TECHNICAL MEMORANDUM

SUBJECT: **Green River Basin Plan**
Water Conservation
PREPARED BY: Wyoming State Engineer's Office, States West Water Resources

Introduction

The purpose of this memorandum is to discuss water conservation issues. The Wyoming State Engineer's Office actively gathers information for public use regarding water conservation programs. State and federal funding is available for various conservation programs. As the leading use of water in the state is irrigation, a majority of these programs targets irrigation efficiencies. One technique to conserve irrigation water is the conversion from uncontrolled flood irrigation to sprinkler irrigation. This memorandum discusses two conversion projects.

State Water Conservation Program

(Note: This section contributed by Ron Vore and Sue Lowry of the Wyoming State Engineer's Office.)

Introduction

Conserving water is a function of water management. It is a tool to help meet the demands society places on a finite supply of water. Saving water is not necessarily simply the result of water conservation implementation but is also the outcome of water management influences related to history, custom, culture, and politics. As such, conserving water is not only an activity involving irrigation efficiency, low-flush toilets, and xeriscaping but an idea regulating growth, development, and environmental mitigation.

Water conservation is not a new idea. It has been practiced as a tool for managing scarce water resources from the initial beneficial use that water was put to in Wyoming's arid environment. Conserving water has transcended from a time when water use was a survival issue to a time when economic considerations predominate. It has evolved from a time when efficient water use was a necessity of living to a time when water allocation is an ethical and political consideration.

Water in Wyoming was initially used for development of the extensive natural resources available to early settlers. Putting ample reserves of water to work raising crops, mining ore and moving materials was the foundation of early water allocation. More recently, as this resource has become more fully allocated, water conservation is being looked to for meeting rising demands. Population growth, community change, environmental mitigations, and other state and regional issues are influencing water conservation efforts.

With these issues in mind, the Wyoming State Engineer's Office, in participation with the U.S. Bureau of Reclamation, is developing strategies and options for a water management and conservation program for the State of Wyoming. The intent of this effort, initiated August, 1998 is to research, document, discuss, and organize water management and conservation information which will ultimately be available to water users and the public for use in making decisions relating to voluntary water conservation implementation.

The objectives of the water management and conservation program are as follows:

- address water conservation practices for agriculture, municipalities, industry, and fish and wildlife,
- investigate water conservation strategies most beneficial to irrigation districts, land owners, municipalities, industry, and fish and wildlife,
- evaluate methods and types of water conservation measures,
- analyze ramifications of implementation of water conservation measures,
- evaluate impacts to surface and ground water by water conservation measures,
- identify sources of assistance for implementing water conservation practices,
- research water law and regulations in Wyoming and other western states for options providing incentives that encourage wise use.

The efforts of the water management and conservation program have been developed and driven within the context of the intent of this program and relate to the objectives stated above. All efforts have been performed under two overriding themes. The first is that the no-injury principle would continue to be applied by the State Engineer and the State Board of Control in any water rights transactions. The second is that all water conservation activities would work within the doctrine of prior appropriation. Specific activities undertaken to address these issues are research and review of information sources, public outreach, program coordination, state water planning participation, and an evaluation of western state's water statutes.

Public Outreach: Water conservation is an issue that is addressed by a State of Wyoming Water Planning Questionnaire survey conducted in 1997. The development of strategies to increase water conservation and reuse is considered to be very important to over 75 percent of survey respondents. Needs assessment, identification of future water use opportunities, participation interest, potential impacts and ramifications of water management change, and incentives are all issues and concerns relative to water conservation. These issues, and others, have been and continue to be discussed in public settings in order to stimulate interest in this program and to receive feedback and direction from the water using public.

Program Coordination: Irrigation, livestock water, municipal use, industrial demands, and fish and wildlife interests continue to be primary uses of Wyoming's water resources. Also, advances in water management and subsequent water conservation have been and continue to be incentive driven. These issues, coupled with increasing project development and implementation costs, emphasize the need for program coordination. Identification of interest in water conservation program participation by agencies and water users is an important strategy of this effort. A product resulting from this effort is the Water Management and Conservation Assistance Programs Directory publication. This is a compilation of local, state, and federal agency and organization programs that provide planning, technical, and financial or administrative assistance in an introductory context. This information is available in hard copy or can also be accessed through the World Wide Web at **http://seo.state.wy.us**.

