

8.0 STRATEGIES AND RECOMMENDATIONS

8.1 INTRODUCTION

The previous chapters of this plan characterized the nature, distribution, and current uses of the Green River Basin's water resources and provided estimates of future water needs. Compiling this information was the primary purpose of the 2010 Green River Basin Plan.

The secondary purpose of this project was to perform planning. The Basin's water users face challenges concerning present and future water uses, and these challenges go beyond the need for locating and beneficially using more water. Users are faced with challenges related to water quality, infrastructure maintenance, water supply reliability, climate variation, project funding, energy costs to move water, and many others. In addition, the span of water issues and challenges is broad, from relatively small specific problems affecting a particular community or irrigation district to widespread issues potentially impacting users within and outside of the Basin.

8.2 PLANNING OBJECTIVE

The objective of this chapter is to present a useful continuation of the 2001 Green River Basin Plan's planning process. During and immediately after preparation of that plan, a great deal of work was done to identify and discuss water issues and challenges. While issues and challenges do not remain static and deserve a continuous discussion, at some point effective planning must advance beyond issues discussion towards a solutions discussion. Therefore, a clear objective of this 2010 Green River Basin Plan Update is to advance the planning process beyond issues identification and into a useful identification of strategies and recommendations for addressing issues.

The following definitions are used for this planning process to help explain the important difference between strategies and recommendations:

- **Strategies:** broad and general activities that stakeholders may employ to address what is typically a host of issues. As an example: A Municipal Master Plan is a strategy that a community can use to address the multitude of issues typically facing this particular user group. This can include economic development, water supply and distribution, wastewater treatment, infrastructure funding and financing, etc.
- **Recommendations:** specific activities that individual stakeholders may implement to address specific and well defined strategies.

8.3 ISSUE SUMMARY

The 2001 Green River Basin Planning process initiated an identification and discussion of water issues and challenges in the Basin. Through a series of public meetings, the many challenges facing water users were identified and recorded. The Basin issues list was refined and consolidated by Water Development Office (WDO) staff and completed in November 2005. Table 8-1 presents the issues list.

Agricultural Issues

Agriculture is the major water consumer in the Green River Basin. In some areas and in some years irrigators in the Basin experience large seasonal shortages. The major reservoirs in the Basin, Fontenelle and Flaming Gorge Reservoirs, are downstream of most of the Green River Basin irrigated areas and are virtually unused for irrigation in Wyoming.

The distribution of water storage is uneven, so that some irrigated areas are well served by one or more reservoirs while others have little or no storage. The Upper Green River except for the New Fork River has little storage; in this area there are a total of 119,302 irrigated acres but only 6,495 acre-feet of storage. This provides a ratio of 0.05 acre-foot of storage per acre of irrigated land, and the irrigated lands in this area typically do not receive a full water supply in most years. Another reach with water supply problems is the Henrys Fork, which has a storage ratio of about 0.41 acre-foot of storage per acre of irrigated land. The Hams Fork is another portion of the Basin without irrigation water storage.

Besides inadequate storage, agriculture faces infrastructure deficiencies. There is a lack of water measurement devices to aid in water management, canals leak, and many diversion and headgate structures are old and in need of repair.

Municipal and Domestic Issues

Municipal systems are challenged to meet water quality treatment requirements and to produce and distribute adequate supplies, especially during drought conditions. Some municipalities need more storage, replacements for aging infrastructure, or to extend their networks into new service areas. The water sources (ground and surface water) are also threatened by contamination from water users, unregulated rural septic systems, failing infrastructure, and natural sources. The presence of senior water rights poses a threat to some municipalities, such as Baggs and Bairoil, if informal agreements with industrial and agricultural sectors are not honored or if growth in municipal water demand is large.

Table 8-1 Issues Identified in the Green River Basin

Issues Identified	Sub-Issue	Current Status ¹
Agriculture	Additional Storage	- Church Reservoir Study
		- Upper Green Study
		- BLM Stock Reservoirs (small water projects)
		- Viva Naughton Level II Phase I and II Studies
		- Middle Piney Reservoir New Project Application
		- Eden Valley Pipeline Level III Project
		- Boulder Reservoir Level II
		- Weather Modification Study
		- Water Value Study
		- Green River Groundwater Recharge and Alternate Storage Study
		- High Savery Reservoir
		- Salinity Control Project
		Groundwater
- WWDC Small Water Projects		
- Sweetwater Conservation District - 14 wells and 1 pipeline		
- Little Snake River Conservation District - 8 spring developments and 2 solar platforms		
Economic Development		- Wamsutter Well
		- Water Value Study
Downstream Claims, Compacts and Decrees	Instate	- Upper Green Joint Powers Water Board
		- Colorado River Compact Administration Report (Mike Purcell)
		- ~3 public meetings
		- SEO budget request for Colorado River Coordinator position
		- Upper Colorado River Compact Commission
		- 7 States discussion
	Downstream	- California quantification
		- Lake Powell/Lake Mead storage equity
		- Additional supply needs for City of Las Vegas
		- Quantification of supply under compact
		- Big Sandy pipeline
		- WWDC Small Water Projects
		- Sweetwater Conservation District - 14 wells and 1 pipeline
Instate	- Little Snake River Conservation District - 8 spring developments and 2 solar platforms	
	- SEO Atlantic Rim Water Management Study (2006 Legislation)	
	- 205 (j) Projects	
	- Salinity Control Forum	
	- Ft. Bridger area salinity review	
	- 303 (d) (DEQ)	
Water Quality	Basinwide	- Fremont Lake Monitoring (municipal supply for Pinedale) in conjunction with Lakeside Lodge Expansion EA
		- Coalbed Natural Gas Development
Municipal and Domestic		- Baggs
		- Wamsutter
		- Bridger Valley
		- Green River/Rock Springs Master Plan
		- Metering requirements
Water Conservation and Reuse		- Green River Supply Canal Level II and Level III Projects
		- Little Snake System
		- Eden/Farson (Big Sandy Salinity Control Project)
		- Eden/Farson pipeline
		- Green River/Rock Springs water reuse on parks and golf courses
		- Municipal metering requirements
		- Coalbed natural gas development (water discharge, storage, reinjection)
Non-consumptive and Aesthetic Uses		- Pinedale desire for instream flow through town
		- Water Plan listing of instream flow applications
		- High Savery Reservoir fish pool
		- Maintaining overall watershed/environmental health (wetlands)
Water Development		- Coalbed Natural Gas Development
		- (revisit entire list)
		- Fontenelle Water Sales
		- Quantification of remaining compact allocation
		- BORs management of water in Fontenelle Reservoir
Federal Involvement, Regulations, and Lawsuits		- High Savery Reservoir fish pool for Colorado River cutthroat trout
		- Endangered Fish Recovery Program
		- Yampa Programmatic Environmental Impact Statement (EIS)
		- Energy Development (leasing of federal lands and mineral rights)
		- Marketing of water out of Fontenelle (Bureau of Reclamation)
		- Coalbed Natural Gas Development
Recreation		- Green River Water Park
		- Storage
		- Flaming Gorge Reservoir
		- Viva Naughton Reservoir
		- Fontenelle Reservoir
		- High Savery Reservoir
		- BLM Stock Reservoirs (Old Steve Adams #5)
		- Purchase of agriculture lands for "non-traditional" uses
		- Other recreational uses on reservoirs and streams in the Basin (fishing, floating, bird watching, etc)
		- Trona
Industry, Minerals, and Manufacturing		- Jim Bridger Power Plant
		- Kemmerer need for reliable water supply
		- Coalbed Natural Gas, Oil and Gas Development (Jonah)
		- Oil Shale Development
		- Simplot Phosphates
		- Synthetic-based fuel from coal (coal liquification)
		- Enlargement of Jim Bridger Power Plant (possible enlargement of Viva Naughton Reservoir and others)
		- Governor's proposed energy corridor (water needs)
- Reinjection of produced water below 7500' (Pinedale Anticline and Jonah Field)		
Drought Mitigation and Flood Control		- Dry year leasing
		- Temporary water right transfers
		- Drought updates from State Climatologist
		- Winter snowpack augmentation
Water Rights		- Bureau of Reclamation operation plans
		- Pinedale: instream flow through town
		- Transbasin diversions
		- Subdivision administration
		- SEO: increased penalty to those taking water without a permit
		- Ongoing Compact Work
		- Mapping project (SEO) and consumptive use analysis (Colorado River Compact Administration Project)
		- Increased measuring devices and accuracy in diversions
Implementation		- Upper Green River Joint Powers Board
		- Water Value Study
		- Groundwater in Water Plan updates

