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Initial Drafts of Possible Recommendations
Water Adaptation Policy Work Group
June 4, 2007

WA-Introduction
Vulnerability and Risks

Draft by Susan Avery and Brad Udall [to come]

WA-1
Need for Leadership

Draft by Brad Udall

Recommendation

1. The Governor of Colorado should direct the Department of Natural Resources, the State Engineer, the Colorado Water Conservation Board, and the Colorado Department of Public Heath and the Environment to establish methods to rigorously investigate and adapt to the impacts of climate change on all appropriate (water-related?) activities so that the health and welfare of the people of Colorado are maximized to the best extent possible. (Other agencies to be included?)

WA-2
Colorado River Water Availability

Draft by Eric Kuhn

The 2007 version of the Colorado Water Conservation Board (CWCB) annual project authorization bill (SB-2007-122) includes the following language in section 15.

> "(1) In addition to any other appropriation, there is hereby appropriated, out of any moneys in the Colorado water conservation board construction fund not otherwise appropriated, to the department of natural resources, for allocation to the Colorado water

> conservation board, for the fiscal year beginning July 1, 2007, the sum of five hundred thousand dollars ($500,000), or so much thereof as may be necessary, for the board to evaluate water availability in the Colorado river basin and its tributaries. The board shall work in full consultation with, and with the active involvement of, the basin roundtables. The study shall consider current and potential future in-basin consumptive and nonconsumptive needs. The board, in consultation with the basin roundtables, shall recommend whether additional study or phases of study should be undertaken."

In simpler terms, the General Assembly has asked the CWCB to conduct a study to evaluate how much remaining Colorado River water the State of Colorado has to develop.

This is an essential public policy question. Under 2005 legislation, (HB-2005-1177) the State of Colorado is engaged in a broad public effort to take a comprehensive evaluation of Colorado's future water needs and identify solutions to meet the identified needs.

Through the HB-1177 process and the companion Statewide Water Supply Initiative (SWSI) process, a number of new projects have been proposed in the future. These projects range in size from small local projects to improve water use efficiency to large multi-state, multi-billion dollar projects that would convey water as far away as Flaming Gorge Reservoir to the Colorado Front Range.

Determining now much Colorado River water is available to Colorado under various federal statutes, state statutes, interstate compacts and international treaties (commonly referred to as the "Law of the River") is going to be a complicated and difficult endeavor.

The issue is complicated by the potential impacts of climate change. For decades, Colorado water officials have assumed that the State of Colorado could develop at least 3.0 million acre feet per year. However, this conclusion is based on the basic assumption that in the future, the Colorado River flows will be similar to the most recent past (1905-2000).

Climate scientists have released a number of research studies that suggest that, because of warming, future Colorado River flows are likely to be reduced below those seen in 1905-2000. The Colorado River research has been summarized by Brad Udall in the May 2007 edition of the "Intermountain West Climate Summary" published in the Western Water Assessment. Results of the most recent studies vary from a very significant reduction of up to 50% by Hoerling and Eicheid to a modest reduction of a few percentage points to11% by Christiansen and Lettenmaier.

The policy question facing the CWCB and HB-1177 participants is how to address possible flow reductions caused by climate change. The CWCB staff is currently consulting with Roundtable members and has begun the process of scoping the study.

Recommendation

1. If the Colorado River water supply study is going to be widely accepted and useful for future decision making, it will have to address climate change. However, how to actually bring climate change into the study remains a challenge.

WA-3
Consideration of Climate Change in Water Decisions

Draft by Brad Udall

The vast consensus of the scientific community is that the planet has warmed and will continue to warm because of emissions of human-caused greenhouse gases. The American Water Works Association, the primary trade group of water management professionals has written that "global warming is a fact and water managers need to plan accordingly."

Water engineering and water management have always been based on the idea that the future will look like the past. Reservoir design, flood planning, municipal yield are but three of the critical water management areas where good engineering practice has dictated the use of historical hydrology in planning.