State Water Planning: Almost 84 percent of the respondents to the 1997 State Water Planning Questionnaire survey agreed that water conservation efforts should be assessed in a statewide water plan. Therefore, the water management and conservation program has been involved in the statewide water planning process. This water conservation component to the water plan is available for consideration by the Basin Advisory Groups for their review and discussion concerning water management and conservation opportunities within their respective basins.

Legal Topics Review: Conservation is a recognized and accepted practice of water management. Water conservation has been implemented as advances in technology progress and economics allow. Conservation has been and continues to be incentive driven but there is little motivation for conserving unless a benefit for that effort can be realized. Current state law is restrictive to water conservation, reuse and salvage opportunities for water right holders with an interest in these pursuits. Other western states have addressed some of these institutional issues relative to water use, conservation and reuse. As such, it is of value to the water management and conservation program to identify, review and evaluate neighboring programs, projects and efforts that have attempted to address this issue. Through this process, potential changes in the institutional aspect of Wyoming water administration may be developed that will be of benefit to the water resource of the state.

Water Conservation Concepts

Water use in Wyoming is a reflection of contrasts. Each of the major river basins is unique and diverse. Within reaches of stream and river systems that make up the natural water conveyance of basins differences in water generation, diversion, storage, and use are found. Given these disparities, water conservation takes on different meanings depending upon many factors. As municipal and industrial uses of the state's water supply are minor, this discussion concentrates on agricultural water use. As such, it is necessary to look at water conservation in Wyoming as two concepts, irrigation application efficiency and riparian maintenance. These concepts are viewed differently by irrigators in the high elevation areas of the state where the primary crop is one cutting of meadow hay. The more intensive row-crop agriculture parts of the state have different water conservation needs.

Irrigation Application Efficiency: A significant loss of water in the irrigation system in Wyoming is attributed to conveyance. Generally, conveyance canals and ditches are unlined dirt construction through a variety of soils found in the state. Many of these soil types are not conducive to sealing and therefore allow for potential loss through seepage. In some instances, losses of up to 40 percent have been determined. Calculations of conveyance loss show actual losses of from 0.27 to 2.89 acre feet per linear foot of canal. Lining of canals and ditches is an effective and economical means of reducing conveyance loss when compared to new storage development. Concrete, PVC incorporation, fabrics, and lining with other materials are techniques used for dealing with conveyance loss. Additional benefits to implementation of these water conservation measures are reduced maintenance, drought impact insurance, and improved water quality delivered to the farm.

Additional irrigation application measures that conserve water are sprinkler irrigation which provides a 25 percent increase in efficiency compared to flood irrigation. Another 10 percent increase in efficiency can be gained by low pressure sprinkler application. Additional benefits to sprinkler irrigation include savings in labor and reduced power requirements for low pressure systems. Other water savings technology includes automated diversions, gated pipe application, and surge valves. Management strategies such as cropping systems featuring low consumptive irrigation requirement crops, application of soil amendments, and irrigation scheduling are considerations for reducing water use on farms.

Riparian Maintenance: Wyoming is predominated by rangeland. This is a resource that produces forage for livestock grazing and wildlife habitat. However, riparian zones are critical to this forage resource as they produce a significant portion of total forage availability. Riparian zones produce both standing seasonally grazed forage and annual hay production that is processed and stored for winter feeding. As such, many of the state's upper basin reaches are recognized as man-made riparian areas due to the diversion of stream flow during periods of spring run-off. This extensive flood irrigation provides a water storage function, allows for later season return flow, maintenance of stable stream characteristics, and contributes to improved water quality through energy dissipation and sediment trapping. It also provides opportunity for diversity of plant communities and maintenance flows that subsequently provide for excellent fishery habitat.