1. Issues list current as of November 2005.

Industrial Issues

Industrial users have adequate supplies to meet existing uses. In general, the supplies are reliable due to their location in the Basin and the presence of water storage facilities and long-term supply contracts. Future industrial users will be challenged, depending on project-specific requirements and location in the Basin. Industrial water issues include water quality treatment and disposal regulations. In the Basin, compact salinity requirements place additional constraints on already stringent EPA and WDEQ regulations with the goal of meeting the Colorado River Salinity Control Act requirements by eliminating additional salt loads. A major obstacle to CBNG development was the question of alternatives for disposal of byproduct saline groundwater considering the expense of injecting the water into brackish formations. Aging transmission systems, outdated technology and equipment, and the cost-benefit ratios that constrain updating are all issues in this sector.

Recreational and Environmental Issues

Environmental water uses are non-consumptive, but important to the Basin. As an example, instream flows promote more favorable late season water temperature (i.e. lower), dilute pollution, and help maintain habitat quality for sport fisheries. While stream barriers, such as diversion dams, are a necessary and long-standing part of legitimate water use, fish bypasses and fish-friendly headgate/diversion structures can provide important benefits to fish and other species. Non-native species infestation, water quality impairments such as sediment, nutrients, salt loading, and other pollution all threaten environmental uses.

Recreational water use can conflict with the consumptive water uses of the other sectors. Water diverted for irrigation reduces flow rates in a particular reach of stream. During late summer, particularly in dry years, legitimate and longstanding uses can temporarily eliminate some recreational uses such as floating. Projects to develop water for new or supplemental uses can be designed to furnish multiple use benefits. Some specific recreational water use issues in the Basin include maintaining minimum pools, bacteria levels in recreational waters, and general aesthetic benefits of having adequate water or flow levels in streams, lakes, and reservoirs.

Basinwide Issues

Recently the Colorado River Basin suffered the worst drought in a century and one of the most severe in 500 years. Recent research from tree ring studies and hydrologic data have shown that the Colorado River is drier and more prone to severe drought than previously believed. It has also become apparent that the period of record of hydrologic conditions that was available and on which the Colorado River and Upper Colorado River Basin Compacts were negotiated were wetter than the long-term norm. Although to date there has never been a compact call on Upper Colorado River Basin states due to shortages, scientific evidence points to the likely probability that the compacts were signed under assumptions of wetter hydrologic conditions than can be

expected over the long term. This affects Wyoming's compact allocation, because the Upper Basin states must still comply with the depletion requirements of the Compact, as presented in Chapter 3. The potential for drier conditions and sustained drought in the future establishes a need for the Basin to have an operating procedure in place to meet future compact calls.

8.4 APPROACHES TO STRATEGY IDENTIFICATION

As previously discussed, the issues identification process began in the previous basin plan and a goal of the current plan is to shift planning focus from issues towards strategies. The Planning Team performed the following activities to support the strategy-related planning recommendations presented in this chapter:

Basin Advisory Group (BAG) Meetings

Facilitated BAG meetings held around the Green River Basin included presentations from a variety of BAG members. The presentations were an opportunity for the Basin residents to describe their challenges and the strategies that they were evaluating or using to meet the challenges. The presentations were followed by open audience discussions brainstorming ideas for how the stakeholders could address the issues. BAG meeting notes provide a record of the information and suggestions collected at these meetings. These notes are compiled in the Plan Project Notebook, a single copy of which is possessed by the WDO.

Stakeholder Interviews

A phone survey, performed by WWC Engineering staff in late 2008, was directed at approximately 115 Basin stakeholders (55% response rate), including municipalities, industrial water users, agricultural interests, recreational interests, and a number of local, state and federal agencies. The survey had two objectives. First, the survey was used to identify water use issues currently affecting individual stakeholder groups. The 2008 issues survey was used to supplement and build on the extensive issues identification work performed as part of the 2001 Plan. The 2008 phone survey provided an opportunity for individual stakeholders to voice their personal opinions and ideas.