In addition to heating the planet, global warming will also directly impact the water cycle. This is because warming will redistribute the flows of energy around the planet, and the water cycle is the primary way in which heat moves from areas of plenty (the equator) to areas of less (the poles). As the globe warms, all assumptions about municipal yield, supply, demand, flood control and other water management issues based on historical hydrology will become less valid.

Impacts to the water cycle in Colorado will likely include more rain and less snow, earlier runoff, and more evaporation. Changes in total precipitation are not known. The incidence of heavy precipitation and more droughts is also an expected outcome. There are also a number of important secondary impacts which have the potential to affect water management including more forest fires with a risk of sedimentation of reservoirs, and forest pest outbreaks which may affect total runoff and runoff timing. Many of these impacts have already been seen in the West, if not in Colorado.

Many climate change studies have investigated future Colorado River flows. Using the most recent models temperature and precipitation projections, several studies project less flow in the Colorado River. Decreases range from -10% to -50% depending on the technique used.

Aside from changes to the physical system, changes in runoff timing will affect the yield of water rights. Changes in amount of total runoff have the potential to affect Colorado's interstate compact deliveries.

Recommendations

1. Colorado Water Managers should investigate the impacts of climate change on existing water supply systems. This means yields, flood control issues, and any other functions based on historical hydrology.

2. Planning for new water projects should use both paleohydrology and climate change hydrology

3. The state should develop the capacity to generate future and paleo hydrology for all river basins using inputs from multiple climate models and multiple hydrology models.

   [Do we want to say something about new storage projects? This is obviously a contentious issue.]

4. The state should make an effort to educate the public about the impacts of climate change on water supplies.

WA-4
Interstate Compacts

Draft by David Robbins

Colorado's interstate compacts generally apportion the right to make beneficial consumptive use of interstate rivers and related water supplies among the signatory states. Several compacts, including the Republican River Compact and the Rio Grande Compact, contain mechanisms to adjust Colorado's apportionment based on climatic conditions. Others, such as the Colorado River Compact, contain minimum delivery requirements, causing Colorado to bear a greater share of any significant shortage.

Recommendation

1. Although it is a popular topic of discussion, the reality of renegotiating interstate compacts is not appealing. All of the signatory states to compacts in the western United States are suffering from varying degrees of water shortage and will be similarly affected by water shortages brought about by climatic change. Each signatory state will have a similar goal in any compact negotiation, namely to acquire a greater share of the available supply for its citizens. As a result, Colorado needs to begin developing mechanisms to deal with climate change induced shortages within the supplies that will be available under the existing compact apportionment. Water supply planning with this goal will produce realistic projections. Planning based upon assumed changes in compacts will undoubtedly lead to nothing but frustration and disappointment.

WA-5
Regional Modeling and Data

Draft by Ben Harding

Climate change will impact water supply by changing the amount and timing of streamflows and the amount and timing of water requirements for agricultural, industrial and municipal uses. A water user requires estimates of future water use to plan its own system and operations, but also to understand how competing water rights will affect its water supply.

The nature of future water supply conditions can be estimated based on projections of future climate conditions from GCMs but such estimates require that GCM output be translated into projected streamflows and water requirements at relevant locations. Because the GCMs use large grids (a typical grid cell covers one-fourth of Colorado) GCM results must be "downscaled" to a finer level of detail prior to translation to streamflows.

Making estimates of future water supply conditions presents a number of technical challenges:

- Scale/Translation—For the reasonable future, GCM data will be available at scales that are far too large for planning and decision making by water users and these results must be translated to streamflows. Downscaling and translation techniques are necessary and these are just becoming available outside the research community.

- Observed data—Downscaling and translation require good records of observed climate and streamflow. The programs for collecting and disseminating these data have deteriorated or have been diverted over the last quarter-century, with the result that many long-term climate and streamflow records have been interrupted.

- Water rights response—Almost all water supply models in Colorado rely on historical records of water rights yields, calls, or both. Climate-change induced changes in streamflows and water use will affect the yield of individual water rights and the pattern of calls. Historical water rights yields and calls can no longer be depended on to represent future conditions.