Riparian maintenance in many upper basin reaches is a function of irrigation. Diversions from mountain fed streams during 30 to 40 day run-off periods in the spring provide stream bank storage for water that otherwise would remain in the channel in uncontrolled release. This water, when spread over the land surface adjacent to rivers, streams, and creeks loses velocity, dissipates energy, drops sediment and percolates into the alluvium. A portion, approximately 25 percent, is consumptively used for forage production. The remaining 75 percent is returned to the system either as overland return flow, accounting for 42 percent, or underground flow, accounting for 33 percent. The entire alluvial aquifer acts as an underground water storage reservoir that can store as much as 1.33 acre feet of water per surface acre of land.

Riparian maintenance through upper basin flood irrigation and the resultant return flows provide beneficial use for the downstream system by reducing high spring flow to a slower, more constant rate over a longer portion of the year. Alluvial aquifer storage is beneficial by reducing evaporation loss, provides opportunity to use and re-use a finite resource numerous times thus increasing efficiency, provides forage production on the land surface, and provides storage, delayed release, and regulated flows without expensive water storage construction. As a result of continuous diversion application, as has been the case for generations on many of Wyoming's upper basin reaches, stream systems have reached dynamic equilibrium. Dynamic equilibrium is a point of stability reached where stream width and depth remain relatively unchanged and reflect the maximum stream flow velocity that the channel has had to carry. The result is a stable functioning stream system that provides diverse riparian vegetation, exhibits little or no stream bank erosion, has few or no active bedscarps and minimal sediment loading. Large scale changes in the management of the water resource in these stretches can alter the dynamic equilibrium resulting in change to the appearance and quality of the stream system.

Additional valuable upper basin reach water conservation practices include beaver dams and other small water impoundments such as stock ponds, grazing management to enhance riparian condition, and snow harvesting to increase water production resulting from winter precipitation. Other land based treatments such as forest timber management, phreatophyte management, and deep rooted perennial plant control such as sage brush and salt cedar can result in increased water production within watersheds.

Summary

A challenge to meeting water use demands in Wyoming with water management and conservation programs will be to find a balance between consumptive and non-consumptive uses. To make this a reality in this state of such diverse water basins and uses of a finite water resource will require several things. First, it is important to recognize the value of historical uses to the state, not only the contributions made to our rural population and the environment but to the economic base of the state which continues to be primarily agrarian. On the other hand, it is also important to recognize that as our communities change, so do the values given to the water resources in our streams and valleys.

Water rights are recognized as valuable property rights in the arid west. It is also important to understand that solutions to these issues are complex and that management changes can result in impacts and ramifications that alter the natural or induced functions of rivers, streams, and creeks.

Case Study – Big Sandy River

Introduction

The predominant form of irrigation in western Wyoming is flood irrigation. Uncontrolled flood irrigation, however, is known to be an inefficient irrigation practice, and conversion to sprinkler irrigation can save water. Various projects around the state have converted flood irrigated land to sprinkler irrigated land. One such project exists in the Big Sandy River Basin. Since 1989, federal assistance has helped operators in the Farson/Eden area convert from flood irrigation to border and row or sprinkler irrigation techniques. These changes stem from the desire to reduce long-term salinity contributions to the Big Sandy River and, ultimately, the Colorado River System. Flood irrigation is suspected as the culprit in historically high deep percolation rates in the Eden Valley area, a phenomenon suspected in causing increased salt loading to the downstream system. Further detail is provided in the Technical Memorandum entitled “Colorado River Basin Salinity Control Program” (Tyrrell, 2000).

It is felt that conversion from traditional flood irrigation to border and row irrigation and center-pivot sprinklers has had a water-saving effect in the valley. Since 1989, approximately 8,680 acres of the 18,370 acres in the unit have been treated by changing irrigation techniques. To determine if the water conservation effects could be quantified, a review of existing hydrologic records was performed.

