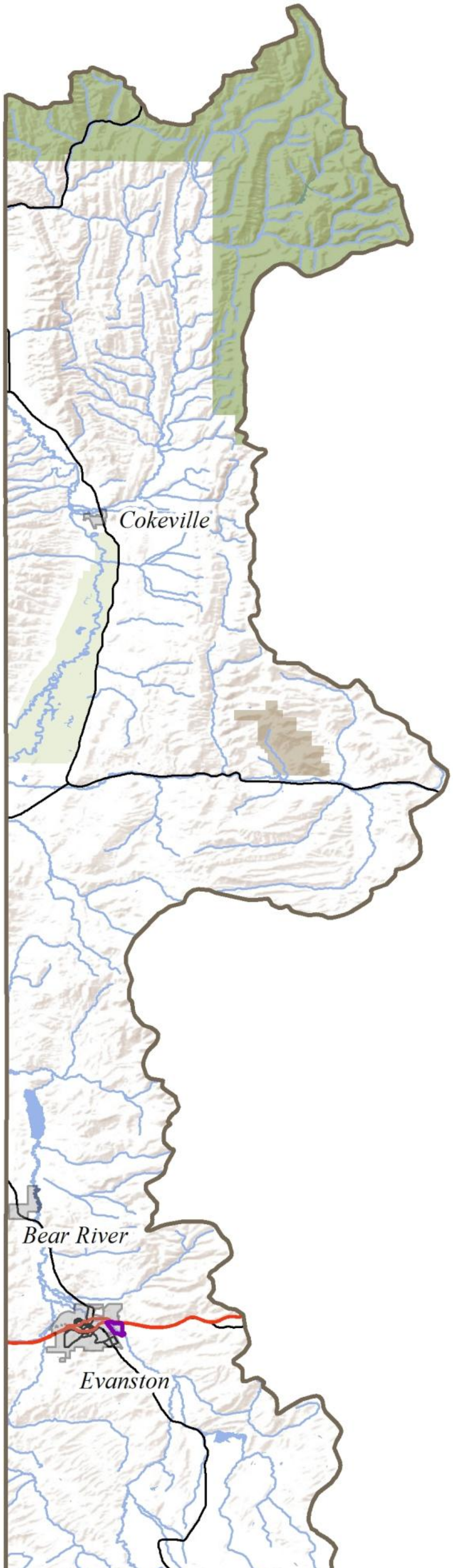

VOLUME 1

2011 BEAR RIVER BASIN PLAN UPDATE

JUNE, 2012

PREPARED BY:

THE STATE OF WYOMING

Water Development Office

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Prepared by Water Development Office staff with assistance from State Engineer's Office staff and University of Wyoming, Water Resources Data System staff

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LIST OF ACRONYMS

AF ....Acre-Feet

AFY......................Acre-Feet per Year

AIEAD ....Wyoming Department of Administration and Information, Economic Analysis Division

AUM ....Animal unit months

BAG ....Basin Advisory Group

Basin ....Bear River Basin

BLM.....................United States Department of the Interior, Bureau of Land Management

cfs.........................Cubic feet per second

CU ....Consumptive use

DEQ ....Wyoming Department of Environmental Quality

EPA ....United States Environmental Protection Agency

F ....Fahrenheit

GFD......................Wyoming Game and Fish Department

GIS ....Geographic Information System

gpcpd....................Gallons per capita per day

gpm ....Gallons per minute

GPS ....Global positioning system

IWR......................Irrigation water requirement

JPB ....Joint Powers Board comprised of the town of Bear River and the North Uinta County Water and Sewer District

lbs.........................Pounds

MGD ....Million Gallons per Day

MW ....Megawatts

NEPA ....National Environmental Policy Act

NOAA ....National Oceanic and Atmospheric Administration

NWI......................National Wetland Inventory

PFW .....................U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program

RAS......................BLM's Rangeland Administration System

Refuge ....Cokeville Meadows National Wildlife Refuge

SEO ....Wyoming State Engineer's Office

States West...........States West Water Resources Corporation

TDS.......................Total dissolved solids

TMDL..................Total daily maximum load

TU.........................Trout Unlimited

USDA...................United States Department of Agriculture

USFS....................United States Forest Service

USFWS/FWS.......United States Fish and Wildlife Service

USGS...................United States Geological Survey

WDC....................Wyoming Water Development Commission

WDO....................Wyoming Water Development Office

WNRT..................Wyoming Wildlife and Natural Resources Trust

WQD....................Wyoming Department of Water Quality, Water Quality Division

WRDS..................Water Resources Data System

WSGS..................Wyoming State Geological Survey

1.0 INTRODUCTION

1.0 INTRODUCTION

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1.0 INTRODUCTION

1.1 OVERVIEW

The 1999 Wyoming Legislature approved the river basin planning framework and authorized the Bear River and Green River Basin Plans. The planning framework was developed through a program initiated in 1996 to establish a continuing water planning process for Wyoming. The continuing planning process was established to keep river basin plans and state water planning current through review and revision of plans on a periodic basis.

At the initiation of the river basin planning process, the state was divided into seven river basins (Figure 1-1). The planning process was started in 1999 and the final basin plan of the first round of planning was completed in 2006. The Wyoming Framework Water Plan, which combined the seven individual basin plans into a single statewide perspective and set guidance for further basin planning, was completed in 2007.

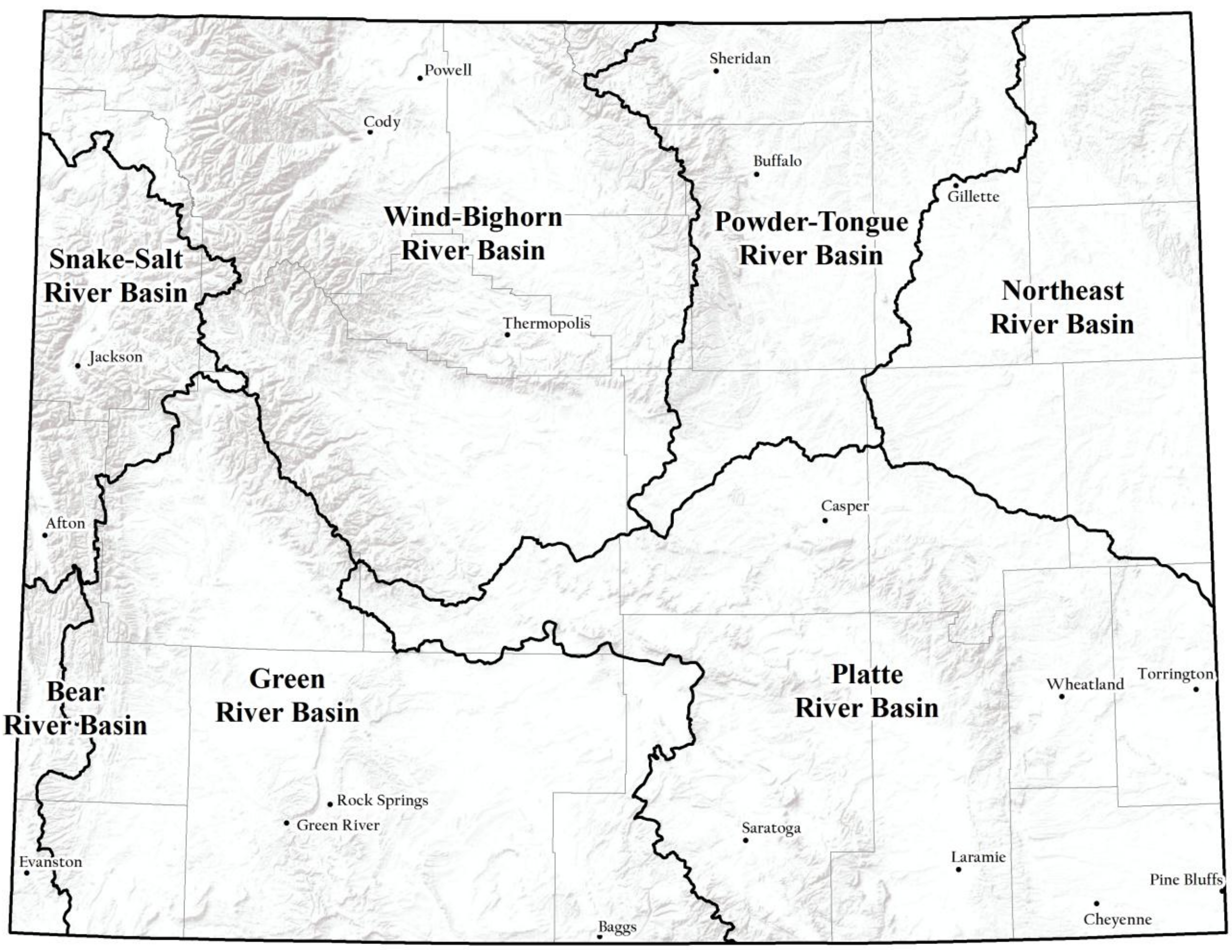

Figure 1-1: Wyoming River Basin Planning Program Basins

The first Bear River Basin Plan was completed in 2001 and has been a low priority for updating because little demographic change has occurred within the Bear River Basin (Basin). However, because the plan was one of the first water plans conducted, it was determined that an update of the plan would be prudent. The update was conducted by a team of professionals with the Wyoming Water Development Office (WDO), the Wyoming State Engineer's Office (SEO), and the University of Wyoming, Water Resources Data System (WRDS).

This update will not totally replace the 2001 plan or the supporting technical memoranda, but will provide updated information and make recommendations for the collection of additional information and data to appropriately keep the plan current. The update will provide new and updated information for as many portions of the plan as possible.

1.2 BASIN ADVISORY GROUPS

As part of the river basin planning outreach and public involvement processes, Basin Advisory Groups were developed. Basin Advisory Groups are made up of interested citizens, federal and state agency personnel and special interest group representatives. These groups were established in each of the seven major river basins in Wyoming and have been an important part of the planning process providing local concerns and information to the planning teams. Presentations and discussions of local issues were conducted in each basin.

The mission of Basin Advisory Groups is to assist the WDO and the state planning team by identifying water related issues, problems and concerns in the individual river basins. Through public participation, the group advises the WDO and the planning team on local issue priorities, data needs, and regional concerns. Basin Advisory Groups also assist the planning teams and local officials through review of basin planning products.

The Bear River Basin Advisory Group was first assembled in 1997 as part of the river basin planning process feasibility study (Boyle Engineering, 1998). The group members represented agricultural, municipal, industrial, recreation and environmental water uses within the Basin. The meetings were open to the public, and participation was good. Currently, the Bear River Basin Advisory Group is an *ad hoc* group with participation from most water use sectors and the public.

Several meetings were held to discuss the plan update. The Basin Advisory Group and public will have an opportunity to review and comment on the report. A meeting will be held to discuss the report and recommendations.

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Several meetings were held to discuss the plan update. The Basin Advisory Group and public will have an opportunity to review and comment on the report. A meeting will be held to discuss the report and recommendations.

1.3 REPORT ORGANIZATION

This Bear River Plan Update is presented in two volumes. Volume 1 is comprised of the report and Volume 2 is made up of the updated technical memoranda. The report is organized into nine chapters and follows the outline established in the Wyoming Framework Water Plan (WWC, 2007). References are presented at the end of each chapter for the reader's convenience. A summary of the report chapters, except this chapter (Chapter 1), is presented below:

> Chapter 2 Presentation Tool, describes the online report and web-based tools that are available along with a brief description of other documents, tables and maps that are available online. This chapter also provides a listing of appendices and technical memoranda associated with this report.
>
> Chapter 3 Setting, provides a physical description of the Basin, a discussion of Basin economics and population, a discussion of compacts and legal constraints, and a discussion of recent studies and projects conducted in the Basin.
>
> Chapter 4 Water Resources, presents the Basin's total supply of surface water and groundwater and the quality of these resources.
>
> Chapter 5 Current Water Use, quantifies Basin water use in consumptive and non-consumptive sectors including agriculture, industrial, municipal, rural domestic, environmental and recreation.
>
> Chapter 6 Water Use Projections, provides estimates of future water uses for the Basin for all use sectors. The estimates are prepared for two different projected growth scenarios.
>
> Chapter 7 Water Availability, presents estimates of the amount of water remaining for development considering the growth scenarios presented in Chapter 6.