- Uncertainty—Projections of future climate contain much uncertainty, arising from projections of future policy and economic responses (which are necessary to estimate future GHG concentrations), and from simulations of future climate responses. Further uncertainty is introduced by downscaling and translation methods.

Collecting the data and constructing and running the models necessary to project future streamflows is a substantial effort. Many smaller municipalities and most individual agricultural users will not have the resources to make these assessments. Further, virtually every productive

watershed in the State is shared by many water users, so if water users made independent assessments, the result will be much duplication of effort.

Recommendations

1. The state government should lead an assessment of the information water users need to plan for adaptation to climate change.

2. The state government and water users should support additional data collection with an emphasis on preserving and extending long-term records.

3. The state government along with coalitions of water users should work in together to:

4. Develop common practical tools and databases for downscaling and translation of GCM outputs. These tools should allow for the flexibility, on the part of water users, to choose from a variety of approaches.

5. Provide a "live" clearinghouse of GCM climate projection data.

6. Support cooperative efforts among users to make basin-wide assessments of water rights yields and call patterns in support of the individual water supply modeling of water users.

7. Do not adopt common planning assumptions.

WA-6
Municipal Water Supplies

Draft by Marc Waage

Potential impacts. Climate change is projected to alter, primarily by reduction and degradation, municipal water supplies in Colorado. [Question – will the report describe the observed climate change in Colorado and the projections for Colorado?] Potential impacts include:

- **Reduced streamflow.** There is a consensus of model projections that warming will continue in Colorado. Most models predict less precipitation but there is no consensus. Studies indicate that a substantial increase in precipitation would be needed to offset the reduction in streamflow from more evaporation and plant use, and other stream system losses caused by warmer weather. Most municipal supplies in Colorado come from streamflow.
- **More drought**. The frequency and severity of droughts is projected to increase, making water use restrictions more likely and the provision of water for essential human uses subject to more risk and variation.
- **Earlier snowmelt**. Warmer weather is expected to melt mountain snowpack earlier. An early melt potentially increases evaporative losses, reduces summer streamflow,

and disrupts the pattern of water capture and use in the water rights allocation system, all of which could reduce municipal water supplies.

- **Intense precipitation**. Precipitation is expected to be more concentrated or intense, potentially making the capture and storage of water more difficult. Increases in flooding could reduce raw water quality.
- **Increased water needs**. The growing season is expected to be longer and warmer. This will increase the water requirements of plants. Irrigation of landscapes account for roughly half of the municipal water use along the urban Front Range. Increases in water use in others sectors, particularly agricultural uses with senior water rights, could reduce the supplies available to municipal providers with more junior water rights. Water use for cooling and other weather dependent uses could increase with temperatures.
- **Degraded water quality.** Water quality is projected to degrade due to reduced streamflow, increases in forest fires, higher stream temperatures and other factors. (See Water Quality section for details). This potentially will increase maintenance and treatment costs. Sedimentation is expected to increase and this could decrease water storage capacity and increase maintenance costs.
- **Compact calls**. Reduced streamflow and increased water use could increase the contention over interstate allocations which are based on "normal" precipitation patterns. (See River Compacts section for details).

Recommendations

The following are recommended techniques for incorporating climate change into municipal water planning. The recommendations where adapted from industry organizations, consultants, and municipalities.

1. Don't assume the future will necessarily be like the past. Most water supply planning in Colorado is based on past hydrology. New plans should consider other future scenarios in addition to historical hydrology.

2. Assess vulnerability.

3. Identify and preserve adaptation options.

4. Apply risk management and adaptive management.

5. Explore phased approaches to adjust with climate changes.

6. Increase water system reliability, diversity and flexibility.

7. Use no regrets planning. Make plans that work well under a wide range of future scenarios.

8. Create and participate in regional efforts to model and analyze the impacts of climate change.

Recommendations with respect to adaptation:

9. **Reuse.** A reduction in the water available for first use within a municipal system could also reduce the water available for water recycling systems. Suppliers should analyze their system vulnerability.