Records analysis

Data from four USGS gaging stations were evaluated to estimate conservation efforts. The Big Sandy River Above Farson gage (number 09213500) is located upstream of the project. The Big Sandy River Below Farson gage (number 09215550) is located downstream of the project. The Big Sandy River at Gasson Bridge gage (number 09216050) is located below Eden, after the Big Sandy River collects water from several other tributaries. The Green River at Warren Bridge gage (number 09188500) is located in the northern part of the Green River basin near Daniel. The Green River gage was used as a “control” comparison to evaluate if low/high flows are due to a dry/wet period of time. The Gasson Bridge gage was used because it is downsteam of all project effects and may show net project effects. The data were split into two groups: the Pre-1989 (June, 1981, to September, 1989) data represent the period of time before initiation of the project, and the Post-1989 (October, 1989, to September, 1999) represent the period of time during irrigation conversion.

The following relationships were graphically compared:

1) The monthly and annual flow volumes at the Big Sandy River below Farson gage were plotted for each year. The average total flow for each year and month during the Pre-1989 and Post-1989 periods were then calculated and plotted. These comparisons aimed to evaluate whether less water was being used from the river system after conversion to sprinklers.

2) The total annual total flow volumes for one gage versus the other for the following combinations were compared for both the Pre-1989 and Post-1989 periods: Green River at Warren Bridge versus Big Sandy River Below Farson; and Big Sandy River at Gasson

Bridge versus Big Sandy River Below Farson. These comparisons evaluated whether the flow in the Big Sandy River changed in comparison to the flows at the lesser affected gages.

3) The total annual flow volume for each year and average for the period for the above mentioned combinations were also compared. (Figures 1 and 2) Again, these comparisons evaluated whether the flow in the Big Sandy River changed in comparison to the other gages.

Conclusions

No conclusive evidence of water savings was seen in this analysis. While the Big Sandy River gages showed less water in the river below the project after implementation of the project, this could to be due to a "dryer" period of time in the Big Sandy sub-basin, as evidenced by the Warren Bridge gage. The reduction in flow appears to be less just below the project than further downstream, but the difference is very slight. A more successful analysis of the data would involve a comparison of the gages immediately above and below the project, but year-round data were not available for the upper gage. A major complication in attempting to quantify the water savings is that the conversion to sprinklers has been very gradual and is still on-going. Therefore, significant "post-project" records are not yet available.

A case study on the effectiveness of conversion to sprinkler irrigation with ample data do exist for the Salt River basin. The Salt River case study, as discussed below, differed from the Big Sandy in that more extensive records were available, the conversion to sprinklers took place over a relatively short period of time, and more than eight years of records were available for the time after completion of the project. The general methodology for the Big Sandy and Salt River studies are similar.

Case Study – Salt River Drainage Basin (Star Valley Wyoming)

Introduction

The Salt River basin drains approximately 829 square miles, with approximately 60,000 acres (94 mi^2) of irrigated land. During 1971-1974, approximately one-half of the irrigated acres in the valley were converted to sprinkler irrigation. A study presented in July, 1985, discussed the hydrologic impacts seen downstream of the project (Sando, 1985).

Statistical Analysis and Conclusion

An evaluation of gaging station flow data was performed for the Salt River and Greys River, both for the "pre-sprinkler" period and the "post-sprinkler" period. The Greys River basin is adjacent to and northeast of the Salt River basin. It is approximately half the size of the Salt River basin, and contains very few irrigated acres. However, the climate and run-off characteristics are comparable. The Greys River data were used to help determine if any changes in river flow were due to changes in climate (i.e. a "wetter" or "dryer" period). The "pre-sprinkler" period is defined as October, 1953, to April, 1971, and the "post-sprinkler" period is defined as May, 1971, to September, 1982 (Sando, 1985).