Chapter 8 Basin Issues, Strategies, and Water Use Opportunities, discusses Basin issues identified by the Basin Advisory Group (BAG) and strategies developed with the BAG. In addition, water use opportunities, which would help meet water demands within the Basin, are discussed.

Chapter 9 Program Strategies and Recommendations, summarizes proposed program strategies that will guide further river basin planning in the Wyoming portion of the Bear River Basin. Recommendations for further work and data collection within the Basin are also presented.

There are also two appendices included as part of the report. Appendix A presents the Framework Water Plan Tables, which were developed as part of the 2007 Framework Water Plan (WWC, 2007). These tables were designed to be updated as new information becomes available and are available online at the water planning web site [http://waterplan.state.wy.us/plan/statewide/tables/tables.html]. Appendix B presents the Wyoming Department of Environmental Quality, Water Quality Division, Wyoming Surface Water Classification List, which is referenced in Chapter 4.

Two references used often and throughout the report, and which may not be fully cited each time are the Bear River Basin Water Plan Final Report (Forsgren Associates, Inc. 2001) and the Wyoming Framework Water Plan, Volumes I and II (WWC Engineering, Inc. 2007). These reports may be referred to in various ways including but not limited to: the 2001 Bear River Basin Plan, the 2001 Basin Plan and the 2001 Plan; and the 2007 Framework Water Plan and the 2007 Framework Plan. Appropriate citations are presented in the references section.

REFERENCES

Boyle Engineering 1998. State Water Planning Process Feasibility Report. Prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming.

Forsgren Associates, Inc. 2001. Bear River Basin Water Plan, Final Report. Prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming. Prepared in association with Anderson Consulting Engineers, Inc; Leonard Rice Engineers, Inc.; and BBC Research and Consulting.

WWC Engineering, Inc. 2007. Wyoming Framework Water Plan Volume I, and Volume II Planning Recommendations. Prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming. Prepared in association with Hinckley Consulting; Collins Planning Associates; Greenwood Mapping, Inc.; and States West Water Resources Corporation.

2.0 Presentation Tool

2.0 PRESENTATION TOOLS

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2.0 PRESENTATION TOOL

This Bear River Plan Update is available to view and download at http://waterplan.state.wy.us/plan/bear/bear-plan.html. In addition to the final report, technical memoranda, hydrologic models and related GIS data are also available for download.

2.1 SEARCHING

The *Water Search Engine* (http://waterplan.state.wy.us/sites.html) may be accessed from the Wyoming State Water Plan website. This customized Google search engine allows users to search the State Water Plan and the Wyoming Water Development Commission (WDC) websites for information related to river basin planning, WDC reports, and other documents and data housed by the WDO and WRDS.

2.2 DATABASE TABLES

Data presented in the 2007 Framework Water Plan represent values compiled from the seven individual river basin plans created during the first round of basin planning (1999-2006). Twenty-one data tables from that plan were revised with new values derived from the Bear River Basin Plan Update. These updated data tables, along with links to the values from the original plans are available at http://waterplan.state.wy.us/plan/statewide/tables/tables.html. The values in these updated tables represent the most recent data available at the time of publication. Those values that were revised after the completion of the Framework Water Plan are identified in red and the date of the update is given. Data tables comparing the 2001 data and 2011 data are presented in Appendix A.

2.3 MAPS

High resolution PDFs are available for all of the maps generated during the Bear River Plan Update. Viewing or printing the PDFs requires the Adobe Acrobat PDF viewer, which is available for free download at http://www.adobe.com/products/acrobat/readstep2.html.

2.4 TECHNICAL MEMORANDA CHANGES

During the review of the 2001 Bear River Basin Plan, it was decided that original technical memoranda that were unchanged would not be altered in the new document. These unchanged sections would be referenced in the body of the update and would refer the reader to the original technical memoranda. Technical memoranda that had substantive changes would be updated and revised. A summary of these changes is listed in Table 2-1 below. Two new technical memoranda were created for the update and they are also listed in Table 2-1. These new memoranda address climate and reservoir evaporation.

In some instances (i.e. municipal water use data) even though the technical memoranda were not changed, new and additional data were collected and analyzed. These data and analyses are discussed in the body of this report.

Table 2-1: List of Technical Memoranda from the 2001 Bear River Basin Plan

Tab	Title	Status
A	Wyoming Water Law Summary	Unchanged
B	Amended Bear River Compact	Unchanged
C	Surface Water Data Collection & Study Period Selection	Updated
D	Diversion Operation	Updated
E	Irrigated Lands Mapping	Unchanged
F	Water Rights Permits GIS Development	Unchanged
G	Crop Consumptive Use	Updated
H	Efficiencies & Return Flow Patterns	Unchanged
I	Storage Summaries	Updated
J	Municipal Water Use- Town of Cokeville	Unchanged
	Municipal Water Use- Town of Evanston	Unchanged
K	Industrial Water Use	Unchanged
L	Environmental Water Use	Unchanged
M	Recreational Water Use	Unchanged
N	Surface Water Quality	Unchanged
O	Groundwater Resources	Updated
P	Spreadsheet Model Development	Updated
	Use of Bear River Spreadsheet Model	Updated
	Surface Water Calibration	Updated
	Available Surface Water Determination	Updated
Q	Historic & Current Economic & Demographic Conditions	Unchanged
	Future Economic & Demographic Scenarios	Unchanged
	Future Water Demand Projections	Unchanged
	Future Recreational Demands	Unchanged
--	Climate	New
--	Reservoir Evaporation	New

REFERENCES

WWC Engineering, Inc. 2007, Wyoming Framework Water Plan Volume I, and Volume II Planning Recommendations. Prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming. Prepared in association with Hinckley Consulting, Collins Planning Associates; Greenwood Mapping, Inc.; and States West Water Resources Corporation. .

3.0 BEAR RIVER SETTING AND DESCRIPTION

3.0 BEAR RIVER SETTING AND DESCRIPTION

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3.0 BEAR RIVER SETTING AND DESCRIPTION

3.1 PHYSICAL DESCRIPTION

The Bear River Basin is located in northeast Utah, southeastern Idaho and southwestern Wyoming (see Figure 3-1). The Bear River is the largest tributary to the Great Salt Lake and its headwaters are in the Uinta Mountains of Utah. Several mountain ranges (Wyoming Range, Wasatch Range and Uinta Mountains) divide the Basin from the Green River Basin and other portions of the Great Salt Lake Basin.

3.1.1 LAND AREA AND OWNERSHIP

The entire Bear River Basin covers a total of approximately 7,500 square miles including 2,700 square miles in Idaho, 3,300 in Utah, and 1,500 (960,000 acres) in Wyoming (Utah Water Research Laboratory, 2011). In Wyoming, the federal government owns about 54% of the land. Approximately 38% is privately owned lands and the State of Wyoming owns about 8% of the lands. Figure 3-2 shows the distribution of land ownership within the Wyoming portion of the Basin.

3.1.2 PHYSIOGRAPHY AND TOPOGRAPHY

The Bear River Basin is primarily located within the Middle Rocky Mountains Province. The physiography of the Basin includes mountain ranges, hills, uplands, plains, and valleys of these two geomorphic provinces.

The Bear River Basin in Wyoming is made up of a series of north-to-south trending mountains, ridges, hills, plains, and valleys that express the underlying geologic structures of the Overthrust Belt and easternmost extension of the Basin and Range Province. In Wyoming, the stream drainages generally follow the north-south structural trend except some reaches of Twin Creek, Smiths Fork, Water Canyon Creek, and Thomas Fork where portions of these streams cut across the structural trend.

The topographic elevations of the Bear River main channel, within Wyoming, range from a high of about 7,772 feet above mean sea level where the Bear River enters Wyoming at the Utah-Wyoming border, to a low point of about 6,055 feet above mean sea level where the Bear River enters Idaho near Border, Wyoming.