The second goal of the phone survey was to inquire about possible solutions (strategies) to issues that are affecting water users. While strategies for addressing issues are generally intuitive and in many cases widely known and discussed, the current water plan update was designed to directly ask the user groups themselves for strategy ideas. It was expected that water users would have different perspectives on possible strategies than the Planning Team and the WDO wanted to employ a grass-roots approach to preparation of the 2001 Basin Plan.

Planning Team Input

During the course of completing the various technical efforts, such as the water availability quantification in Chapter 7 and the technical memoranda regarding water related topics (e.g. Augmentation, Climate, etc), the Planning Team Members (consultants, state agency staff, and state agency directors) cooperated, discussed and evaluated strategies and considered specific

recommendations. Many of the ideas generated in this way are expressed in a later section of this chapter.

8.5 GENERAL STRATEGIES

This section presents a general discussion on strategies. The strategies offer benefits to each water use sector in the Green River Basin, some more directly than others. Many of the concepts are not new; some were previously presented in the Wyoming Framework Water Plan. Wherever possible, the strategy concepts have been tailored to specific issues in the Green River Basin. These concepts supplement the more specific recommendations presented later and are described below in an order that does not indicate any particular priority.

8.5.1 Continue to Support Planning

The foundation of sound water planning strategies is the collection of information through planning studies and reports. Information collected in planning studies and reports, such as municipal master plans and watershed plans, are a major funding and improvement tool for municipalities and conservation districts, irrigation districts, and virtually any other non-municipal stakeholder in the Basin. The WWDC New Development Program and Rehabilitation Program provide opportunities for municipalities and other stakeholders to sponsor Level I and II studies, including municipal master plans and watershed plans (also see Chapter 9). These state-funded planning tools make possible the identification of problems and provide funding sources to help correct those problems. State-provided planning funds make it feasible for municipalities and stakeholders with limited financial resources to develop plans to solve critical water-related problems. The WWDC's Small Water Project Grant Program, Groundwater Development Grants, and New Development and Rehabilitation Programs provide entities with the means to begin addressing specific municipal, agricultural, and domestic water issues.

The water planning process documents the Green River Basin's intent to develop the means to use the allocations that have been made to the Basin through interstate compacts.

8.5.2 Consider Transbasin Diversions

The movement of water from areas of surplus to areas of need is woven through the water development history of the West, including Wyoming. It can create conflicts between water users in adjacent river basins, but it can also be a positive solution for the basin needing the water while addressing other needs in the basin of surplus via mitigation. Transbasin movement of water is expensive (thus precluding its use for irrigation), time-consuming (due to the number and complexity of environmental and other regulations that require permits, NEPA documents, etc.), and fraught with political and social debates. Before any transbasin diversion out of the Green River Basin is considered, there should be an evaluation showing that the basin receiving water has effectively developed and is using all reasonably available supplies. Also, in the event a transbasin diversion project is pursued, any resulting impacts to the basin providing the water must be mitigated according to Wyoming statute (W.S.41-2-121). Because the Green River Basin has unused compact allocations and is therefore the Basin most likely to be the source for

water in any transbasin diversion, the requirement for mitigation could be an opportunity to barter surplus water for in-basin improvement projects such as reservoir construction or enlargement and infrastructure improvements to agricultural and municipal sectors. High Savery Reservoir is an example of mitigation constructed in exchange for an out-of-basin diversion by the City of Cheyenne.

The Million Conservation Resource Group (MCRG) has proposed the Regional Watershed Supply Project. The project would divert as much as 250,000 acre-feet of water per year from the Green River in Wyoming, possibly at Flaming Gorge Reservoir and pump the water through a pipeline along the I-80 corridor to Laramie, providing 25,000 acre-feet per year to water users in the Platte River Basin in Wyoming and transporting the remaining 225,000 acre-feet per year to the Front Range in Colorado. An Environmental Impact Statement (EIS) is being financed by the MCRG and prepared by the U.S. Army Corps of Engineers (USACE). It is anticipated that it will take more than five years to complete the EIS. The Bureau of Reclamation, as the federal agency in charge of Flaming Gorge Reservoir, is completing a study to determine the amount of water that may be available to the project.

In addition, a coalition of public entities in Colorado and Wyoming are pursuing a similar project as the Colorado/Wyoming Water Supply Project. The physical project is essentially the same concept, however, public financing is being sought by the coalition. This coalition is presently seeking members among public entities in Colorado and Wyoming.

The State of Colorado has not taken a position on either trans-basin diversion proposal. The State of Colorado's support is critical to the proposals as the water to be delivered to Colorado must come from that state's compact allocation under the Upper Colorado River Compact. The compact allows one state to divert its compact allocation in another state.

The transbasin diversion proposals are being monitored and scrutinized in Wyoming for potential environmental and economic impacts. On July 27, 2009, Governor Dave Freudenthal provided scoping comments on the EIS to the USACE. While the comments were comprehensive and expressed several concerns about the proposal, the Governor was particularly emphatic on the following issue:

*“Wyoming recognizes Colorado’s right to develop its compact allocation pursuant to the Upper Colorado River Basin Compact, and that development in one state for use in another is allowed... **However, and I mean to add emphasis by employing bold font, the Colorado uses served by this project cannot affect, in any way, or deny any future uses in Wyoming, which of course will have later priority dates.** As such the NEPA analysis must consider that diversions for use in Colorado will be conditioned by Wyoming such that they will always be the most junior users of the lower river above Flaming Gorge.”*

The project has many hurdles to overcome if it is to become a reality, including, but not necessarily limited to, difficult environmental permitting and political issues; an estimated construction cost in excess of 3 billion dollars; and very extensive annual operating costs.

8.5.3 Evaluate Water Rights Leasing

The vast majority of early-priority water rights in Wyoming are direct flow surface water rights for irrigation. The property right that is conferred with an adjudicated water right makes these early water rights very valuable. As the state's economy diversifies, the municipalities and industries that require a consistent, dependable water supply might look to these senior agricultural water rights for transfer, as has happened in other parts of the state. While permanent changes of use are allowed under existing water law, and qualifying temporary changes of use are allowed for up to two years, more flexibility in the ability to transfer water rights on a temporary basis may be sought by water users. Concepts such as rotational land fallowing and dry year leasing have been used in other states to keep agricultural water rights tied to the land but give the water right holder the flexibility to make contractual arrangements with others in need of a dependable water supply during times of drought. These arrangements keep land in a higher category of agricultural land use (i.e., irrigated vs. dry land), which is good for local economies since property taxes are based on land valuation. It also provides water to those entities in need of water only in the years when their other water supplies are insufficient without permanently severing the water rights from the land. Some relatively minor changes in water right law could allow for more flexibility and better adaptation to the changing demands on water today.