A comparison of the flows in the Salt River after completion of the project showed significantly higher monthly flow volumes during spring and early summer, slightly higher flows in late summer and fall, and slightly lower flows in winter. The flows were as follows (Sando, 1985):

	Mean Flow (AF)		
	Pre-Sprinkler	*Sprinkler*	*Percent Change*
October	37,466	39,188	+4.6
November	35,174	35,579	+1.2
December	32,310	31,987	-1.4
January	28,154	27,528	-2.4
February	25,165	24,097	-4.3
March	26,700	30,293	+13.5
April	51,641	56,932	+10.2
May	88,422	130,329	+47.4
June	34,492	109,559	+69.9
July	45,532	64,244	+41.1
August	38,396	41,136	+7.1
September	38,614	40,531	+5.0

An evaluation of the flows in the Salt River versus the flows in the Greys River was then performed. The analysis concluded that, as the total annual flow volume in the Greys River increased, the increase in flow in the Salt River was greater after the conversion to sprinklers than before. This suggests that more run-off (and therefore river flow) exists after the project, even when factoring in climate changes (Sando, 1985).

A study of annual flood peaks was also performed. The 50-year recurrence flood flow for the pre-sprinkler period was calculated from Log Pearson III distribution curves. An inspection of the flow data after sprinkler conversion revealed that this 50-year flood flow was exceeded in seven of the 12 years. The probability of that happening without outside influence was found to be approximately one in 225. When comparing floods of varying recurrence intervals, it was found that the flows were greater in the post-sprinkler period than pre-sprinkler for all recurrence intervals greater than 4 years (Sando, 1985).

An investigation to determine if other factors, such as climate or development, influenced the changes in river flows was completed. This study determined that there were no other significant changes in hydrologic conditions (Sando, 1985).

Water Conservation Opportunities

In addition to improved irrigation practices, other opportunities exist for more efficient water usage. One of these techniques is to improve the means of conveyance of water from the streams to the point of usage. Conveyance losses were mentioned earlier as a major factor in contributing to inefficiency in agricultural use. Many ditches and canals in the basin experience higher than normal conveyance losses. This is generally due to porous soils. Lining with concrete or other material can greatly reduce the amount of flow lost to the surrounding soils.

Losses in irrigation ditches and canals are considered normal, or typical, if they in the range of 10 percent. Ditches and canals in sandy, cobbled, or alluvial soils, or fractured rock, where losses exceed 10 percent are potential candidates for rehabilitation. The ditches within the basin that experience greater than 20 percent losses and may warrant consideration for improvement are:

Ditch	*Source*	*Reported Losses (percent)*	*Ditch Length (miles)*	*Permitted Flow (cfs)*	*Permitted Acres*
Utah-Wyoming Number 2 (last 1/2)	Black's Fork River	95	50	13.26	927.95
Anderson and Howard (first 1/3)	LaBarge Creek	60	15	45.02	3,163.41
Interstate Canal	Burnt Fork	50	Unknown	Utah permits for 5813.34 AF	
Converse Ditch	West Fork New Fork River	50	11	24.85	1,742.00
East Fork Canal	East Fork New Fork River	40	8	26.10	1,830.00
Highland Canal (first 1/2)	Pine Creek	40	22	83.06	5,847.56
Eden Canal	Big Sandy River	30	10.8	114.29	8,007.64
Milich	East Fork Smith's Fork Creek	30	20	59.76	4,179.47
Pine Grove Canal	Black's Fork River	25	25	88.31	6,185.93
Uinta Number 3 Canal	Black's Fork River	25	25	57.13	4,000.03
Boulder Canal	Boulder Creek	25	14	142.27	9,972.57
Pole Creek Number 2	East Fork New Fork River	25	3	25.98	1,820.00
Apex	Green River	25	3.5	54.00	3,783.50
Ashley-Wolf (first mile)	Green River	25	3	15.62	1,102.00
Moore and Bagley	Ham's Fork	25	15	10.80	756.00
Continental Divide	Little Sandy Creek	25	8	13.25	927.50
Davis and Company	Smith's Fork Creek	25	8	26.66	1,868.54
Yankee (first mile)	South Piney Creek	25	4.5	19.64	1,074.38

References

Sando, Steven K., John Borelli, and Donald J. Brosz, Hydrologic Impacts of Improved Irrigation Efficiencies, Proceedings of the Specialty Conference "Development and Management Aspects of Irrigation and Drainage Systems", IF Div., ASCE, San Antonio, TX, 1986.