10. **Conservation.** Water conservation is favored by most water suppliers as a cost-effective means to supply Colorado's growing population. Climate change poses a new dilemma. Do the suppliers continue to use the water saved from conservation to supply the state's population growth or do they now reserve some or all of the saving to protect against shrinking supplies? The saving cannot be used to do both. When the supplier uses the savings to supply growth in its service area, water efficiency is increased but more people become dependent on the same supply of water. If that supply shrinks, the additional savings needed to provide for the essential human uses could come at the cost of landscapes and businesses. Water suppliers need to carefully consider the role of conservation in climate change adaptation. [Need to adjust this to the language in the Conservation section]

11. **Storage.** The value of new storage in reducing the impacts of climate change on municipal water supplies is being debated in the west. Some believe that reduced streamflow would mean there would no longer be additional water available for storage in new reservoirs. Others believe new storage could play a role along with other measures to smooth out what could become an even more variable supply. Only added storage could capture the more intense precipitation events. Suppliers should carefully consider their local situation.

References

AWWA - Climate Change Primer for Water Providers (2006) and Climate Change Webcast (2007) Stratus Consulting- Climate Change Report for Denver Water. (2006) National Research Council – Colorado River Study (2007) Southwest Hydrology – Inconvenient Hydrology (2007) Water Utility Climate Change Conference, San Francisco (2007) [Need to add exact cites]

WA-7
Conservation

Two drafts were submitted

Draft #1 by Andy Colosimo

The potential impacts of climate change and variability and the fact that considerable growth will continue past 2030, it is clear that additional water conservation will be needed to meet future water demands in Colorado.

Recommendations

1. Water providers should implement water conservation concurrently with structural water supply development to meet these demands. Effective conservation programs make other supply alternatives, such as agricultural transfers and new reservoirs, more palatable to all parties, including utility customers, agricultural water users, environmental and recreational interests and citizens, businesses, and local government in neighboring river basins.

2. Water providers should consider water conservation in the larger context of sound water management, and water conservation planning should be integrated into as many aspects of local water resource planning as possible to achieve overall water resource management goals. Water conservation planning can help water providers identify where future planning efforts need to be focused. The planning process helps the provider look at the effect of water conservation on future water supply and demands, and how water conservation may affect timing and cost of new water supplies and other investments. Integrated water resources planning is designed to put water conservation on an equal basis with water supply development when analyzing options for meeting future water needs. However water conservation takes time to implement and produce the desired reduction in demand or increase in yield.

3. Water providers are strongly encouraged to implement and maintain strong and diversified water conservation programs. These programs should consider measures that are cost-effective for both the utility and customers and that accomplish significant water savings. Conservation programs should address all customer segments, particularly those that demand the greatest volume of water or place the greatest burden on the water system in terms of peak use. Regulatory and voluntary measures are necessary and each should be evaluated and utilized to address different aspects of both indoor and outdoor water use.

4. Water providers should evaluate the actual impacts of conservation on system yields and reliability through model runs and reasonable assumptions about technological and behavior savings that may be expected from customers during droughts before and after

the implementation of conservation measures. Mechanisms must be devised and applied to effectively and accurately monitor and report program savings in order to evaluate this impact. Water providers should also understand that conservation takes time to implement and verify. It is, in this way, different than traditional supply development in that it is truly an incremental process.