8.5.4 Evaluate Changes to the Instream Flow Law

Modifying the Instream Flow Law enacted in 1986 could prove beneficial to the Green River Basin. The law does not currently allow for a private water right holder to retain his/her water right and change the existing use to instream flow, but requires that the right be turned over to the WWDC if the use is instream flow. Some landowners are interested in the fishery and environmental attributes of surface water resources on their properties. The ability to have more flexibility in the use of their surface water rights appears to be desired, and it is possible that changes to the instream flow statute and temporary change statutes could occur to accommodate the needs. Since 2002, at least twelve bills addressing the concepts of temporary in-channel uses or other flexibilities in the temporary use law have been introduced in the Wyoming Legislature, but none have passed. The Green River Basin planning process has identified that there is some support (Trout Unlimited, WG&F, and some landowners, as examples) for reserving water for instream purposes. Future BAG meetings can provide a forum for the public to provide input on whether increased flexibility is desired by water right holders for these uses of water.

8.5.5 Prepare for Climate Variation

Climate extremes contribute to seasonal and annual fluctuations in water supply and, to a lesser degree, changes in water quality. Impacts of climate change on water supplies are difficult to predict, but if the 1998-2007 trend of reduced snowpack, earlier snowmelt, and lower runoff amounts continues, stakeholders in the Green River Basin will have to adapt. Adaptation,

supported by planning and preparation, will lessen the impacts. Below are specific ways the different water use sectors can prepare for climatic variation.

- Irrigators may want to ensure that their most senior water rights are on their most productive lands. This would assist in achieving the maximum benefits from a limited water supply. Moving the senior water rights will require approval of the Wyoming Board of Control, and there are some costs associated with the preparation of the necessary petitions.
- It is incumbent on municipalities and purveyors of domestic water to ensure that their citizens have enough water for the public's health and safety. Some Green River Basin communities have programs that place restrictions on the watering of lawns and gardens during periods of limited supplies. These restrictions help reduce the demand on available supplies. However, municipalities relying solely on direct flow diversions gain little from such water restrictions. These communities need to pursue supplemental storage or obtain water from senior water rights through temporary use agreements in times of drought when their direct flow water rights may be subject to regulation.
- During extreme, short-term drought events, industries may consider temporary use agreements with water users having very senior water rights.

8.5.6 Continue to Evaluate Storage

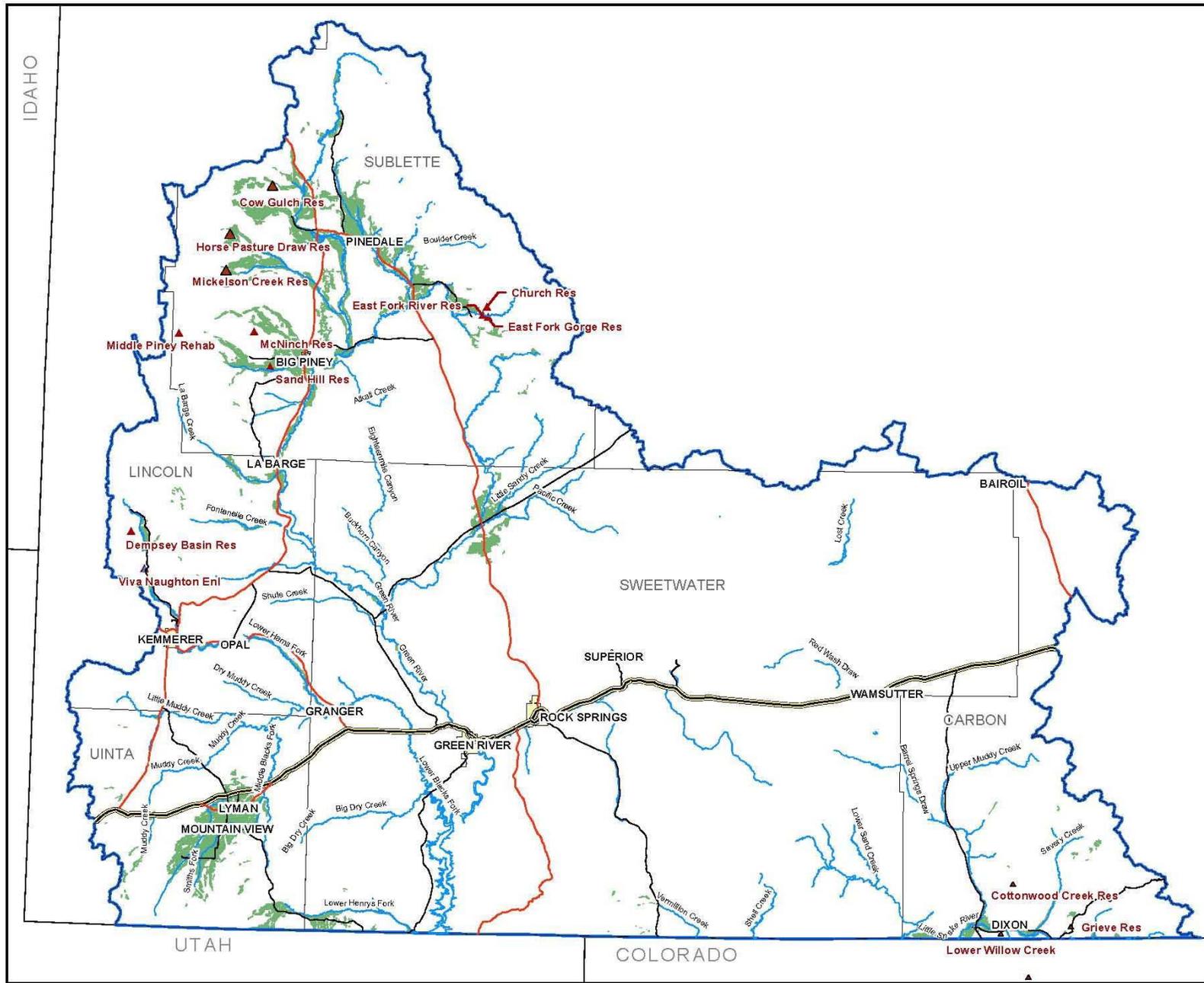
One water-shortage strategy that has always received considerable attention is the construction and enlargement of reservoirs. Although storage is generally a more expensive option than change of use from irrigation to municipal or industrial use, and may face environmental, cultural, technical, and legal obstacles, it is often preferred because it is a way to capture and store water for Wyoming and the Green River Basin's use without sacrificing another beneficial use. Storage helps to secure future supplies, may help to meet compact calls with the least impact to individual stakeholders, and generally enjoys widespread public support, especially when accompanied by environmental provisions such as minimum pools, minimum releases during low-flow periods, and fish bypasses. However, it is necessary for a sponsor of a reservoir construction project to demonstrate a need for the storage, including identification of alternatives considered and specific uses once completed. Water placed in storage must have a specific use, and until currently un-leased water in Fontenelle and Flaming Gorge Reservoirs is leased, it will be hard to demonstrate a specific need for additional storage in the Basin aside from areas which cannot be served by these two reservoirs. Table 8-2 and Figure 8-1 show a general list and location of potential reservoir sites and potential reservoir enlargement projects that have been identified by previous planning studies in the Green River Basin.