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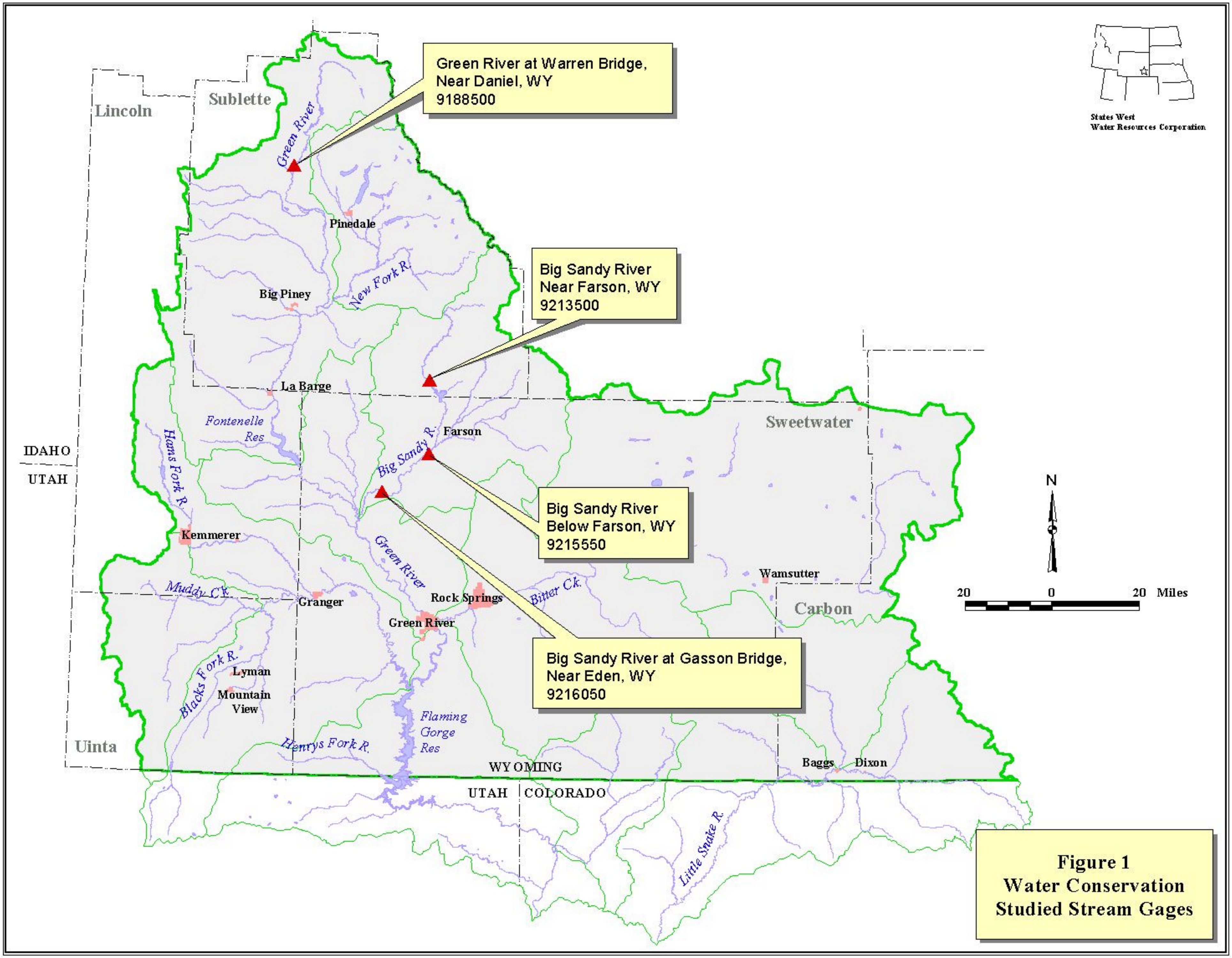

Figure 1
Water Conservation
Studied Stream Gages

Figure 2: Annual Flow Volume Comparison
Big Sandy River at Gasson Bridge and Big Sandy River Below Farson