5. Some specific recommendations for demand-side programs and/or measures for water providers are:

A. Develop and maintain a strong and consistent water conservation education and awareness program including a school education program.
B. Attempt to fully meter all customers. "Automated" meters are highly recommended as they may offer various conservation opportunities and provide valuable access to information not available otherwise.
C. Institute strong water loss reduction programs. Water loss reduction decreases treatment costs and plant capacity needs.
D. Consider using non-potable water supplies for landscape or other appropriate water use whenever possible.
E. Implement regulations and enforcement that prohibits the waste of water, particularly in irrigation use.
F. Implement "conservation oriented" water rate structures for residential customers and seasonal rates for commercial and industrial that use a strong price signal to encourage conservation.
G. Encourage or provide commercial and residential landscape audits to ensure effective and efficient landscape water use.
H. Consider offering rebates for landscape retrofits. This measure is relatively high cost and may require a high level of effort to implement, so market penetration may be low.
I. Consider incentives or regulations that promote or require the "best available" landscape irrigation technologies for retrofit and/or new construction.
J. Consider landscape ordinances designed to reduce water use in new commercial or residential landscapes. Ordinances for new construction are generally very beneficial and cost-effective because of the high rate of growth in Colorado and the high cost and difficulty associated with landscape retrofits.
K. Consider offering incentives for high-efficiency (1.28 gallons per flush or less) toilet retrofits. These programs may be best targeted at commercial users and may at some point, become code for new construction.
L. Consider implementing residential indoor audits particularly targeting low-income and older residences. The audits should lead to appropriate retrofits of efficient appliance and equipment.
M. Implement commercial indoor audits that target process water use, cooling towers and older inefficient appliances and equipment.
N. Encourage commercial customers with cooling towers to increase their cycles of concentration. The cycles should be closely monitored to ensure acceptable water quality and proper tower function.

O. Consider offering incentives for high efficiency clothes washers. These programs may only be short-term as efficiency standards are increasing as is the popularity of high efficiency washers.
P. Consider turf removal incentives for both residential and commercial customers. Landscape changes may lower owner's maintenance costs. Reduction in turf is much easier to implement in new construction so programs that either encourage or require reductions are recommended.

Draft #2 by Bart Miller with input from Marc Waage

Decreasing river flows and lake and reservoir levels that are the expected by-product of climate change provide great incentives to step-up water conservation throughout Colorado.

Role of Governments: While the bulk of conservation work needs to be carried-out by municipal governments, State agencies can play an important role by providing funding and technical assistance and helping shape regional and state-wide education and message development.

Planning: Recent additions to state law require more frequent conservation planning and conservation goal-setting by water suppliers. Substantial state funding is available in the form of planning and implementation grants from the Colorado Water Conservation Board.

Water Supplier Dilemma: Water conservation is favored by many water suppliers as a cost-effective means to decrease the need for new water development. The risk of a drying climate poses a new dilemma for water suppliers. Do the suppliers use the water saved from conservation to: (1) supply new population growth, (2) reserve some or all of the saving to protect against shrinking supplies; or (3) set aside some savings to improve river habitat. If the supplier uses the savings exclusively to supply growth in their service area, water efficiency is increased but more people become dependent on the same supply of water. If that supply shrinks, the additional savings needed to provide for the essential human uses in that supplier's service area might affect landscapes and businesses within the service area. Water suppliers need to recognize that the choices are very case-specific and should carefully consider the risks and potential tradeoffs.

Implementation: Many cities across the state have demand management programs but, in many areas, improvements can still be made as cities refine their conservation programs and savings goals. Conservation program elements often include:

- Rate structures that reward conservation and provide incentive to avoid water waste;
- Rebate programs the assist customers (both residential and business) with installing high efficiency water fixtures, appliances, and devices;

- City ordinances and utility programs that encourage efficient irrigation;
- Business and residential audits that identify property-specific water issues;
- Education programs that deliver a consistent conservation message to all;

Outdoor Water Use: As municipal landscapes irrigation accounts for roughly half of total annual municipal water use, it deserves special attention. Successful outdoor programs include:

- Incentives and requirements to amend the soil before planting new landscapes;
- Encouraging Xeriscape—to boost the prevalence of water-saving landscapes and, in some cases, limiting the amount of turf as a percentage of total landscaped area;
- Increasing efficiency by changing watering habits (decreasing the numbers of watering days per week and lowering the amount of time per sprinkler zone);
- Irrigation improvements, including rains sensors (that turn off sprinkler systems during rain) and more efficient sprinkler head placement and water pressure.

Looking Forward: Because Colorado's new residents have not yet arrived, there can and should be a special focus on new development to decrease the future water-use footprint. This involves encouraging residential and commercial developers and builders to use state-of-the-art conservation practices.

References:

American WaterWorks Association, "*Water Resources Planning (M50), Second Edition," 2007.*

Colorado Foundation for Water Education, "Citizen's Guide to Colorado Water Conservation," 2004.

