads to the strong impression that additional transmountain diversions should be considered only after other solutions have been exhausted.

## **8. LOCAL ORDINANCES**

Colorado's Water Plan needs to focus on the development and promotion of guidelines and standards that reduce transaction costs and risk by providing more certainty in local regulations, easement definition, stormwater regulations, property rights disputes, taxation, and lender relationships. Guidelines and standards can take the form of model regulations and laws, as well as conceptual principles that may encourage more effective cooperation between ditch companies and local communities.<sup>10</sup> These guidelines and standards will lay the groundwork for more flexible ditch companies and irrigators that are able to take advantage of subsidies and capital investment in return for the public benefits they provide. In addition, by further demonstrating the need for and ability to access such funding, expanded investment in infrastructure needs may be encouraged. As a result, local communities, downstream users, and the recreation and tourism economy will continue to receive the myriad benefits provided by healthy ditch systems and productive agriculture into the future.

A better partnering with local governmental entities can compensate ditch companies for the positive externalities that they provide to Colorado's citizens, often without cash expenditure. These can be considered a type of micro-subsidy at the local level, in recognition and support of benefits and mutual goals, which can complement state and federal government supports, such as property tax exemptions and federal tax exemptions respectively.

## **9. INFRASTRUCTURE**

The Basin Implementation Plans submitted include requests for approximately \$8 billion for projects that are mainly focused on meeting future municipal water supply gaps and firming existing M&I supply. Despite the fact that ditch companies handle and distribute far more water across very large and productive areas, the plans omit sufficient requests for the funding of ditch companies priorities and agricultural needs, including infrastructure (diversion, conveyance, on-farm improvements, and storage) that will help ditch companies and agriculture prosper and shelter them from an uncertain future of climate variability, a growing state population, and other pressures. In light of the consensus that has emerged and the Governor's focus on "protecting ag" and avoiding buy and dry approaches, there is still sharply insufficient proactive state support for enhancing the future of agriculture. It is not sufficient to simply consider the virtues of slowing further decline.

### **9.1 Alternative Financing Mechanisms**

Colorado's ditch and reservoir companies are fortunate to have the benefit of attractive low interest loans available from the CWCB and many do avail themselves of these programs. This important funding mechanism from the state needs to be adequately protected from depletion by the state during times of

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<sup>10</sup> DARCA has compiled a report, DARCA Model Land Use Codes, that have been distributed to Colorado's Land Use Departments. The report provides recommendations on how to better work with and help Colorado's ditch companies. (<http://www.darca.org>).

downturn in the economy. However, many ditch companies feel that although improvements to their systems may be of benefit, the benefits do not justify the costs and risks associated with undertaking such a project. Other incentives should be considered such as: 1) creation of a transferable state tax credit for improvements much like the ones currently used for conservation easement; 2) lowering the rate of CWCB loans for infrastructure loans; and 3) providing or promoting mechanisms where private individuals can furnish funds for ag/ditch company improvements.

Although there may be hesitation of ditch companies and local municipalities to work together, ownership stakes are held by local municipalities in many ditch companies. Ditch companies need to better partner by taking advantage of local governments' ability to obtain low cost long term financing through bonding capabilities in support of the benefits provided by ditch companies.

## **10. PERMITTING PROCESS**

Storage water will play a critical role in maintaining and enhancing the water portfolio of mutual ditch and reservoir companies, especially with the surging population base in Colorado and the uncertainties of a changing climate. The development and expansion of high mountain reservoirs, allowing more options for all users within the system, are promising strategies. For instance, a reservoir close to the headwaters of a water source may be allowed to fill out of priority with the condition that the water may have to be released to senior downstream users. Moreover, many existing reservoirs can be expanded with relatively minimal cost and impact to the ecosystem.

Unfortunately, transaction costs (permits, required studies...) in today's regulatory climate make it too costly, and therefore infeasible for limited resource ditch companies to expand, let alone build new reservoirs. Other barriers may take the form of environmental requirements such as wetland and endangered species issues. Limited resource ditch companies may be forced to convert historic agricultural water to municipal or industrial as an easier alternative.

Some seemingly simple improvements to existing reservoir have stalled as they have become bogged down in the federal regulatory process which has been challenging for small and medium size ditch companies with limited means. Until a more streamlined permitting process for reservoir expansion results, it is DARCA's finding that few storage expansion projects will be undertaken. DARCA's membership is concerned that current interpretations and expansion of limitations on restoration, reservoir dredging and expansion, and other limits on resource management are hindering critical, economically sound, and desirable improvements.<sup>11</sup>

DARCA is not endorsing changes which would further aggravate the huge power imbalance between ditch companies and irrigators compared to M&I interests. This imbalance results from the lack of capacity to access engineering, economic, technical, legal services, and planning by ditch companies.

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<sup>11</sup> DARCA is able to document ditch and reservoir company projects that have been undergoing what appears to be an endless review process.

## **11. OTHER SOURCES OF WATER TO FILL THE GAP**

While the availability of new water sources in Colorado is limited, demand from a growing population will increase. Once demand overtakes the available supply, sources of water once considered unfeasible or improbable will need investigation.

New opportunities in conservation may be the first explored. While residential water saving technologies have been in existence for years, higher water bills may force residents to adopt these to a much greater degree. Higher cost may also lead to the widespread utilization of graywater and even the reuse of domestic water.

However, conservation and reuse may not be sufficient. Colorado may need to secure new sources of water for its growing communities. First, attention to the timely expansion and renovation of existing reservoirs needs to be addressed along with the addition of new storage facilities. These projects take decades to complete from inception and we need to start planning for them now.

Policy makers need to think about broad spectrum projects, not just on a basin or statewide level but rather on a national level. Such solutions might be the increased use and new construction of desalination plants in California and brackish groundwater desalination plants throughout the Colorado basin. While the technology is energy intensive and costly, with growing demand and limited supply this may become an economically viable option. The proximity of supply to demand and easy disposal of brine may be increasingly important advantages, especially with improvements in renewable energy resources

DARCA is requesting that all options be explored and evaluated including piping water from the water-long area of the Missouri/Mississippi River system to Colorado. Storage could be provided in eastern Colorado in off stream reservoirs or stored in aquifers.