In addition, the Wyoming Water Development Program (Program) should remain committed to the construction of reservoirs (also see Chapter 9). Increased environmental regulations have made the construction of large dams on main stem rivers very costly and, absent

Table 8-2 Potential Reservoir Rehabilitation or New Construction Sites

Project	Storage	Irrigated Lands	Project Yield	2007 Project Cost	Storage Cost	Sponsor Cost per Acre*	Sponsor Cost per Acre-Foot*	Comments
	ac-ft	acres	ac-ft per year	\$M	\$ per ac-ft	\$	\$	
Middle Piney Rehab	4,200	NA	NA	NA	NA	NA	NA	Piney Creek drainage.
Horse Pasture Draw Res	5,710	15,151	5,152	20.6	3,608	33	98	North Horse Creek drainage off-channel site.
Sand Hill Res	14,500	10,000	14,100	32.8	2,262	80	57	Piney Creek drainage off-channel site would require 3-mile canal.
Church Res	10,000	5,497	4,200	20.5	2,050	91	120	East Fork drainage off-channel site would require 2-mile canal; water supply concerns.
Dempsey Basin Res	24,000	10,287	10,700	NA	NA	NA	NA	Off-channel site; Hams Fork drainage; critical cultural impacts.
Grieve Reservoir Rehabilitation	400	NA	300	0.5	1,250	NA	41	Little Snake drainage, off-channel.
Viva Naughton Enl	24,000	10,287	10,700	NA	NA	NA	NA	Hams Fork drainage; critical cultural impacts; large wetland impacts; multipurpose reservoir.
Mickelson Creek Res	7,300	19,183	5,835	31.9	4,370	41	133	South Cottonwood Creek drainage off-channel site.
Cow Gulch Res	13,330	11,583	2,793	19.5	1,463	41	170	Beaver Creek drainage off-channel site.
McNinch Res	4,600	6,000	5,600	28.6	6,217	117	125	Piney Creek drainage off-channel site would require 6-mile canal.
Lower Willow Creek Res	23,190	10,011	5,943	45.1	1,945	110	185	Willow Creek drainage.
East Fork Gorge Res	1,900	5,497	1,900	30.7	16,158	137	395	New Fork drainage.
East Fork River Res	1,700	5,497	1,700	19.1	11,235	85	275	New Fork drainage.
Upper Willow Creek	10,000	NA	4,570	22.5	2,250	NA	121	Little Snake drainage located in Colorado.
Upper Cottonwood Creek	1,000	NA	NA	7.2	7,200	NA	NA	Little Snake drainage.

* Assumed WWDC Standard Funding Package of two-thirds grant and one-third loan at four percent interest rate.



- LEGEND**
- Irrigated Lands
 - Future Water Use Opportunity Sites

Figure 8-1
Green River Basin
Potential Reservoir Sites

federal reform to these requirements, virtually infeasible. Therefore, the Program should concentrate on smaller reservoirs on tributaries or off-channel reservoirs where environmental consequences can be effectively mitigated and managed. In addition, enlargements of existing reservoirs should be considered. Reservoir projects are more feasible if the Program works with project sponsors who are willing to commit political and financial capital towards the construction, operation, and maintenance of the project. In these situations, the Program should fund the permitting and design costs and provide construction funding commensurate with any water supply benefits it may retain for environmental purposes or future marketing. The sponsor should be able to finance a portion of the construction costs through a loan from the Program. The amount of the loan would be based on ability to pay for the benefits that the sponsor will realize in keeping with current practices of the Program. The sponsor should be responsible for operation and maintenance of the dam and appurtenances. In addition, developing partnerships with industries to construct new storage should be pursued. The Program's role in such partnerships would be to assist in the permitting of the project and invest in a portion of the storage for purposes of supplemental municipal and irrigation supplies. Also, much of the permitted capacity in existing reservoirs is eroding due to the accumulation of sediment. Given the value of storage to the state and the fact that many dams fill only in wet years, perhaps the state's one-fill rule should be revised to allow dam owners to ensure that the total permitted capacity is either used or stored.

8.5.7 Consider Water Conservation

Water conservation, both municipal and agricultural, is often touted as an approach to stretching water supplies. Conservation of water cannot be forced, however, and creating financial or other incentives to encourage reduced water consumption is typically required. Water conservation activities can also be complementary in addressing concerns with aging infrastructure. Over a hundred years of use has taken its toll; physical wear and time have deteriorated many of Wyoming's major water storage and delivery projects, leading to reduced water delivery efficiencies. Further, as competition for limited federal dollars increases, funding to replace or repair these projects will likely come from a combination of sources, not just the federal government. Future water plans should address the physical condition and continued functionality of aging water projects in the Basin and estimate the rehabilitation needs and costs. With this information, funding packages can be investigated, whether the funding is from federal, state, or private sources.

8.5.8 Consider Water Augmentation

The states of the Colorado River Basin are jointly exploring the feasibility of augmenting supplies through such means as weather modification, water conservation, water reuse, and desalination. It is difficult to distinguish between water that is a direct result of augmentation (e.g., cloud seeding) and naturally-occurring water. Therefore, augmentation is a strategy for the state to consider.