Metro Mayors Caucus and Colorado WaterWise Council, "Best Management Practices for Water Conservation and Stewardship," 2005; found at www.coloradowaterwise.org

Pacific Institute, "Waste Not, Want Not: the Potential for Urban Water Conservation in California," 2003. [*DW needs to review this*]

Western Resource Advocates, "Smart Water: A Comparative Study of Urban Water Use Efficiency Across the Southwest," 2003. [*DW thinks this report reflects an environmental bias; Bart Miller thinks it's a useful document for utilities and citizens to reference in the context of other sources*].

OTHER ??

WA-8
Agriculture

Draft by David Robbins

Agriculture consumes a significant majority of the water resources apportioned to the State by interstate compact. Consequently, if climate change produces a more restricted water supply over the long term it will have a commensurately greater impact on agricultural production in the State. Because of the close relationship between agricultural production and water consumption it will be necessary to develop strategies which trade some measure of increased productivity for a known amount of actual conservation.

However, it is unreasonable to assume that increased conservation practices and efficiencies in agriculture will result in a long-term quantity of "saved" water. If the "saved" or conserved water is in turn applied to consumptive purposes. The cold hard facts are that as water supplies become more scarce, the amount of land in irrigated agriculture will have to be reduced and if water conservation is viewed as a source of supply for municipalities the amount of irrigated agriculture will have to be reduced even more. In the event of shortages, there will be a movement of water use from lower intensity uses to higher intensity uses, such as municipal supplies.

WA-9
Energy and Water

Two drafts were submitted

Draft #1 by Andy Colosimo

Hydropower is a proven technology that by improving efficiency of existing plants or taking advantage of existing water storage and conveyance facilities can provide additional generation with little or no negative environmental impacts.

Colorado's geography provides for a unique synergy between water providers and energy generation through the use of hydroelectric power. Communities especially front-range water providers have ideal attributes for development of small hydroelectric projects – significant volumes of water flowing from higher elevations to water treatment facilities at lower elevations.

Successful small hydropower projects require adequate flow rate and water pressure, reasonable physical access for construction and maintenance, access to transmission lines and ability to secure a FERC license or exemption.

Climate change or drought conditions could pose challenges to hydropower generation located in snowmelt dominated basins. A decrease in water supply could limit power generation opportunities.

Another relationship also exists between water and power and that may be impacted from higher temperatures. Power generation is highly dependent upon water for cooling use – increased temperatures may place additional demands on water resources to cool the plants.

Recommendations

1. Additional hydropower opportunities should be evaluated and encouraged while recognizing the costs and risks associated with additional units.

2. Cooling technologies should be evaluated on all new electricity generating facilities.

Draft #2 by Brad Udall

Water and Energy are inextricably linked. In the case of drinking water, drinking water treatment, distribution, and waste water treatment all require energy. Heated water also requires energy, typically electricity or natural gas. In most cases this energy comes from fossil fuels which result in carbon dioxide emissions. Conserving water therefore not only saves water, but it also saves energy and may reduce carbon dioxide emissions.

On the other hand, there is no power without water: water is used for cooling, for hydropower. (See Andy's stuff).

Colorado's geography means that most established water distribution is accomplished using gravity. However, some pumping does occur and at eight pounds per gallon pumping costs can be significant sources of carbon dioxide if conventional energy is used.

New water projects in Colorado frequently involve moving water over significant distances because of the scarcity of undeveloped water near population centers. Unallocated water is usually far downstream or even across mountain ranges from the anticipated point of use. In these cases Colorado's geography may impose potentially significant pumping requirements. If the energy for these projects comes fossil fuels, significant carbon dioxide may be emitted.

Recommendations

1. Link between water conservation, energy conservation and carbon dioxide must made visible.

2. New water projects must explicitly consider carbon dioxide emissions.

WA-10
Information Exchanges

Draft by Ben Harding

Climate change presents complex policy, planning and operational issues to water users, water managers and appointed and elected officials. Planning for adaptation requires an understanding of the potential impacts of climate change, of the probabilities that particular impacts will occur and of the range of potential technical and policy responses to those impacts. While there is no shortage of information about climate change, much of that information exists at two extremes: academic journal articles, research reports and policy analyses; or articles in the popular press (not to mention the entertainment industry). It is difficult and inefficient for water resource managers to use the academic resources, but the value of the information in the popular press is dubious.