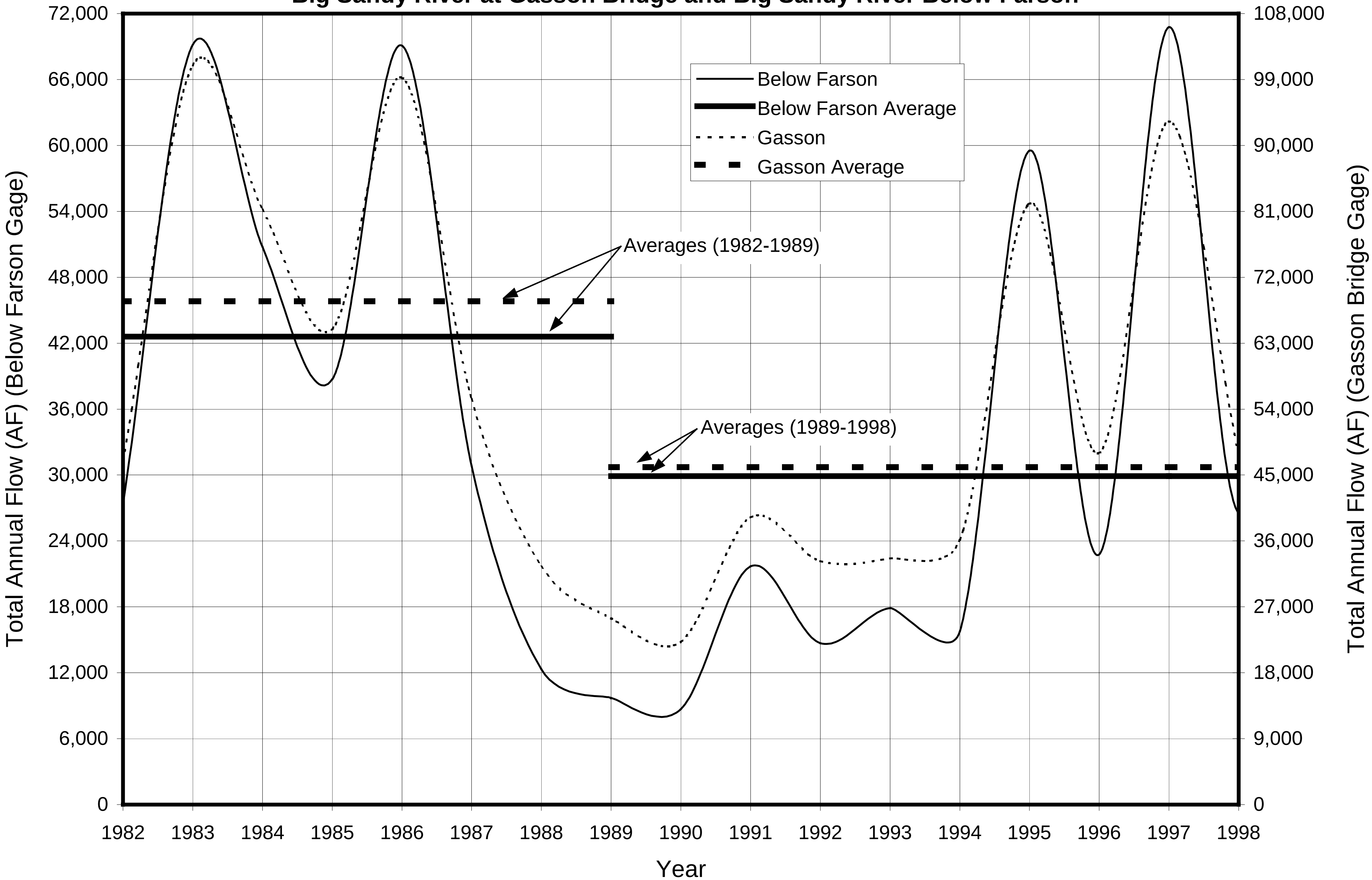

Figure 3: Annual Flow Volume Comparison
Green River at Warren Bridge and Big Sandy River Below Farson