8.6 RECOMMENDATIONS

This section presents specific strategy recommendations for water development in the Green River Basin. For clarity:

- The recommendations are organized by the use sector categories.
- The recommendations are brief. Many of these recommendations have been previously published (in technical memoranda and other reports) along with well developed arguments to support the recommendations.
- The section includes suggested action items that were extracted from the BAG meeting notes, and some of the concepts are not fully developed or feasibility has not been determined.

8.6.1 Agriculture

Watershed Plans

Based on the distribution of agricultural interests and population, the following is a suggested prioritization of the order in which watershed plans should be initiated in the Green River Basin:

	HUC-8 (4 th Level)
1) Upper Green	(14040101)
It is suggested that the west side of the watershed have a higher planning priority than the east side.	
2) Blacks Fork	(14040107)
3) New Fork	(14040102)
4) Big Sandy	(14040104)
5) Upper Green Flaming Gorge	(14040106)
6) Little Snake	(14050003)
7) Muddy (west)	(14040108)
8) Muddy (east)	(14050004)
9) Vermillion	(14040109)

Simply stated, the above proposed order reflects the author's opinion assuming that watershed plans are initiated by the State. This is not the case. In fact, the WDO does not initiate or solicit projects. Projects come forth based on the efforts of sponsors.

8.6.2 Municipal and Domestic

Municipal Master Plan

Of the 14 municipal water providers, a review of records indicates that water master plans are either non-existent or more than 10 years old for the following: Bridger

Valley Joint Powers Water Board, LaBarge, Marbelton, Superior, and Wamsutter. If true, these entities should consider making requests to WWDC to fund updated plans.

Water Rights

Municipal water systems that use surface water should work to identify what early-priority agricultural water rights might be available for leasing, which was described in the strategies section of this chapter. These entities include the Green River Rock Springs Joint Powers Board, Baggs, Bridger Valley Joint Powers Water Board, Dixon, Granger, Kemmerer-Diamondville Joint Powers Water Board, LaBarge, and Pinedale. Assuming water quality needs are met, owners of water wells might also be considered for leasing of water rights. Perhaps the municipal water providers can execute first right of refusal agreements with likely agricultural interests, at very modest cost. Certainly this proactive work would position the water provider better than a reactionary approach to a curtailment. It is suggested that the state entertain the idea of funding the process of identification of these agricultural water right holders within the context of an updated municipal water master plan.

8.6.3 Industrial

Fontenelle Reservoir

Industrial interests may firm up their water supply situation by purchasing contracts to use Fontenelle water. An additional specific recommendation for achieving this is provided below under the action list for state government.

Agricultural Water Rights Leasing

As with municipal providers, industrial water users should carefully consider the benefits and costs associated with making advanced arrangements for temporary agricultural water right leases. See Section 8.6.2.

8.6.4 Recreation and Environmental

Riparian Areas

The benefits of riparian areas to the Green River Basin watershed are not easily quantified, but widely understood as having value. Riparian areas provide opportunities for water quality enhancement, stabilize stream flows, and provide many conditions needed to sustain beneficial ecological functions. This sentiment was consistently voiced at BAG meetings during the course of this study. The state might consider how to specifically quantify the benefits of riparian areas, in addition to quantifying benefits water brings to Wyoming's broader society and ecology.

8.6.5 Basinwide (State Agency)

State Engineer's Office

The SEO should continue to execute the recommendations presented in the Colorado River Compact Administration Project (Purcell, 2005), specifically:

- Prepare current and searchable water right tabulations.
- Update estimates of irrigation consumptive use.
- Obtain annual reports of water use from municipalities and industries.
- Measure and report on the annual exports out of the Basin.
- Collect annual records for reservoir storage, including amount stored, spilled, evaporated, released for use, and carried over.

The Colorado River Compact Administration Program (2008)

This SEO program is well thought out and broad in content. From the recommendations presented in the Colorado River Compact Administration Program: Consumptive Use Determination Plan (2008), the state should continue to fund and execute:

- 5 recommendations directed at climate and hydrology.
- 4 specific recommendations directed at measurement of diversions and determination of consumptive use. The importance of collecting good quality data cannot be overstated as a fundamental recommendation for future planning.
- 1 recommendation directed at water rights attribution.
- 2 recommendations related to reservoir operations and water storage.
- 1 recommendation for providing outside experts in the field of geohydrology.
- 4 recommendations related to administration and decision support tools.

Green River Basin Plan

It is suggested that this plan be re-examined in 2015 via an internal review by WDO staff. If changes are significant at that time, funding and planning for the next update should be performed by 2020. If major changes in water supply or water use have not occurred by that time, WWDC should shift focus towards watershed plans rather than updating basin-wide plans.

Irrigation Shortages

The scope of work in the next Green River Basin Plan or watershed plan or other efforts administered by the SEO should strive to more accurately quantify agricultural shortages.

Green River Basin plans to date have focused on estimating water available to new development or expansion of existing projects and providing a tool for testing effects of new development on the downstream basin. They have not focused on estimating the shortages, or difference between an ideal supply and the amount of water actually supplied to irrigators. The basin plans show how much water is used under the constraints of a limited supply and timing, location, and quantity of water left after the current level of use is exercised, no matter if the amount was adequate or not. The piece not quantified is the amount, timing, and location of the difference between an ideal supply for the acreage currently under irrigation and the existing supply. If this difference could be better estimated, then planners and engineers can evaluate how water could be made available to irrigators through storage or by moving water from one place to another to reduce the shortages.

The state must continue to collect records of diversion practices and quantities and to digitize historical data to facilitate its use in water accounting models. The state must also implement the climate data collection program recently invested in - both for the purposes of improving estimates of ideal supply as well as historical consumptive use, and then look at the difference between those quantities. This data collection effort would further the state's investment in a Decision Support System (DSS) project for the Basin.

Marketing

The state might consider preparing a marketing plan for the water allocated to Wyoming by compact and stored in Fontenelle Reservoir. The plan should have all the elements of a sound marketing plan and be prepared by experts. The water marketing effort could be coordinated by the Wyoming Business Council (WBC) as a part of an overall effort to attract new businesses and industries to Wyoming. The WDO would be the logical technical support group for the marketing effort.