Likewise, the sophistication of water-dependant organizations in Colorado covers a very wide range. Large organizations, such as large utilities or large water conservancy districts, have their own technical staff, while a small town or a small mutual ditch might have only a part-time manager or maintenance person.

For these reasons it will be difficult to convey information about climate change to the broad spectrum of water users throughout the state. But, on the other hand, Colorado is blessed with exceptional technical, research and educational resources in the fields of climate, water resources and policy.

Recommendations

1. Support the development of at least one journal, using either traditional or electronic media, that addresses an audience of water resources professionals, managers and policy makers. Such a journal should translate research products to useful practice- and policy-oriented information. In order to be authoritative, such a journal will need some degree of peer review.

2. Support efforts, by state universities, state and federal agencies, and other organizations, to:
    - Provide practice-oriented information about climate change;
    - Host information exchanges among water management organizations, at both the policy and technical level, where they can trade experiences, successes and failures;
    - Conduct research oriented toward practical issues of water resources management and policy in the face of climate change; and
    - Provide opportunities for training and education in specific, practice-oriented topics related to climate change.

3. Encourage and facilitate cooperative working relationships among water-provider organizations in order to facilitate joint adaptive responses.

4. Develop training and education opportunities for elected officials.

WA-11
Recreation, Tourism, and Environment

Draft by Bart Miller, Chris Crosby

Projected decreases in river flows and lake and reservoir levels, coupled with a projected increase in population, are likely to have a wide range of impacts on Colorado's recreation and tourism industry as well as aquatic environments, species that depend on water, and our quality of life. These impacts threaten to decrease the intrinsic and economic value of water resources that currently bring enjoyment to millions of residents and add billions to the State's economy.

Several recreational and environmental impacts include:

- Fishing: warmer trout streams will eliminate or weaken trout in many river reaches and lower flows will make trout more susceptible to disease, winter kill, and angling pressure. Angling and related activities are estimated to bring hundreds of millions annually to the economy.

- Endangered Fish: four federally endangered fish, already at the brink of extinction in the Colorado River and its main tributaries, will face additional pressure due to additional loss of peak and base flows, and degradation of other habitat elements.

- Skiing: less snow and warmer temperatures means shorter ski seasons and fewer days of champagne powder. Increased snow-making will reduce stream flows farther, potentially affecting angling and increasing pollutant concentrations that are harmful to aquatic life.

- Rafting and Boating: less runoff will shorten the prime spring runoff and affect river running (rafting was estimated to have $135 million in economic benefit in 2006). Many lakes and reservoirs are likely to have decreased levels, affecting marinas and exposing sand and dirt to wind, snow, and erosion.

- Hunting: fewer wetlands will leave fewer nesting ponds for ducks and geese and few hunting spots in the fall. Vegetation changes may affect elk and deer food supply at different elevations.

- Camping, Hiking, and Biking: more forest fires will mean more forest closures and campfire restrictions. The aesthetic value of streams will decrease as flows drop.

In sum, tourism, recreation, and the environment will be negatively impacted by climate change. Ironically, tourism itself is partially responsible for the reduction in recreational quality and quantity because it increases impacts to outdoor resources by tourists themselves and the increase in residents who move to Colorado after a visit as a tourist. In the face of increasing demands on a limited supply of water, it's necessary to re-think some of our sacred cows, such as the assumption that population growth in Colorado can continue indefinitely.

Recommendations

1. State and federal agencies should undertake studies to evaluate possible impacts on recreation, tourism, and the environment. Responsible state agencies include the Division of Wildlife (DOW), Parks, Water Quality Control Division, Air Pollution Commission, as well as the state legislature; responsible federal agencies include the Forest Service, Bureau of Land Management, US Fish and Wildlife Service, Corps of Engineers, Department of Agriculture, and EPA.