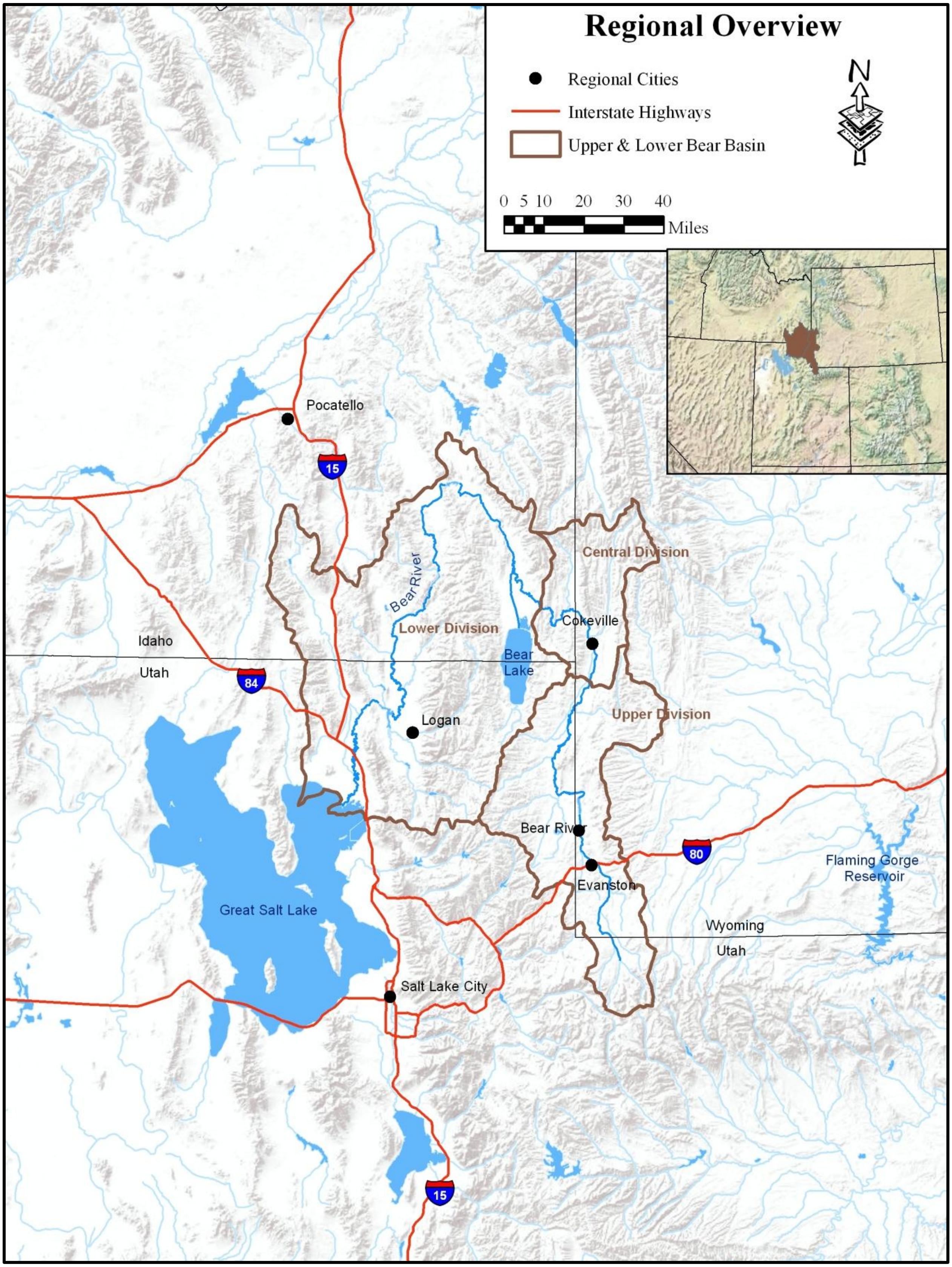

Figure 3-1: Bear River Basin Regional Overview

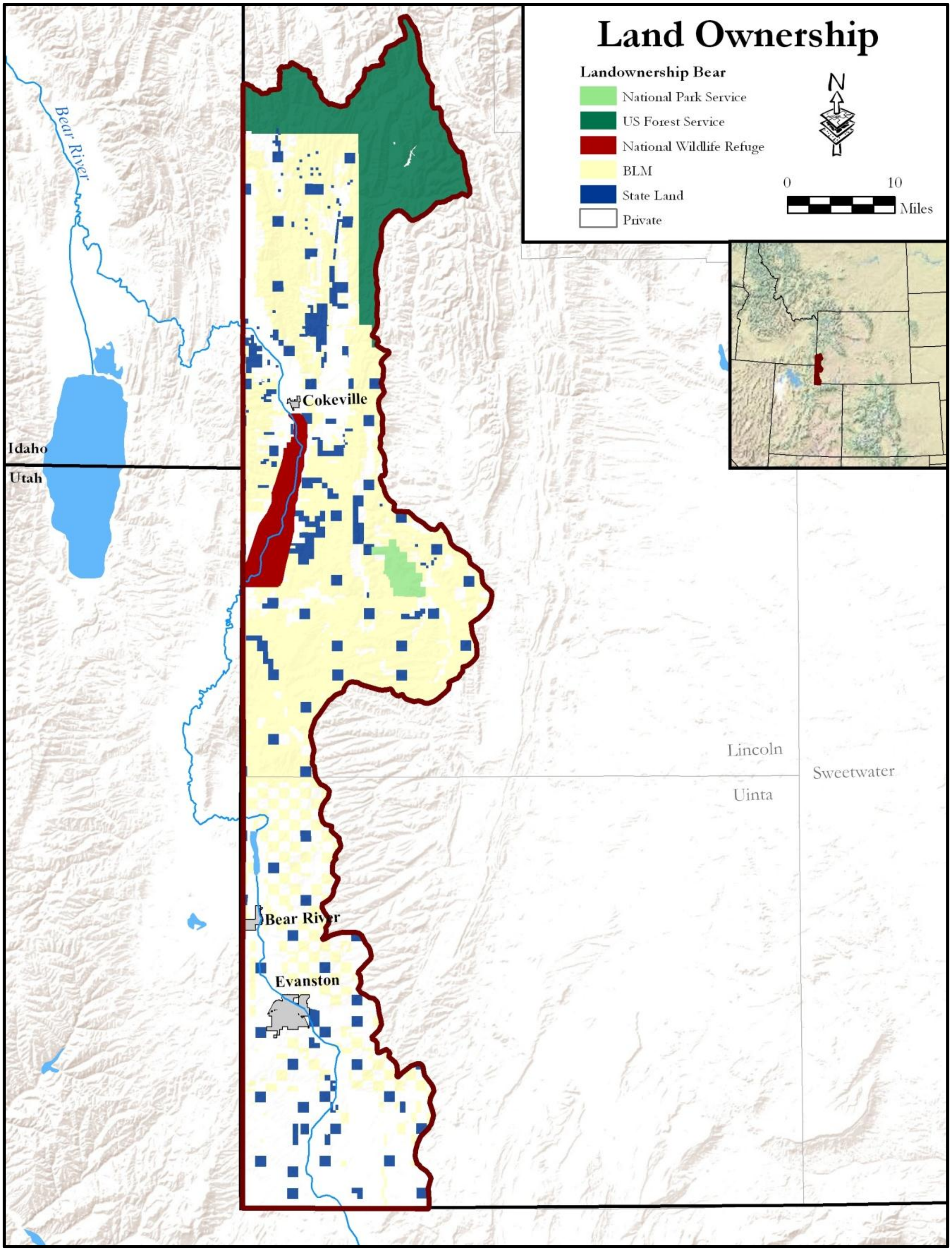

Figure 3-2: Land Ownership in the Wyoming Bear River Basin

3.1.3 DRAINAGE SYSTEM

The Bear River Basin in Wyoming, Idaho, and Utah drains an area of 4,759,680 acres and the Basin elevations range from 11,089 feet to 4,198 feet above mean sea level. The Bear River flows for a distance of approximately 500 miles through the three states and crosses the state boundaries a total of five times (Utah Department of Natural Resources, 2010).

The Bear River is the largest tributary to the Great Salt Lake. The Great Salt Lake drainage basin is an internal drainage basin without an outlet to an ocean. The Bear River flows northward from its beginning in the Uinta Mountains of Utah into Wyoming; back into Utah at Woodruff Narrows Reservoir; back into Wyoming; then into Idaho; and finally back into Utah to discharge into the Great Salt Lake.

In Wyoming, the Bear River flows through two counties, the western part of Uinta County and the southwestern portion of Lincoln County. Elevations of the Bear River Basin in Wyoming range from approximately 6,055 to 10,761 feet above mean sea level. Major tributaries to the Bear River Basin in Wyoming include Sulphur Creek, Mill Creek, Aspen Creek, Coyote Creek, Shearing Corral Creek, Bridger Creek, Rabbit Creek, Clear Creek, Twin Creek, Rock Creek, Coantag Creek, Smiths Fork, Water Canyon Creek, and Thomas Fork (Figure 3-3).

3.2 CLIMATE

Annual precipitation for the entire Bear River Basin ranges from a low of 9 inches to a high of 61 inches, with an average of 21 inches over the region (Utah Department of Natural Resources, 2010). In Wyoming, average annual precipitation ranges from a high of 40 inches in the north, near the headwaters of the Smiths Fork, to a low of 10 inches near the confluence with Twin Creek. The towns of Evanston, Cokeville and Bear River receive approximately 11 to13 inches of precipitation per year.

Seasonality of precipitation across the Bear River drainage as a whole shows three distinct patterns (Figure 3-4). In the Uinta Mountains headwaters, maximum precipitation tends to occur January through May, with each month providing roughly equal amounts of precipitation (WRDS, 2010). Drier conditions typify June through September in the Uintas. Following the river out of the mountains and into the lower country around Evanston, peak precipitation shifts to the month of May, with a smaller, secondary peak in September and October. Winter, December through February, is typically the driest season in Evanston. A similar May precipitation peak characterizes the Bear River lowlands throughout the remainder of the Upper and Central Divisions. The seasonal distribution of precipitation also changes with elevation in Wyoming's portion of the Basin. In higher areas to the northeast of Evanston, such as Medicine Butte (8,608 feet), peak precipitation tends to occur across the months of March through May. At Mount Isabel (10,761 feet), the highest point in Wyoming's portion of the Basin, precipitation shows a definitive winter peak, with January averaging as the wettest month. This winter peak for precipitation is also typical of the Bear River Range in Utah and Idaho, as well as the Wasatch Range. Winter precipitation in the mountain areas is in the form of snow.