WBC's publication, a newsletter entitled "Wyoming Business Images", presents material on wind energy potential, coal gasification, and other natural resource subjects. The newsletter is directed at people doing or contemplating doing business in Wyoming and would be a logical place to present information on the availability of water resources in the Basin.

Instream Flows

The water availability analysis (Chapter 7) reflects the application of instream flow water rights. During BAG meeting No.4, a BAG member expressed concern that instream flow rights would impact the viability of other water projects by making less water available for consumptive uses.

A more detailed evaluation and description of how instream flows might limit water storage projects should be contemplated. If possible, WDO should identify, through

cooperation with WG&F, WDEQ and others, the specific reaches of streams that have the most promise for being managed as instream flow segments. Next, an analysis of water rights and water supply through a time series simulation should be performed to see how reservoir yields would be reduced by the imposition of instream flow requirements in various drainages.

Glaciers

The base flow associated with glaciers should be monitored and trends should be noted (BAG meeting No. 8).

Oil Shale

The oil shale issue and its potential impact on the water supply and water use opportunities should be studied by state-funded water planning (BAG meeting No. 3 and No. 6).

Prescriptive Versus Descriptive Planning

Continuous critiquing in the basin planning process and evaluation of how to make the basin plans more useful would be beneficial. The descriptive nature and focus of basin plans is useful, but the scope of work needs clarification and focus. Before planning commences, a clear description of the planning purpose, goals and expected benefits needs to be developed. This recommendation was suggested by a BAG member at BAG meeting No. 6.

Specific Gaging Need

There are 16,000 irrigated acres below the last stream gage in the Little Snake River and above the Colorado state line. The amount of return flows leaving the state are unknown, but need to be assessed. This data would assist with estimating actual depletions. A gage location which would provide this information was identified and a new gage requested by a BAG member during BAG meeting No. 6. Other locations where new gages might be installed to provide key data for water administration or for planning purposes should be identified.

Information

Develop case study information based on successful water development projects and make it available to others contemplating water storage or other development projects. It would be useful to prepare a document that outlines the steps, contact agencies, permits, costs, etc., that went into the High Savery Reservoir storage project. The case study should include sample purpose and need statements.

Simulation modeling

It is recommended that the state develop an extended time period simulation model of the Basin which can simulate dry conditions with a particular focus on Fontenelle Reservoir and compact implications. The benefit of the reservoir for meeting a “call” in any one year seems intuitively obvious given the present hydrologic patterns and demands. The firm yield of the reservoir during extended extreme drought should be quantified. This type of information would possibly assist with the marketing of the water as suggested by a BAG representative during the Stakeholder Survey. This modeling advancement would benefit from the expansion of data collection efforts described elsewhere in this recommendations section.

Groundwater Determination - Wyoming State Geological Survey

The information and data collected and interpreted in the Green River Basin Available Groundwater Determination Report (WSGS, 2008) is an extensive and valuable addition to the water planning process. The summary recommendation presented in that report is directed at preparing accurate inventories of groundwater production and use. The WWDC, in cooperation with the WSGS, might consider translating this recommendation into a specific description of what additional production and use data is needed, and why. If the State Engineer’s Office is not compiling this information, then a new project to do so should be considered.

Water Storage Opportunities Near Warren Bridge

The State of Wyoming and other agencies have studied water storage opportunities at many locations in the Green River Basin. A compilation of those studies has been prepared by the Dam and Reservoir Section at WDO. The subject of water storage and possibilities for hydroelectric power generation near Warren Bridge (Kendall sites) surfaces from time to time, and was most recently mentioned during the BAG process of this current plan. In 2007, WDO prepared a “white paper” presenting a summary of the agency’s best available information and opinion regarding feasibility of water storage at this location. According to that paper, projects at the Kendall sites would require extensive conveyance systems to deliver the stored water on the west side of the Upper Green River Basin, would have significant environmental permitting challenges, would impact permitted instream flow water rights and would be very expensive. Based on 2007 reconnaissance level estimates, Upper Kendall Reservoir costs include \$149,000,000 for construction of the dam and diversion structure, \$67,500,000 for canal construction and \$170,000,000 for tunnel construction, for a total of \$386,500,000. The Lower Kendall Reservoir costs include \$45,500,000 for construction of the dam, \$67,500,000 for canal construction and \$134,000,000 for tunnel construction, for a total of \$247,000,000. The paper essentially concludes that due to high costs, a project at this location should not be pursued with state funding, and that more cost-effective opportunities should be sought elsewhere. Given current conditions that conclusion is still valid.

Watershed Plans

Watershed plans for the Green River Basin should be completed at a pace of about one per year prior to the next complete update of the Green River Basin Plan. This may actually necessitate that two or more plans are prepared concurrently, by WDO staff or consultants. The future basin plan update may take on an entirely new character, as it is likely to be an assemblage of data from several watershed plans (BAG Meeting No. 5). The watershed planning projects need the support and input of local stakeholders.

Recommendations from the Augmentation Technical Memorandum

- Continue to monitor the flow augmentation studies and efforts of others, particularly in the Lower Colorado Basin. With time, water demand and the economics of augmentation may demonstrate that enhancing flows in river basins has a favorable cost-benefit ratio. Since Wyoming contains the mountainous headwaters of the Green River, the opportunities and economics for flow augmentation may differ from those found in other locations.
- Wyoming is well underway on evaluating cloud seeding as one technology to augment mountain snowpack. Both physical and statistical methods will be used to quantify any water supply increases. Based on the findings of the pilot study, the State of Wyoming will need to determine whether cloud seeding is a cost-effective long term strategy for augmenting flows in the respective basins and whether the program should be funded operationally.
- Since the current study was initiated in 2007, there has been a BAG discussion regarding the effects of the pine beetle on water supplies generated from forested land. A study is being performed at the University of Wyoming that addresses this issue (Impact of Bark Beetle Outbreaks on Forest Water Yield in Southern Wyoming, Ewers, Pendall, Williams, & Barnard). The results of this and other studies should be brought to the attention of Basin residents via a public outreach effort.

Recommendations from the Watershed Planning Technical Memorandum

- Watershed plans should reflect and follow the progression of resource elements used to describe the watershed.
- Watershed plans should provide a watershed management and rehabilitation plan including water storage, irrigation and upland water development opportunities and considerations. The study should review permitting and environmental considerations as well as project financing options, cost estimates and the ability of stakeholders to pay for project implementation.