2. The potential impact of climate change on the value of outdoor recreation and the environment underscores how essential it is for natural resource management agencies to set the example in decreasing GHG while at the same time preparing for impacts on Colorado's valuable waterways. Federal, State, and local management agencies should increase funding for programs that lower GHG. For example, Rocky Mountain National Park can help decrease car user miles (and congestion) by increasing bus schedules, especially during the busy summer season. And, the Colorado Water Conservation Board should accelerate its instream flow program to secure water flows and enforce its existing water rights against injury by other water users.

References

Todd Pickton and Linda Sikorowski, "The Economic Impacts of Hunting, Fishing, and Widlife Watching in Colorado"; found at http://wildlife.state.co.us/About/Reports/EconomicImpacts/

Colorado River Outfitters Association, "Commercial River Use in Colorado: 2006 Year End Report"; found at http://www.croa.org/media.htm

WA-12
Water Quality

Draft by Mark Pifher

Climate change can have significant impacts on the quality of our rivers and lakes and the associated aquatic ecosystems. Climate driven increases in water temperature, seasonal decreases

in flow, and changes in the intensity and duration of precipitation events can all influence water quality standards and designated beneficial uses. Potential impacts include:

- Increased pollutant runoff from more frequent and severe rainfall events.
- Periodic drought related low flows below aquatic life needs.
- Loss of anticipated dilution flows.
- Channel reconfiguration and sediment transport through flooding.
- Reduced dissolved oxygen levels in waterbodies.
- A loss of, or change in, biodiversity.
- An increase in forest fires and accompany run-off concerns.

Climate induced hydrologic modifications may similarly affect the implementation of water quality regulatory programs, such as compliance with wet weather mandates. (combined sewer overflow (CSO) and stormwater BMP's); the establishment of permit effluent limitations based on "low flow" averages; and the listing of waterbodies as impaired under Section 303(d) of the Clean Water Act (TMDL program) due to increased pollutant loadings, elevated temperature or the mere loss of flows. Water resource allocation decisions designed to adapt to changes in water availability will also hold implications for water quality. For example, there may be a tendency to expand reuse programs, necessitating additional protective reuse regulations, or to adopt enhanced treatment techniques, such as reverse osmosis, with attendant brine disposal concerns.

Recommendation

1. Additional data gathering and research on water quality impacts related to climate change, along with a re-examination of certain regulatory programs under both the Clean Water Act and the Safe Drinking Water Act, are warranted. EPA and certain states have commenced an examination of these issues and their efforts should be utilized in the development of a response strategy.

References

EPA Website on Climate Change: http://www.epa.gov/climatechange/

Memorandum from Benjamin Grumbles, EPA Assistant Administrator for Water, to office Directors on Climate Change and the National Water Program, dated March 2, 2007.

Climate Change Science Program Synthesis and Assessment Product 4.4, Preliminary Review of Adaption Options for Climate Sensitive Eco-Systems and Resources (EPA et. al., to be completed December, 2007)

WA-13
Groundwater

Draft by David Robbins

The tributary groundwater supplies in the State will respond to the effects of climate change in a manner very similar to that of the surface stream systems to which they are connected. As the surface stream flows diminish their ability to replenish groundwater systems declines commensurately; as surface irrigation supplies diminish the ability of those irrigation systems to recharge the groundwater declines; and as "conservation" and improved efficiency in agricultural irrigation practices increase in response to climate change there is a resulting loss in return flows to the groundwater systems.

Nontributary groundwater systems, such as the Denver Basin, are relatively immune to the effects of climate change. On the other hand, they are effectively non-replenishing from natural sources and as tributary systems are affected by climate change, the temptation to continue to rely upon them and mine the water within them will increase hastening their ultimate elimination as viable source of water supply.

Colorado must be prepared to accept the fact that there will have to be reductions made in all of its groundwater-dependent basins including the South Platte, the Republican, the Arkansas and the Rio Grande with regard to reliance upon groundwater as a source of irrigation supply until the groundwater systems can be managed in such a way that available recharge matches the discharge from pumping, natural losses and the obligations to neighboring states under our compacts.