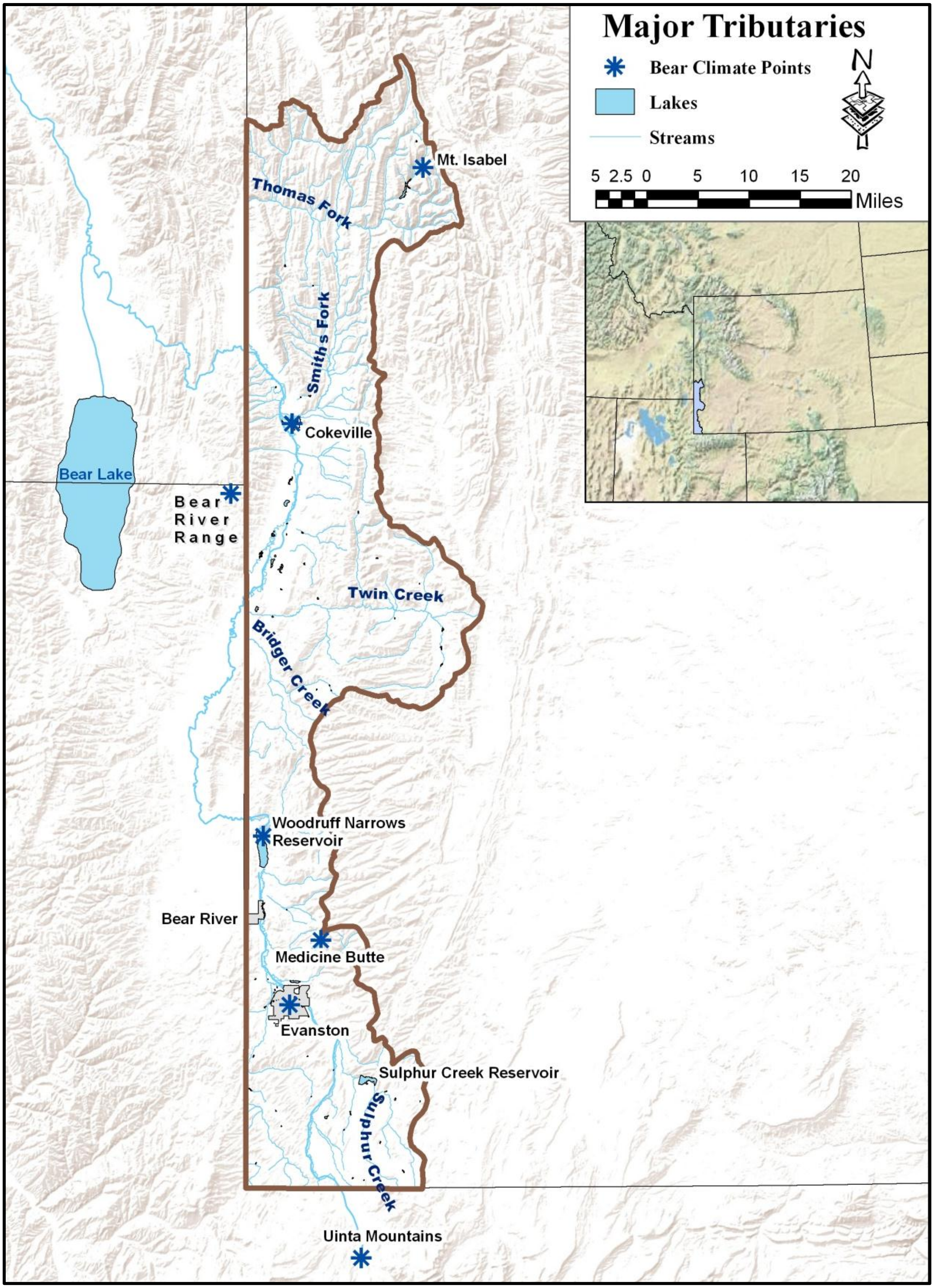

Figure 3-3: Major Tributaries to the Bear River in Wyoming

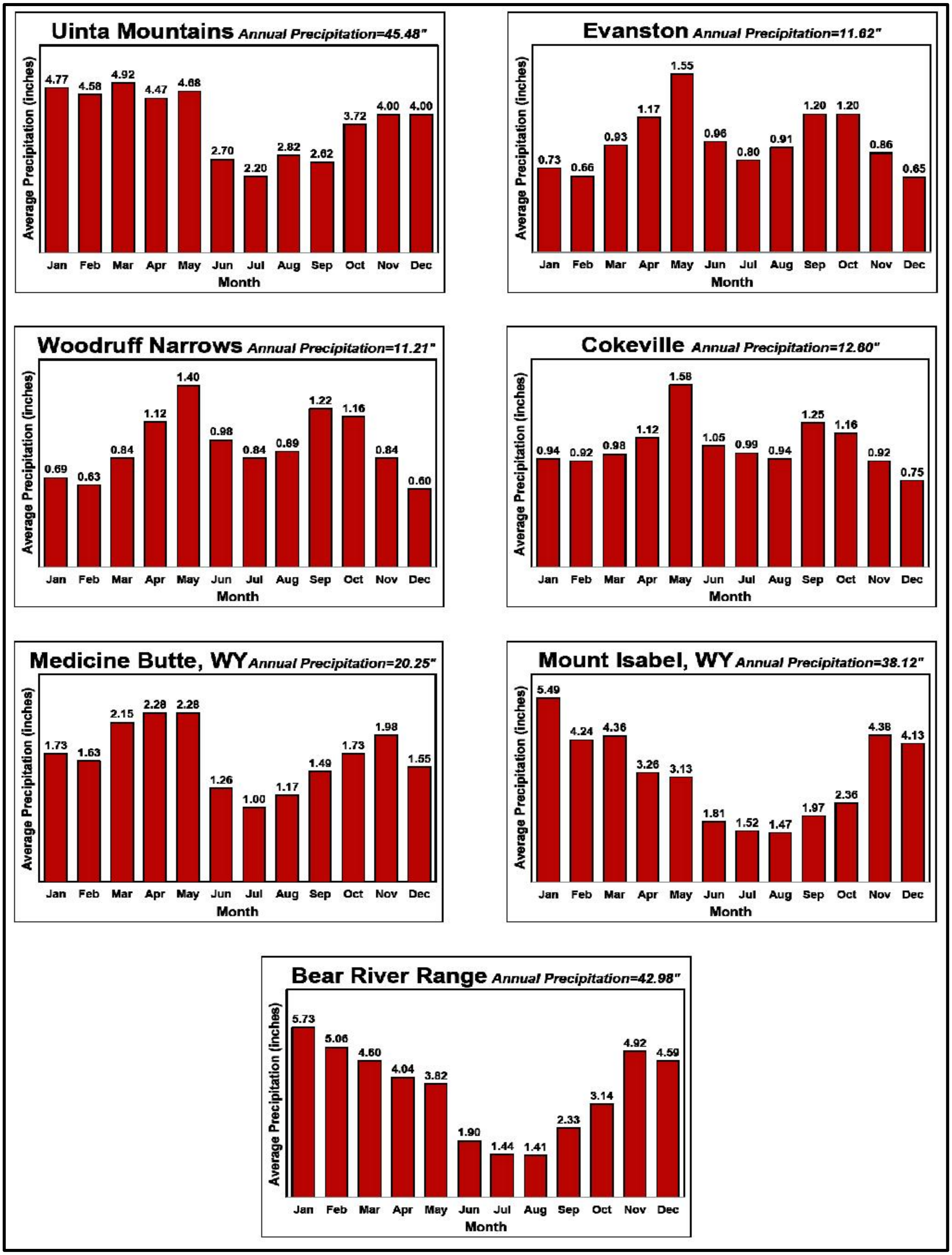

Figure 3-4: Average Annual Precipitation at Seven Weather Stations in the Bear River Basin

Temperatures at the Evanston weather station are typical for the Upper and Central Divisions of the Bear River Basin, with July average maximums in the lower 80's Fahrenheit (F), and January lows near 10° F (WRDS, 2010). Mean annual temperature at Evanston is 40° F, with minimum and maximum temperatures averaged across the year being 26° F and 55° F, respectively. Average temperatures are similar along Wyoming's portion of the Bear River, though extremes tend to be more pronounced in certain portions of the Bear River Valley. Winter temperatures at Sage, Wyoming (approximately 20 miles south of Cokeville), for example, have reached -50° F or lower on several occasions, whereas the all-time low at Evanston is only -38° F (February 12, 1905). In terms of high temperatures, the station at Sage has recorded temperatures as high as 104° F (July 26, 1931), but Evanston has never broken 100° F. Average temperatures decrease with increased elevation, but the low valley areas may often be far colder than the surrounding mountains.

Growing season length is extremely short in Wyoming's portion of the Bear River Basin. Again using Evanston to represent conditions in the Upper and Central Divisions, average last freeze (</= 28° F) occurs June 6, and first fall freeze September 11 (High Plains Regional Climate Center). The average last frost (</= 32° F) in Evanston occurs June 25, with average first frost on August 31. Evanston typically experiences 223 days/year when temperatures reach 32° F or lower.

3.3 ECONOMICS AND POPULATION

The Bear River Basin Water Plan Final Report (Forsgren Associates, Inc., 2001) provides a description of the economics and population of the Wyoming portion of the Bear River Basin. This section reviews the information presented in that report and the associated Technical Memoranda presented in Appendix Q of the 2001 report. Detailed population estimates and evaluations of economic activity were not compiled for this update.

The Bear River Basin area in Wyoming is small in comparison to the area of the other six river basins within the state. Its population is also small with only three municipalities: Bear River, Cokeville and Evanston. Bear River is a new town, incorporated in 2001, and its population was considered part of the rural domestic population in the 2001 plan report. The Basin covers portions of Lincoln and Uinta Counties with 70% of Uinta County's population living within the Basin and only about 7% of Lincoln County's population residing in the Basin.

The Wyoming Bear River Basin population in 2001 was estimated to be about 15,100. This estimate is reasonable when compared to the 2000 Census and recent estimates. According to an analysis of the 2000 Census data completed by the Wyoming Department of Administration and Information, Economic Analysis Division (AIEAD) for the 2007 Framework Water Plan (WWC, 2007) the Bear River Basin population was 14,550. An evaluation of the Census Bureau annual population estimates made by the AIEAD projected the Wyoming Bear River Basin population to be 14,530 in 2005, 14,576 in 2007, 14,938 in 2008 and 15,078 in 2009.

For this update, the economic influences in the Basin are considered the same as in the 2001 report. Economic growth and activity in the Basin are based on four sectors including agriculture, energy, tourism and manufacturing. Water use was divided into five major sectors including agriculture, industrial, municipal and domestic, environmental, and recreation.

Reservoir evaporation was also considered as a consumptive water use. Agriculture was the largest water use sector in the Basin. Industrial water use, which represents the energy and manufacturing sectors of the economy, was only a small portion of the water use in the Basin. Figure 3-5 shows the average annual basin consumptive water use as presented in the 2001 Plan. Environmental and recreational water uses are negligible and are not shown in the figure. Two economic and population growth scenarios were used in the 2001 Plan, a high growth scenario and a low growth scenario. A mid-growth scenario was developed in the 2007 Framework Water Plan to make comparisons with other basin plans.

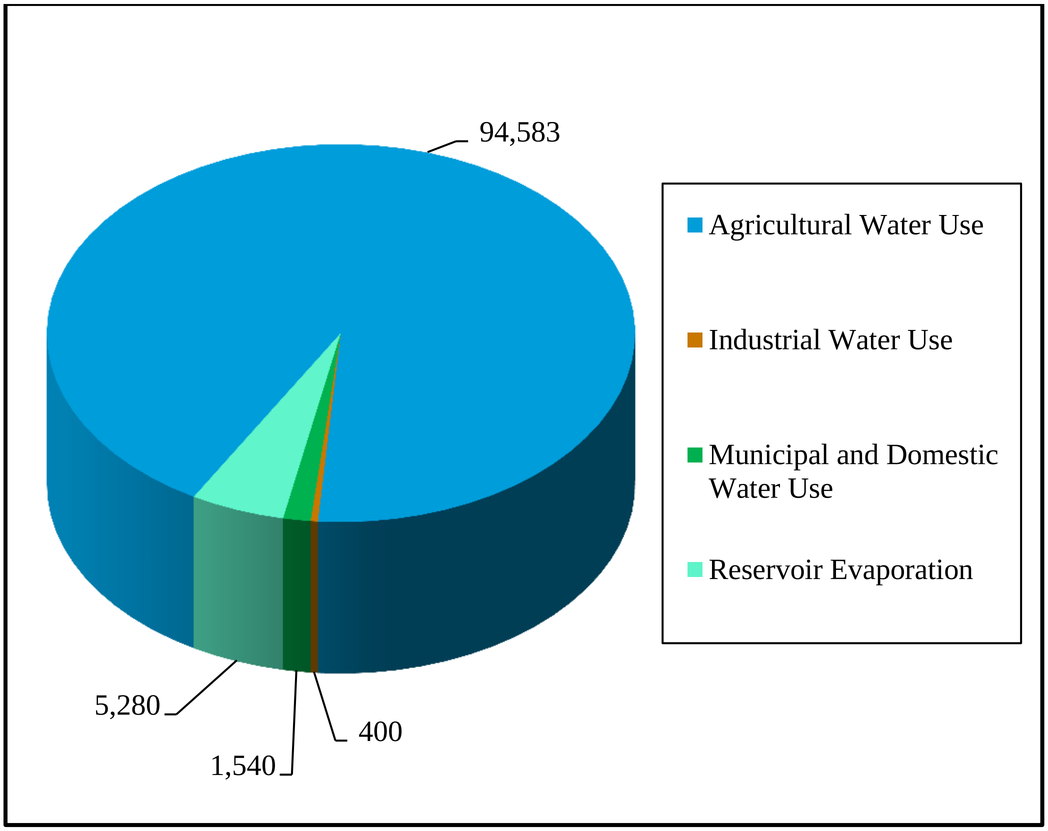

Figure 3-5: Average Annual Basin Consumptive Water Use in Acre-Feet (2001 Basin Plan)

3.4 DISCUSSION OF COMPACTS AND LEGAL CONSTRAINTS

This section contains five subsections, an introduction to Wyoming Water Law, a discussion of the Bear River Compact including the Upper Division and Central Divisions in Wyoming, and other federal laws related to water. Subsections 3.4.2, 3.4.3, and 3.4.4 on the Bear River Compact, Upper Division in Wyoming and Central Division in Wyoming have been taken directly from the 2001 Plan and are presented here in their original form, with the figures and tables numbered as they were in the original report. These sections are displayed in small font and italic so the reader may distinguish them from information developed specifically for this report.

3.4.1 WYOMING WATER LAW

Wyoming's water is administered under the Prior Appropriation Doctrine through the State Engineer's Office. Under this doctrine the first water user to put water to beneficial use has the first right to that water, or "first in time is first in right."

A revised Wyoming Water Law: A Summary was prepared by James J. Jacobs, Associate Dean and Director, Agricultural Experiment Station; Patrick T. Tyrrell, Wyoming State Engineer; and Donald J. Brosz, University of Wyoming Professor Emeritus in 2003. This summary is available online http://seo.state.wy.us/PDF/b849r.pdf from the Sate Engineer's Office or the University of Wyoming, Agricultural Experiment Station, publication B-849R.