- Recommendations should be offered as to specific opportunities for irrigation system rehabilitation, upland water development and surface water storage. Potential projects should be located with some conceptual design offered.

Recommendations from the Institutional Constraints Technical Memorandum

- Project proponents should clearly define the purpose of their project.
- Project needs should be defensible.
- Consider all reasonable alternatives and provide reasons for eliminating those that are not feasible. Prior to concluding that a reservoir or storage impoundment is required to meet water supply needs, be sure to fully evaluate other alternatives, including:
 - Aquifer storage
 - Groundwater
 - Non-jurisdictional impoundments
 - Less environmentally damaging alternatives
 - Multiple projects that achieve the same objective
 - Conservation / reuse
 - Individual alternatives or combinations

Recommendations from the Water Quality Technical Memorandum

- In areas where mineral development is prevalent, such as the Pinedale Field area, and where a water quality concern exists, ongoing data collection and evaluation would provide a scientific basis to determine to what extent, if any, the mineral development and the oil and gas industry disrupt or contaminate water sources.
- Develop more effective ways to disseminate water quality information and educate the public efficiently and effectively (i.e. newspaper announcements of public meetings, published literature centrally posted or delivered by mail, etc., more use of the Internet , particularly social networking applications like Facebook, Twitter, etc.).
- Continue preparation of the Green River Basin Plan as the foundation and framework guidance document needed to better plan and manage the water, ultimately improving water quality by understanding and correcting local water quality challenges.
- Fund additional storage as a way to improve water quality.
- Upgrade infrastructure, irrigation systems and irrigation practices to improve water quality by increasing efficiency through improved irrigation management techniques. Improved management techniques often reduce the

amount of chemicals applied to the land that eventually reach nearby waterways.

Recommendations from the Water Conservation Technical Memorandum

- Support local efforts and initiatives toward water conservation, particularly as irrigation districts consider conveyance improvements which may be beyond their means financially but of benefit to the Basin as a whole.
- Make conservation an opportunity that is evaluated in Wyoming Water Development Commission municipal master plans and watershed planning studies.
- Monitor the conservation studies and efforts of others, particularly in the Lower Colorado River Basin.
- Widen public education and outreach programs. In some cases, local conservation efforts could avoid or delay the need for capital projects.

Recommendations from the Climate Technical Memorandum

- The state should remain financially and technically committed to maintenance of the five Automated Weather Data Network (AWDN) climate stations recently established in the Basin. These stations were installed to support the Colorado River Compact Administration Program and are a significant step toward addressing the most obvious need in the Basin, which is for high quality instrumentation to allow observation of wind, solar radiation, humidity, and soil moisture. These are critical to developing realistic estimates of crop consumptive use and are integrated with an effort to bring new technologies to that task. In addition to their use in consumptive use estimation, these stations can support a variety of applications such as drought monitoring, renewable resources development, irrigation scheduling, and crop protection.
- The state should continue to participate in the National Integrated Drought Information System (NIDIS) through the State Climatologist's Office, and in particular, contribute to the Upper Colorado River Basin (UCRB) subgroup's efforts to develop a basin-focused drought monitor. As soil moisture data becomes available via the new AWDN stations, that information could be incorporated into the drought status reporting.
- The state should monitor progress and outcome of the NIDIS gaps assessment report, as well as the U.S. Climate Reference Network (USCRN) program density study, and pursue establishment of a USCRN station in the Basin. In high-relief areas like the Green River Basin, correlation between reference stations outside the Basin and other stations within the Basin are not expected

to be strong. Establishment of a local high-quality station will help with all of the climate-related analysis that is currently done. The primary objective of USCRN, however, is to help understand long-term changes in climate, and the network is to have a 50 to 100 year life span. The station could eventually be instrumental in downscaling global climate models, which are currently on a scale that does not differentiate between conditions at Lander and conditions at Pinedale, for instance. One criterion for USCRN site selection is proximity and correlation with HCN stations; that requirement suggests a USCRN station near Pinedale.

Conjunctive Use

Specific recommendations to conjunctively manage groundwater and surface water supplies cannot be made without defining or describing the water supply/water quality problem that needs to be addressed. However, it may be possible to identify specific areas in the Basin where this approach may be more promising than others. Akin to a reservoir siting exercise where certain specific attributes are better (e.g. valley cross section geometry), a conjunctive use project also has site considerations that are more favorable at some locations than others (e.g. good geology for storing water and surface water supply to store). A map of the Basin should be produced identifying the ten best places to look at the conjunctive use concept in more detail.

Data Needs

The Availability work in Chapter 7 can be improved with more and better data. The following suggestions were provided by AECOM. AECOM was a subcontractor to WWC Engineering and responsible for determination of water availability in Chapter 7.

- The Little Snake River at Dixon has space in some recent Hydrographer's Report, but no data. There is some question as to whether the station is in place. The filling equations are adequate for winter months but appear to underestimate summer months.
- Throughout most of modeling period, there are only Henrys Fork data at Manila and no gage data at all from 1994 through 2001. This means that hydrology is almost completely estimated from data for late 1940's through about 1962. Seven gages have records for the period 1949 through 1954, 6 gages 1955 through 1962, 4 gages 1963 through 1971, 1 or 0 gages 1972 through 2007; more gages would make estimates of water availability in this area more accurate.
- In the Eden Project area the entire Big Sandy tributary was left out of the Green River model because the existing gage records didn't make sense, and significant pieces of the picture were missing entirely. Diversions off river to Big Sandy and Eden Reservoirs, reservoir contents, deliveries from the reservoir, and return flows via tailwater drainages would all help resolve the

water availability more accurately in this area. That whole system should be instrumented, as least from the perspective of being able to be modeled.

- Abundant diversion data (Blacks Fork, Little Snake River, and maybe the Big and Middle Piney Creeks) should be digitized and reduced to monthly volumes. This data also must have start and end dates. There is also very little new diversion data in New Fork (District 7).
- The ongoing DSS study should consider performing a refined gaging station analysis to identify where and what types of gages would be most useful to meeting the current planning goals of the WDO and water administration goals of SEO. The area of analysis should focus on the west side of the Basin, especially those areas that appear to have promise for water storage projects.

8.7 REFERENCES

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