3.4.2 BEAR RIVER COMPACT

> *Although Wyoming has the right to manage its water resources, it does not have the right to use all the water originating in Wyoming per agreements made by interstate compact or by court decree. Because Wyoming is a headwater state, it is bound by interstate river compacts in seven major basins and is also party to two U.S. Supreme Court decrees and one U.S. District Court Decree. These interstate compacts and decrees dictate either the total amount of water Wyoming is allowed to use in a set time period, or the amount of water Wyoming must allow to flow past its state line.*
>
> *The Bear River Compact is an agreement under Federal Law between Wyoming, Utah, and Idaho which was ratified by Congress in 1980. The original Compact was signed by President Eisenhower on March 17, 1958. The Compact was amended in 1978 and signed into law by President Carter on February 8, 1980. The Amended Bear River Compact, 1978, is included as* ***Appendix B*** (Appendix B of 2001 Bear River Basin Plan). *A brief description of the Compact follows.*
>
> *The original Compact divided the Bear River Basin into three main divisions: The Upper Division, the Central Division, and the Lower Division. The Upper Division includes portions of Wyoming and Utah that are upstream of Pixley Dam, located in Wyoming south of the town of Cokeville. The Central Division includes portions of Wyoming and Idaho, between Pixley Dam and Stewart Dam in Idaho. The Lower Diversion extends from Stewart Dam through Idaho and back into Utah, where the Bear River discharges into the Great Salt Lake.* ***Figure 5*** (labeled as Figure 3-6), *published by the Bear River Commission, shows the three divisions.*
>
> *The original Compact apportioned direct flows of the Bear River and its tributaries between Utah and Wyoming in the Upper Division, and between Wyoming and Idaho in the Central Division. It defined original compact storage in the Upper and Central Divisions to each state as shown in* ***Table 4****.*

Table 4: Original Compact Storage Above Bear Lake

State	*Storage (Acre-Feet)*
Utah	*17,750*
Wyoming	*17,750*
Idaho	*1,000*
Total	***36,500***

The amended Bear River Compact granted additional storage above Bear Lake, allocated as shown in **Table 5***. This additional storage, plus both surface and groundwater appropriated and applied to beneficial use after January 1, 1976, is limited to an annual depletion of 28,000 acre-feet. The annual depletion is apportioned to the three states as follows: 13,000 acre-feet to Utah, 13,000 acre-feet to Wyoming, and 2,000 acre-feet to Idaho. In addition, the Upper and Central Divisions were allowed additional rights to store water spilled or bypassed from Bear Lake when all other direct flow and storage rights are satisfied. The storage rights were allocated as follows: 47 percent to Utah, 47 percent to Wyoming, and 6 percent to Idaho. The amended Bear River Compact also established a minimum Bear Lake level below which Bear Lake cannot be drawn for power purposes only.*

Table 5: Additional Compact Storage Above Bear Lake

State	*Storage (Acre-Feet)*
Utah	*35,000*
Wyoming	*35,000*
Idaho	*4,500*
Total	***74,500***

The Bear River Compact is administered by the Bear River Compact Commission consisting of three representatives from each Compact state and one federal representative. They are required to prepare biennial reports presenting the river operations under the Compact. They are charged with overseeing the interstate river administration when flow is not adequate to satisfy demands within each state, known as a water emergency. Note that when water is plentiful, no interstate river administration is required.

If a water emergency exists, the responsibility falls on each state to curtail diversions and storage in the proportion dictated in the Compact. When this occurs, states administer the river based on their water law. For example, when Wyoming must curtail diversions to meet Compact requirements, the water division superintendent would "shut off" diversions to the lowest priority ditch first, then the second lowest, etc. until Wyoming is able to meet their compact requirements.

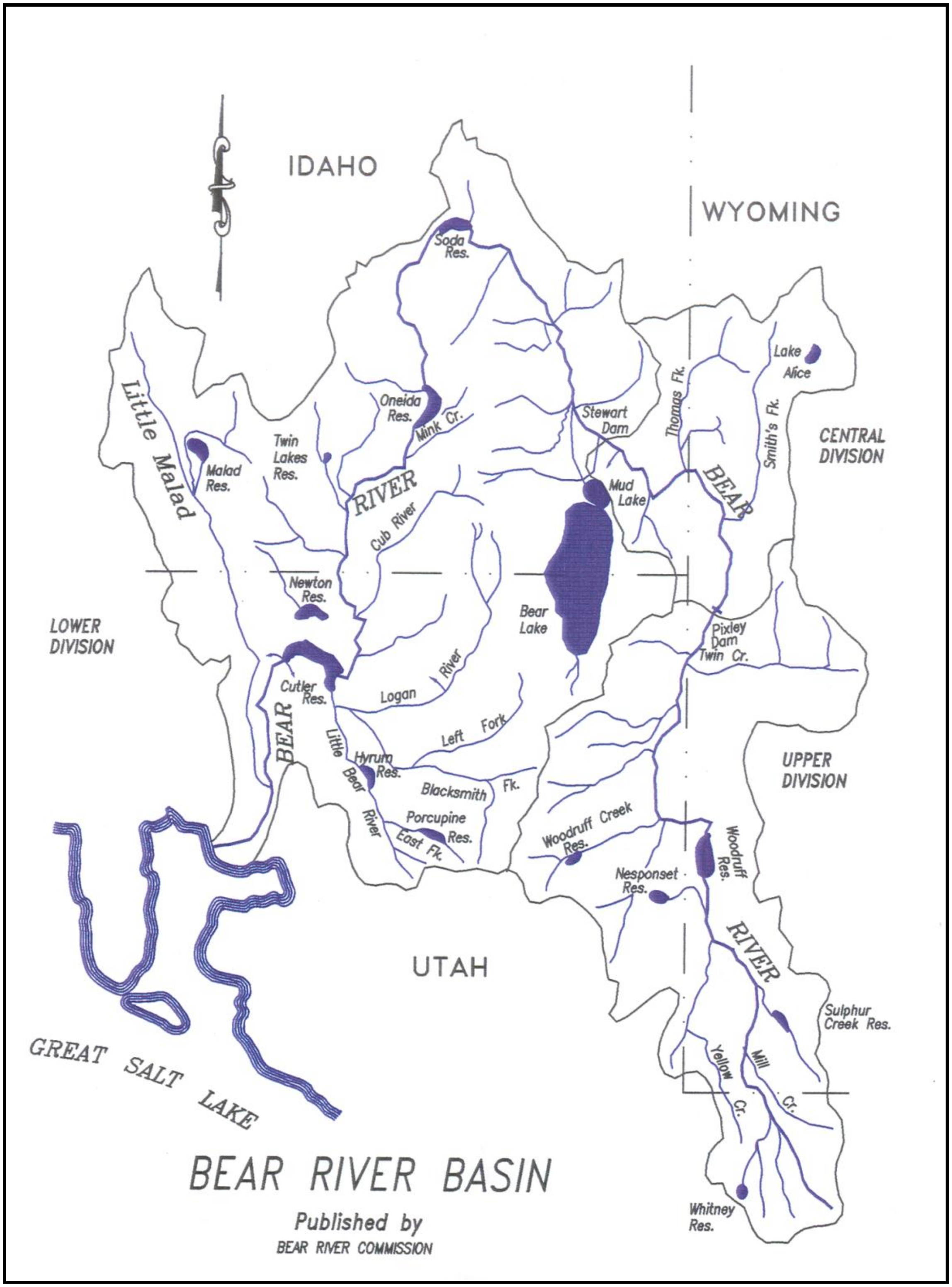

Figure 3-6: Bear River Basin (Figure 5 from the Bear River Compact)

3.4.3 UPPER DIVISION IN WYOMING

The Bear River Basin in Wyoming is divided by the Compact into the Upper Division and the Central Division. Much of the information provided in this document is based on these divisions. Figure 6 (labeled as Figure 3-7) shows the Upper and Central Division of the Bear River Basin and outlines the Wyoming border. The main tributaries in the Upper Division include Mill Creek, Sulphur Creek, and Yellow Creek; however, in the Upper Division interstate regulation applies only to the main stem of the Bear River. Several storage reservoirs supply supplemental water for irrigation and municipal use in Wyoming including Whitney Reservoir, which is on the West Fork of the Bear River Basin in Utah; Sulphur Creek Reservoir; and Woodruff Narrows Reservoir, which releases water for use in both Wyoming and Utah. A relatively small amount of water is exported from the Green River Basin to the Bear River Basin through the Van Tassel Ditch to La Chappelle Creek then stored for downstream use in Ben Reservoir and Broadbent (Heber) Reservoir.

The Upper Division does not regularly fall under Compact regulation, in part due to the supplemental water provided through storage. The amount of groundwater used in the upper division is minimal, again reflecting the benefits of reservoir storage. Evanston once relied upon groundwater to meet their municipal demand, but now primarily uses surface water from the Bear River and Sulphur Creek.

3.4.4 CENTRAL DIVISION IN WYOMING

The main tributary in the Central Division is Smiths Fork, which is administered as a Compact tributary. Pine Creek is within the Smiths Fork drainage but has been defined in a court decree as not being tributary to Smiths Fork, yet still comes under Compact regulation. Twin Creek also contributes to flow in the Bear River but is not regulated under the Compact.

No significant storage exists in the Central Division. Partly due to this lack of storage, the Central Division goes into a water emergency, as defined by the Compact, more frequently than the Upper Division. Twin Creek often falls under state regulation during the irrigation season, since the lowest headgate on the creek has the highest priority water right.

The Central Division uses groundwater as a supplemental source for satisfying irrigation requirements. The town of Cokeville supplies their municipal demand with well and spring water from groundwater sources.

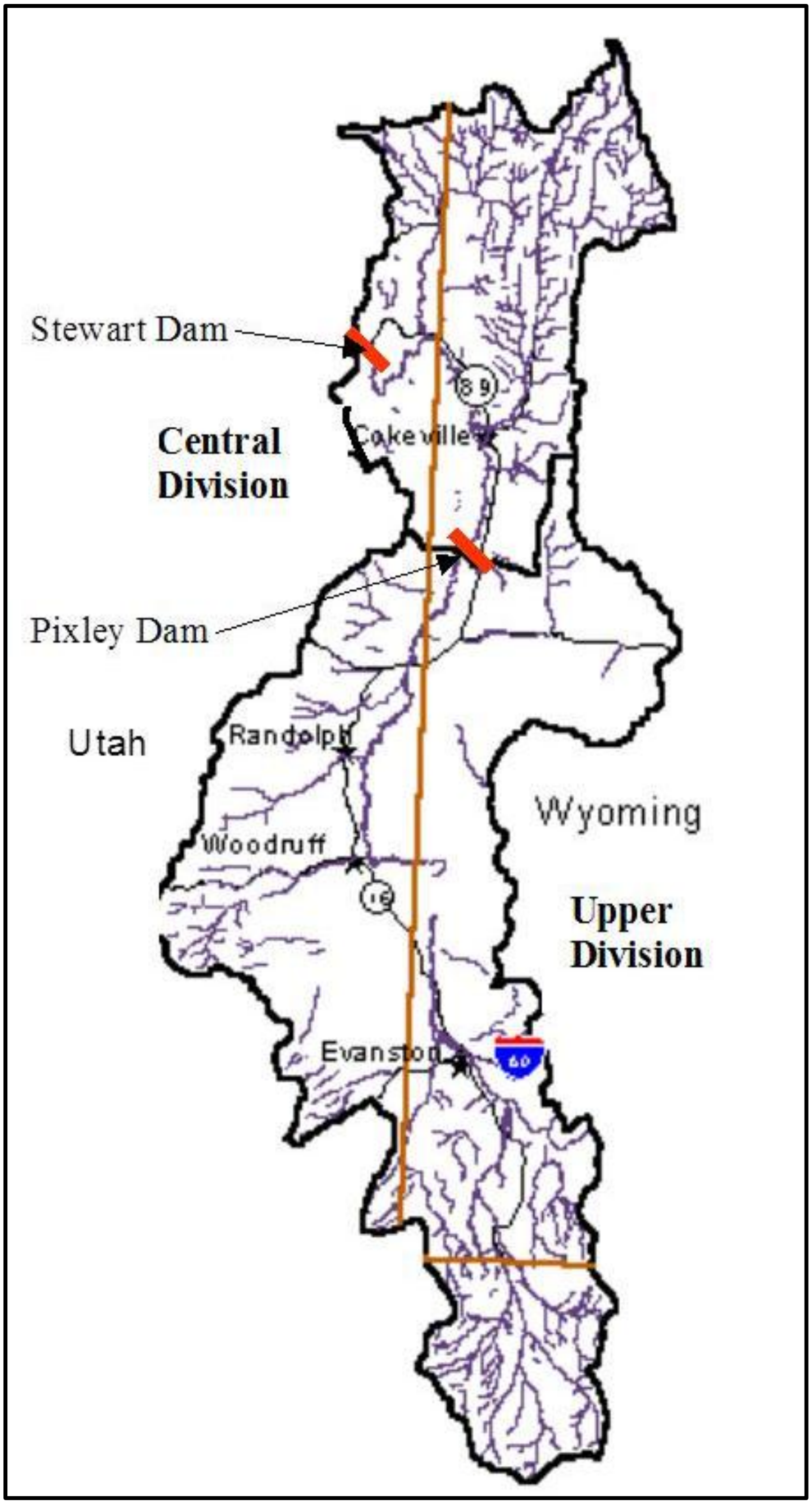

Figure 3-7: Upper and Central Division Boundaries (Figure 6 from the Bear River Compact)

The SEO Division VI Superintendent provided additional information to clarify water administration in the basin, including information on Twin Creek and the diversion from the Green River Basin to Bear River Basin. Twin Creek is a minor tributary to the Bear River at the lower end of the Upper Division, and it often falls under state regulation during the irrigation season because the lower head gates on the creek have the highest priority water rights. The export water from the Green River Basin to the Bear River Basin is diverted from Van Tassel Creek via the Broadbent Ditch to La Chappelle Creek and is stored in Ben Reservoir and Broadbent Reservoir. The Superintendent also clarified that the Smiths Fork in the Central Division is administered as a Compact tributary with the mainstem Bear River. Additionally, the town of Cokeville currently supplies its municipal water demand from wells only and not from springs (Henderson, 2011).

3.4.5 FEDERAL LAWS

There are various federal laws that may affect water development and use. Three of the more important laws are the Clean Water Act of 1972, as amended, the Endangered Species Act of 1973, and the National Environmental Policy Act of 1969. Projects that require some type of federal agency action will trigger involvement of federal environmental and water laws. Examples of these actions include the following:

- Issuance and renewal of special use and right-of-way permits on federal land.
- Contracting for storage water from federal reservoirs.
- Discharge of dredged and/or fill material into waters of the United States.
- Procurement and licenses from the Federal Energy Regulatory Commission to produce hydropower.
- Use of federal loan or grant funds.

The Clean Water Act is primarily administered by the Environmental Protection Agency (EPA) with many of the programs delegated to the states through a primacy process. There may be several portions of the act that need to be considered during planning of water development projects. Administration of Section 404 of the act, which is of particular importance in water development projects, has been delegated to the U.S. Army Corps of Engineers. Section 401 of the act allows the state to review and certify that any federally licensed or permitted project will not pollute waters of the state. If a federally licensed or permitted project will cause water pollution, the state may require mitigation before certifying or may veto the project.

The Endangered Species Act requires the Secretary of the Interior, through the U.S. Fish and Wildlife Service (USFWS), to determine whether wildlife and plant species are endangered or threatened. The act prevents federal agencies from taking actions that might jeopardize the continued existence of an endangered or threatened species. A Section 7 consultation must be initiated with the USFWS if a federal agency is considering an action that may jeopardize an endangered species.

The National Environmental Policy Act (NEPA) requires federal agencies to consider all reasonable foreseeable environmental consequences of a proposed action. Additionally, NEPA requires agency decision-makers to develop and evaluate alternatives to the proposed action including a No-Action Alternative. NEPA allows the federal agency to determine which of the alternatives, including the No-Action Alternative, best serves the project purpose and need. The alternative selected may not be the applicant's preferred choice.

3.5 DISCUSSION OF RECENT BASIN STUDIES AND PROJECTS

This section presents a brief discussion of the studies, reports and projects that have been completed or are on-going in the Wyoming portion of the Bear River Basin. A list of the studies and reports that have been completed since the 2001 Bear River Basin Plan was completed is shown below. Two of the studies were completed before the plan was published in 2001 but were not included in the plan because of the time between data collection, report preparation and publication of the plan.

- Eddy-Miller, C.A., and Norris, J.R., 2000, Pesticides in Ground Water – Lincoln County, Wyoming, 1998-99: U.S. Geological Survey Fact Sheet FS-033-00, 4p.
- Forsgren Associates, Inc., 2000, North Uinta County Improvement and Service District Water Supply Master Plan – Level I. Wyoming Water Development Commission, Cheyenne, WY.
- Trihydro Corporation, 2003, Final Project Report North Uinta Water Supply Project Level II feasibility Study Bear River, Wyoming. Wyoming Water Development Commission, Cheyenne, WY.
- Eddy-Miller, C.A., and Remley, K.J., 2004b, Pesticides in Ground Water – Uinta County, Wyoming. 2002-03: U.S. Geological Survey Fact Sheet 2004-3093, 4p.
- Sunrise Engineering, Inc., 2004, Cokeville Reservoir Level I Study, Final Report. Wyoming Water Development Commission, Cheyenne, WY.
- Sunrise Engineering, Inc., 2005, Evanston/Bear River Regional Pipeline Level II Study. Wyoming Water Development Commission. Cheyenne, WY.
- Short Elliott Hendrickson, Inc., 2009, Final Report Sublette Creek Reservoir and Covey/Mau Canal Rehabilitation Project, Level II Study. Wyoming Water Development Commission, Cheyenne, WY.
- RJH Consultants, Inc. 2010, Sublette Creek Reservoir, Mau/Covey Canal Rehabilitation Level II Project, Volume I and II. Wyoming Water Development Commission, Cheyenne, Wyoming.

3.5.1 GROUNDWATER STUDIES

Two studies (Eddy-Miller and Norris, 2000; Eddy-Miller and Remley, 2000b) looked at pesticides in groundwater in the Bear River Basin. These studies did not look at pesticides in groundwater of the Bear River Basin specifically, rather looked at pesticides in groundwaters of Lincoln and Uinta Counties, Wyoming. However, some of the wells sampled in both studies were within the Bear River Basin boundary.

Eddy-Miller and Norris (2000) tested 15 wells for pesticides in Lincoln County. All of the wells were in alluvial or terrace deposits. Four of the 15 wells tested were in the Central Division of the Bear River Basin and two of these had pesticides detected. There was only one other well in

Lincoln County that tested positive for pesticides. The concentrations of pesticides in the Lincoln County wells, including the two in the Bear Basin, were below EPA's standards for safe drinking water.

Eddy-Miller and Remley (2000b) tested 12 terrace or alluvial deposit wells in Uinta County for pesticides and found pesticides in six of the 12 wells. Seven of the 12 wells were in the Bear River Basin and four of the seven showed signs of pesticides. The seven wells were located in the Upper Division of the Bear Basin. Pesticide concentrations in the Uinta County samples were generally less than 1/66 of the applicable drinking water standards. About one third of the detections were trace concentrations too small to quantify without estimation.

3.5.2 Regional Water Supplies

A Level I study (Forsgren Associates, 2000) was conducted for the North Uinta County Improvement and Service District to determine the best steps for development and improvement of the water supply system. The North Uinta County Improvement and Service District is located about ten miles north of Evanston along Wyoming State Highway 89. The district consisted of six different sections: Whitney Canyon, El Caballo 1, El Caballo 2, Lower Deer Mountain, Upper Deer Mountain1, and Upper Deer Mountain 2. The District requested a Level I master plan from the Wyoming Water Development Commission to determine the best steps for development and improvement of the water supply system. Forsgren Associates (2000) found there were 212 homes (680 individuals) within the district during the study. The area between Evanston and the district was included as part of the study area and there were 210 homes (400 residents) and 39 businesses in this area. Both the North Uinta County Improvement and Service District and the area between the district and Evanston are served primarily by private shallow wells of varying quality and reliability. During the 1980's a water supply system was constructed to serve the Deer Mountain area of the district (Forsgren Associates, 2000). The system consisted of three wells and approximately two miles of water lines. This water system was only marginally adequate to meet the water needs and would not be adequate to meet build out for the Deer Mountain subdivision. During the study, one of the wells began to fail and the district was having trouble providing adequate water to the subdivision. The subdivision was only 50% built out at that time. Forsgren Associates (2000) recommended that a test well be drilled to determine if another well could be developed to serve the Deer Mountain system. The long term recommendation for the entire area was to develop a regional system in conjunction with the city of Evanston.

In 2001, the town of Bear River made application to the WDC for a Level II project to drill a test well in the Deer Mountain area. Trihydro Corporation was hired to undertake the project and they completed the project and report in 2003. During the process of funding and initiating the project, the six entities that were within the North Uinta County Improvement and Service District formed the incorporated town of Bear River and the district was dissolved. The well was drilled in 2002 and the water quantity and quality was adequate to supplement the water supply for the Deer Mountain area. The town connected the well to the Deer Mountain water system using State Land and Investment Board funds. WDC funds constructed a storage tank and transmission line.

The town of Evanston and the new town of Bear River made application in 2004 to the WDC for a Level II study to examine the potential for a regional system to supply water to both towns and the unincorporated area between the towns. Before the town of Bear River was incorporated, the area was included in the North Uinta County Improvement and Service District. The Level II study, conducted by Sunrise Engineering (2005), was tasked with assessing the feasibility of developing a regional system and providing a cost analysis. The study found that the regional pipeline system would be capable of serving the town of Bear River and the unincorporated areas between Bear River and the city of Evanston. A Joint Powers Board (JPB) was formed by the town of Bear River and the North Uinta County Water and Sewer District, who represents the water users in the unincorporated areas, to support and manage the regional system. Evanston is not a member of the JPB but has agreed and contracted to allow the JPB to utilize storage space in Sulphur Creek Reservoir, to treat raw water for the JPB, and to transmit the water through the city system to the JPB delivery line. The town of Bear River has secured from Wyoming a small original Compact interstate storage allocation through the State Engineer's Office to meet their current needs. The town is also pursuing water rights for an expanded service area, including junior direct flow rights. The city of Evanston's storage permit for Sulphur Creek Reservoir needs to be changed to reflect the change in storage allocation.

The JPB made application for a Level III construction project and the project was approved in 2006. The total project cost was estimated to be approximately 5.5 million dollars. Legislation provided about 3.7 million dollars with the remainder to be provided through other sources. The project was completed in 2010 and the pipeline is now in use.

3.5.3 RESERVOIR FEASIBILITY

The Cokeville Development Company applied for a Level II feasibility study to evaluate potential reservoir sites on the Smiths Fork of the Bear River in 2003. The need for supplemental irrigation water and flood control in the Smiths Fork drainage, and the availability of storage water through the Bear River Compact have resulted in several studies to evaluate the feasibility of constructing a dam and reservoir on the Smiths Fork. A 1985 study conducted jointly by Idaho, Utah and Wyoming looked at the potential to develop storage on the Smiths Fork that would benefit all three states (GBR Consultants Group, 1985). The project would have provided a reliable water supply, improved water quality, generated electricity, and provided flood control and recreation. However, the project was only feasible if all three states participated in the financing; Idaho and Utah were not interested in pursuing the project at that time.

Thus, in 2003, Sunrise Engineering, Inc. was awarded the project to study the feasibility of constructing a reservoir on the Smiths Fork of the Bear River (Sunrise Engineering, Inc. 2004). This study looked at several of the potential dam sites that had been considered previously in the 1984 study. Sunrise also studied potential off-channel sites that would have fewer environmental impacts. Sunrise found that a reservoir on the Smiths Fork would have a reliable source of water and could meet a number of water uses and needs, but was not economically feasible.
The Cokeville Development Company decided it would be better to try and develop the 4,100 acre-feet of water allowed under the 1958 Bear River Compact and the Wyoming State Allocation Plan. They requested a Level II Phase I project in 2008 and the project was completed by Short Elliott Hendrickson Inc. in early 2009. The study looked at the possibility of

constructing a dam and reservoir in the Sublette Creek watershed, a tributary to the Bear River southeast of Cokeville. Additionally, the study examined the need for lining and rehabilitation of the Covey/Mau Canal. Results indicate that it may be feasible to build a dam and reservoir in the watershed. A site that can be filled from the Covey/Mau Canal was selected as the preferred site. Lining the Covey Canal and the Mau Lateral was suggested to reduce seepage. Polyacrilomide was suggested for general lining and polyporplyleen/polyurea was suggested for areas of concentrated seepage. The Cokeville Development Company applied for and was granted a Level II Phase II study to gain more information about the Sublette Creek site in 2009.
The Level II Phase II study conducted by RJH Consultants (2010) recommended further evaluation of the geological and geotechnical conditions of site 1 from the Level II Phase I plan. The study also recommended additional evaluations for environmental permitting and cultural resources, continued coordination with appropriate agencies regulating environmental and cultural issues, and identifying improvements to Covey Canal that would be necessary to deliver water to the proposed site.

The Cokeville Development Company has requested further study of the proposed project from the Wyoming Water Development Commission. This request has been approved by the Commission and the requested study was part of the 2011 Omnibus Water Bill - Planning which was approved by the legislature in March of 2011.

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4.0 WATER RESOURCES

4.0 WATER RESOURCES

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4.0 WATER RESOURCES

4.1 SURFACE WATER

As in most Wyoming river basins, surface water is a vital component to the way of life and economy in the Bear River Basin. Snowpack is the primary source of surface water in the Basin, and agriculture is the largest water user, diverting streamflow onto fields where crops consumptively use the water. The remaining unused water eventually returns to the shallow groundwater and streams to be used again.

4.1.1 SURFACE WATER MODELING METHODOLOGY

The methodology used to develop the model and water availability in the 2001 Bear River Basin Plan was employed for this update. The only changes to the models were the streamflow and diversion data. The irrigation efficiency data input and model structure and operation all remain unchanged.

The models are made up of nodes that represent gages, diversions, and storage sites. Nodes are organized into reaches defined by tributaries or sections of the main stem of the Bear River. The gage data represent the inflow to the system and the diversions represent water taken from a reach and used for irrigation. Efficiency calculations are applied to each diversion to determine the water consumptively used and the water that returns back to the system. Available water is calculated at the bottom of each reach based on gage data, return flows, and reach gains or losses. The gains and losses are attributed to ungaged tributaries that are not explicitly modeled, and water that may be lost in the system to sub-irrigated riparian areas and/or recharge of aquifers.

4.1.2 GAGE DATA

It is through a network of streamflow gages that the quantity of water entering and leaving the basin can be measured. Gage data, obtained from the United States Geological Survey (USGS), were placed in an EXCEL spreadsheet for analysis, and eventually exported to the spreadsheet model as the hydrologic input. Generally, the methodology used in the 2001 Bear River Basin Plan (Forsgren Associates, Inc. 2001) was used for this study. Refer to Task 3A. Surface Water Data Collection and Study Period Selection technical memorandum from the 2001 Bear River Basin Plan for explanation of the methodology used to select the index gages http://waterplan.state.wy.us/plan/bear/techmemos/task3a.html. Index gages are those selected to determine hydrologic input to the model. The following are index gages used for the hydrological analysis, and Figure 4-1 depicts the location of each index gate in the system.

- 10011500 Bear River near Utah-Wyoming State Line
- 10015700 Sulphur Creek above Reservoir below La Chapelle Creek near Evanston, WY
- 10016900 Bear River at Evanston, WY
- 10020100 Bear River above Reservoir near Woodruff, UT
- 10020300 Bear River below Reservoir near Woodruff, UT
- 10026500 Bear River near Randolph, UT
- 10028500 Bear River below Pixley Dam near Cokeville, WY

- 10032000 Smiths Fork near Border, WY
- 10038000 Bear River below Smiths Fork, near Cokeville, WY
- 10039500 Bear River at Border, WY

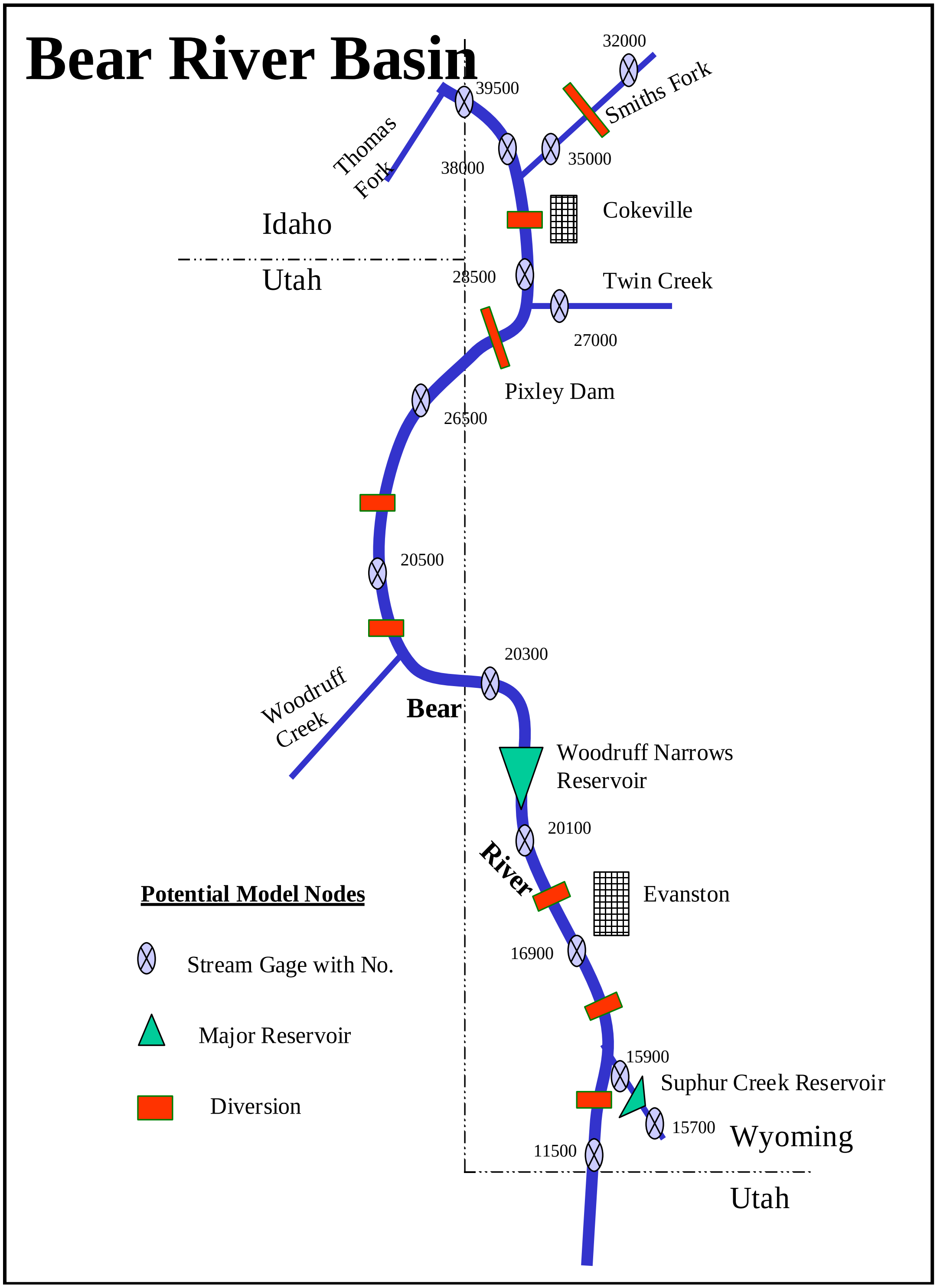

Figure 4-1: Bear River Basin Schematic (Source: 2001 Bear River Basin Plan)

4.1.3 PERIOD OF RECORD

The period of record used for the 2001 Basin Plan was 1971 to 1998. For this study, the record was extended to the year 2008 for every gage. This period is representative of the Basin hydrology over time because some of the driest years on record occurred after 1998 along with representative wet years.

Regarding streamflow gages with missing monthly data, there was a concern about the total number of missing records for these gages. Gages 10011500, 10020100, 10020300, and 10032000 had complete data sets for the period of record. Gages 10038000 and 10039500 had only a few months that required data filling. The remaining gages (10015700, 10016900, 10026500, & 10028500) had a significant amount of missing data that needed to be filled using the regression methods in EXCEL. For further understanding of the study period selection and the filling of missing data, refer to the Surface Water Data Collection and Study Period Selection Technical Memorandum [Volume 2, Tab: I (2011)]. Future updates to this basin plan should require a more thorough investigation of the available gage data and data filling methodology. It is recommended that gage 10015700 not be used in the future because of the lack of data and the number of monthly records that must be modeled. Gage 10015700 was terminated in 1997 and part of this evaluation was to decide whether or not to eliminate this gage from the study entirely or to try to fill the missing data. WWDC has a concurrent study, Sublette Creek Reservoir Level II Study [States West Water Resources Corporation (States West), 2001], which is looking at the potential for building a reservoir in the Bear River Basin. As part of the study, States West is updating BearMod, another type of water budget model, through 2006. BearMod is a river and diversion simulation model that was built as part of the 2001 Bear River Basin Plan. The BearMod model requires the same data as the spreadsheet model presented here. States West decided to extend the flow data for gage 10015700 through 2006. Because of this decision and to be consistent with other WDC projects, it was decided to use the gage in this analysis.

4.1.4 DETERMINATION OF DRY, NORMAL, AND WET YEARS

For this study, three hydrologic scenarios were developed to represent typical dry, wet, and normal hydrology. These conditions are major components of the spreadsheet models. The hydrologic conditions were developed by first obtaining streamflow gage data from the USGS, filling data where missing, and finally ranking the data for analysis. Most of the gages required data filling to develop the hydrologic conditions. The flow scenarios developed in the 2001 Basin Plan differed from how they were calculated in this update. Missing data in the update were filled using both linear and polynomial regression analyses focusing on the regression equation that produced the highest correlation (r^2) value. When the data sets were complete the dry, normal, and wet year conditions were calculated. The driest 20% of the ranked yearly flows were averaged to determine the “average dry” condition; the wettest 20% of the ranked yearly flows were averaged to determine the “average wet” condition; and the remaining years were averaged to determine the “average normal” condition. Each of these conditions was used as the input for their respective model (dry, normal, wet).

In general, hydrologic conditions used for this plan update were drier than those used for the 2001 Plan. This is partly due to a difference in how the modeled hydrologic conditions were developed in the previous plan, and also the fact that some of the driest years on record occurred since the 2001 Plan was completed. In the 2001 Plan, many of the conditions for a specific gage were determined by the locations of "natural breaks" in the ranked flow values. For this study, it was decided to use the 20% dry - 20% wet analysis recommended for basin planning in the Guidelines for Development of Basin Plans (States West Water Resources Corporation, 2001).

Figure 4.2 represents the dry, normal, and wet year classification for each gage and year followed by tables comparing the 2001 Bear River Basin Plan to the update. Table 4-1 presents hydrologic conditions and a comparison of the calculated flows to the 2001 Plan.

Bear River in Wyoming

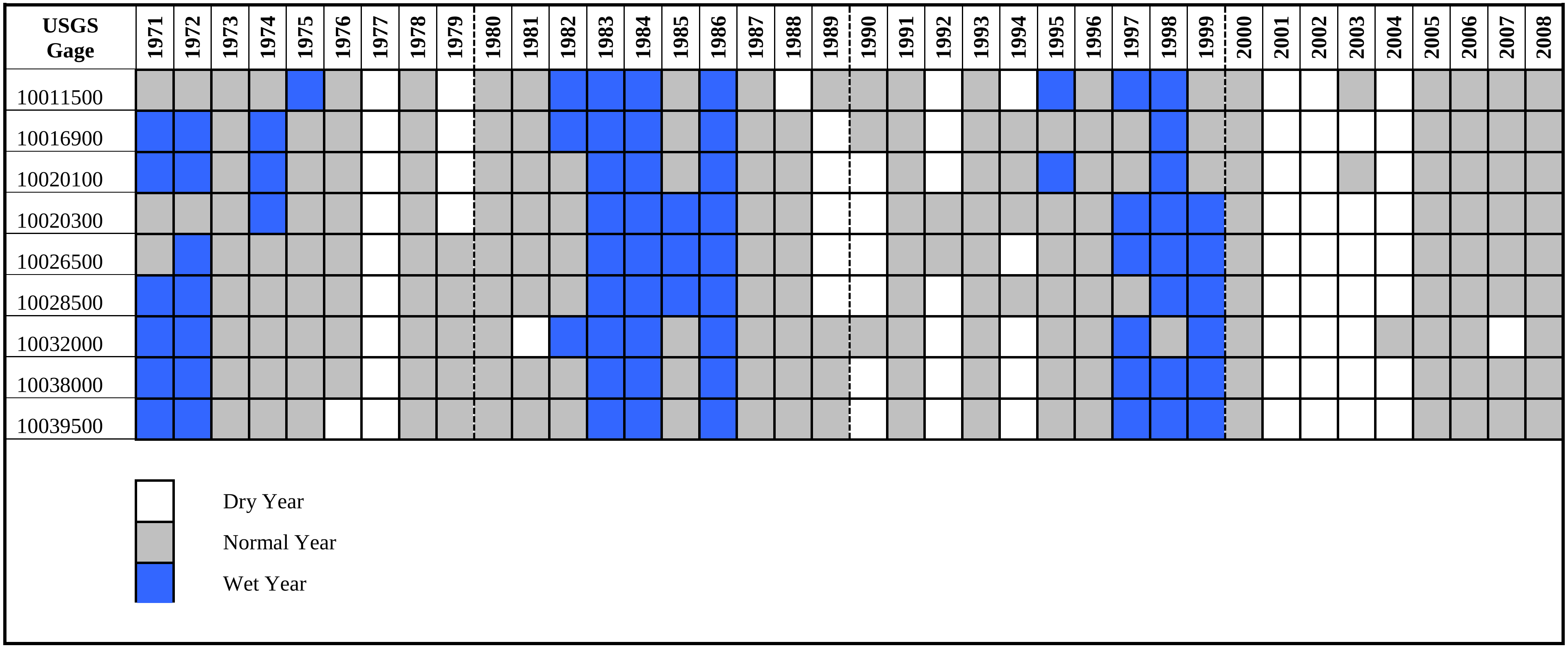

Figure 4-2: Distribution of Dry, Normal, and Wet Years for Period of Record 1977 to 2008

Table 4-1: Comparison of Dry, Normal, and Wet Conditions at USGS Streamflow Gages between the 2001 Plan and the Update

USGS Gages	Dry (AFY)	Normal (AFY)	Wet (AFY)
10011500 Bear River near Utah-Wyoming State Line	85,491	136,746	202,737
10015700 Sulphur Cr above Res below La Chapelle Cr near Evanston, WY	5,307	24,237	12,851
10016900 Bear River at Evanston, WY	85,336	173,201	297,149
10020100 Bear River above Reservoir near Woodruff, UT	61,334	146,595	293,805
10020300 Bear River below Reservoir near Woodruff, UT	65,137	148,917	286,865
10026500 Bear River near Randolph, UT	27,867	125,956	315,583
10028500 Bear River below Pixley Dam near Cokeville, WY	17,170	108,316	263,711
10032000 Smiths Fork near Border, WY	75,340	130,998	207,238
10038000 Bear River below Smiths Fork, near Cokeville, WY	114,006	297,559	610,967
10039500 Bear River at Border, WY	101,937	291,128	624,727

The updated period of record has a four-year dry period with some being the driest on record. 1999 was the last wet year with the most recent four years being in the normal category.

Table 4-2 shows the total annual natural streamflow. These values are derived by summing up the flow at the final stream gage in the Basin and the total consumptive use in the Basin. The final gage in the system is 10039500 and the total consumptive use is the irrigation supply-limited consumptive use, reservoir evaporation, industrial use, and municipal and domestic use. There is no comparison to the 2001 Plan because the analyses for determining dry, normal, and wet conditions were different for the two plans.

Table 4-2: Total Annual Natural Streamflow

Dry Conditions (AFY)	Normal Conditions (AFY)	Wet Conditions (AFY)
202,790	391,981	725,580

4.1.5 KEY DITCHES

For the purposes of basin modeling, the Wyoming diversion records and other data have been gathered for key diversion structures within the Basin. Key diversions were generally defined as those diversions typically diverting at least 10 cfs, or those structures having other regulatory or operational significance within the Basin. The remaining smaller Wyoming diversions were modeled on a cumulative basis within each reach of the surface water model. Listed below are the key diversion structures; they are the same as those in the 2001 Plan:

Upper Division Key Ditches

- Hilliard East Fork
- Lannon and Lone Mountain
- Hilliard West Side
- Bear Canal
- Crown and Pine Grove
- McGraw
- Lewis
- Myers No 2
- Myers No 1
- Myers Irrigation
- Booth
- Anel
- Evanston Water Supply
- Evanston Water Ditch
- Rocky Mountain Blythe
- John Sims
- SP
- Chapman
- Morris Brothers
- Tunnel
- Francis Lee
- Bear River Canal
- Pixley Dam
- BQ Dam

Central Division Key Ditches

- Quinn Bourne
- Button Flat
- Emelle
- Cooper
- Covey
- VH Canal
- Goodell
- Whites Water
- S. Branch Irrigating
- Alonzo F. Sights
- Oscar E. Snyder
- Cook Brothers

Diversion data for these structures was obtained from the Bear River Commission and SEO. Similar to the stream gages, the diversion data were organized into the corresponding dry, normal, and wet conditions. The dry, normal, and wet conditions used to define the diversion data corresponds to the hydrologic condition of the gage immediately upstream of each diversion. For example, if "Gage X" has dry year conditions for 1970, 1972, 2006, and 2008, then these years were used to determine the dry year diversion amounts for the diversions downstream of said gage. The results from the surface water models are presented in Chapter 5.

4.1.6 SURFACE WATER QUALITY

It is difficult to define water quality for the entire basin. There are a variety of natural conditions and land uses that can affect surface water quality and the Bear River Basin is no exception, even though it is a relatively small basin within Wyoming. The purpose of this section is to summarize information presented in the Bear River Basin Water Plan, Final Report (Forsgren Associates, Inc., 2001) and to present new data and information that has been developed since the completion of that plan.

4.1.6.1 SURFACE WATER QUALITY ISSUES FROM THE 2001 PLAN

Authors of the 2001 Bear River Basin Plan used Total Dissolved Solids (TDS) as a surrogate measure for determining surface water quality. This measure was selected because it provides an easily calculated parameter and assessment of overall water quality. Forsgren Associates used five USGS gages where water quality data were collected over an extended period of time. The water quality standards set for groundwater by the Wyoming Department of Environmental Quality, Water Quality Division (DEQ) were used to evaluate the data since there are no set standards for TDS in surface water. Using TDS as a standard, surface water quality within the

Bear River Basin of Wyoming was found to be of acceptable quality for the designated uses. Forsgren Associates (2001) specifically note that "surface water in the Bear River and Smiths Fork is of sufficient quality for domestic use" and that "surface water, in Twin Creek, is of sufficient quality for livestock and agricultural use." Water quality standards for TDS are presented in Table 4-3.

Table 4-3: Water Quality Standards for Total Dissolved Solids (TDS)

Water Use	Domestic (mg/l)	Agricultural (mg/l)	Livestock (mg/l)
TDS Standard	500	2,000	5,000

Adapted from Wyoming Department of Environmental Quality, Water Quality Division, Chapter 8, Water Quality Rules and Regulations, Quality Standards for Wyoming Groundwaters 2007; and Forsgren Associates, Inc. 2001.

4.1.6.2 DISCUSSION OF CURRENT WATER QUALITY ISSUES AND CHANGES

This section discusses current water quality issues in the Bear River Basin compared to the issues discussed in the 2001 Plan.

Current water quality in the Bear River Basin was examined using TDS, the same methodology as was used in the 2001 Plan. The same five gaging stations were used and TDS data were calculated and compiled for the years 1999 to 2008. These data sets were considerably smaller than the data sets used in 2001 but do provide an adequate water quality evaluation when compared directly to, and then combined with the original data sets. Results are presented in Table 4-4; there have not been noticeable water quality changes within the Basin. Bear River and Smiths Fork water quality is suitable for agriculture, livestock, and domestic use while Twin Creek is suitable for agricultural and livestock use. Soils in the Twin Creek watershed are derived primarily from marine and saline lake sediments, which help account for the higher TDS concentrations.

Table 4-4: Bear River Surface Water Quality – Average Calculated TDS for Five Stations on Bear River

Station Name	Station Number	2001 Plan TDS Data (mg/l)	2011 TDS Data (mg/l)	Combined TDS Data (mg/l)
Bear River near Woodruff	10020100	238	247	259
Twin Creek	10027000	565	536	562
Smiths Fork at Cokeville	10035000	222	218	220
Bear River below Smiths Fork	10038000	340	334	330
Bear River at Border	10039500	338	338	341

Major surface water quality problems within the Bear River Basin and adjoining states are related to sediment and nutrients loads. High water temperatures and low dissolved oxygen are also problems in some areas. Concern for these water quality problems is centered on the Bonneville cutthroat trout and water quality in Bear Lake (Wyoming Department of Environmental Quality, Water Quality Division [DEQ] 2008). The Bonneville cutthroat trout was petitioned for listing as threatened under the Endangered Species Act in 1998. It was determined by the USFWS in 2001, that listing was not warranted, because self-sustaining populations are well distributed throughout their historic range and are being protected in all currently occupied watersheds.

Water quality assessments of the Bear River were completed by DEQ in 1995, 1996 and 1998, and indicate it is supporting designated use as a cold water fishery above Sulphur Creek. Monitoring was also conducted below Sulphur Creek in 1998 and those data indicate that Bear River between Sulphur Creek and Woodruff Narrows Reservoir is only partially supporting aquatic life uses due to sediment deposition. Much of this reach has channelized, resulting in the loss of trout habitat. This reach was placed on the 303(d) List in 2002 and has remained on the list through 2010 (DEQ 2010).

The Uinta County Conservation District formed the Upper Bear River Water Quality Steering Committee whose mission was to develop a plan to improve and maintain water quality in the Upper Bear River Basin. The Upper Bear River Watershed Management Plan was published in September 2005 with the aim to improve and maintain water quality in the Upper Bear River, to support all designated uses through public education, public awareness, and voluntary application of feasible Best Management Practices. This plan is currently being implemented.

Bridger Creek is the only other stream within the Bear River Basin currently listed on the 303(d) List. Erosion causing increased sediment and phosphorous loading threatens aquatic life. Recent monitoring studies recommend changes in grazing management that could address erosion issues (DEQ, 2010). All 303(d) listed streams are shown on Figure 4-3.

DEQ surface water quality standards were presented in the 2001 Plan, Chapter 4. The stream classification system was subsequently changed after the plan was published and those changes were adopted by DEQ in April 2007. The revised stream classification system is presented in Appendix B. Classification of streams and stream segments in the Bear River Basin can be found in Wyoming Surface Water Classification List, Wyoming Department of Environmental Quality, Water Quality Division, 2001. The Bear River and most of its major tributaries are listed as class 2AB. The definition of class 2AB streams is presented below.

> *<u>Class 2AB</u> waters are those known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where a game fishery and drinking water use is otherwise attainable. Class 2AB waters include all permanent and seasonal game fisheries and can be either "cold water" or "warm water" depending upon the predominance of cold water or warm water species present. All Class 2AB waters are designated as cold water game fisheries unless identified as a warm water game fishery by a "ww" notation in the "Wyoming Surface Water Classification List". Unless it is shown otherwise, these waters are presumed to have sufficient water quality and quantity to support drinking water supplies and are protected for that use. Class 2AB waters are also protected for nongame fisheries, fish consumption, and aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value uses.*

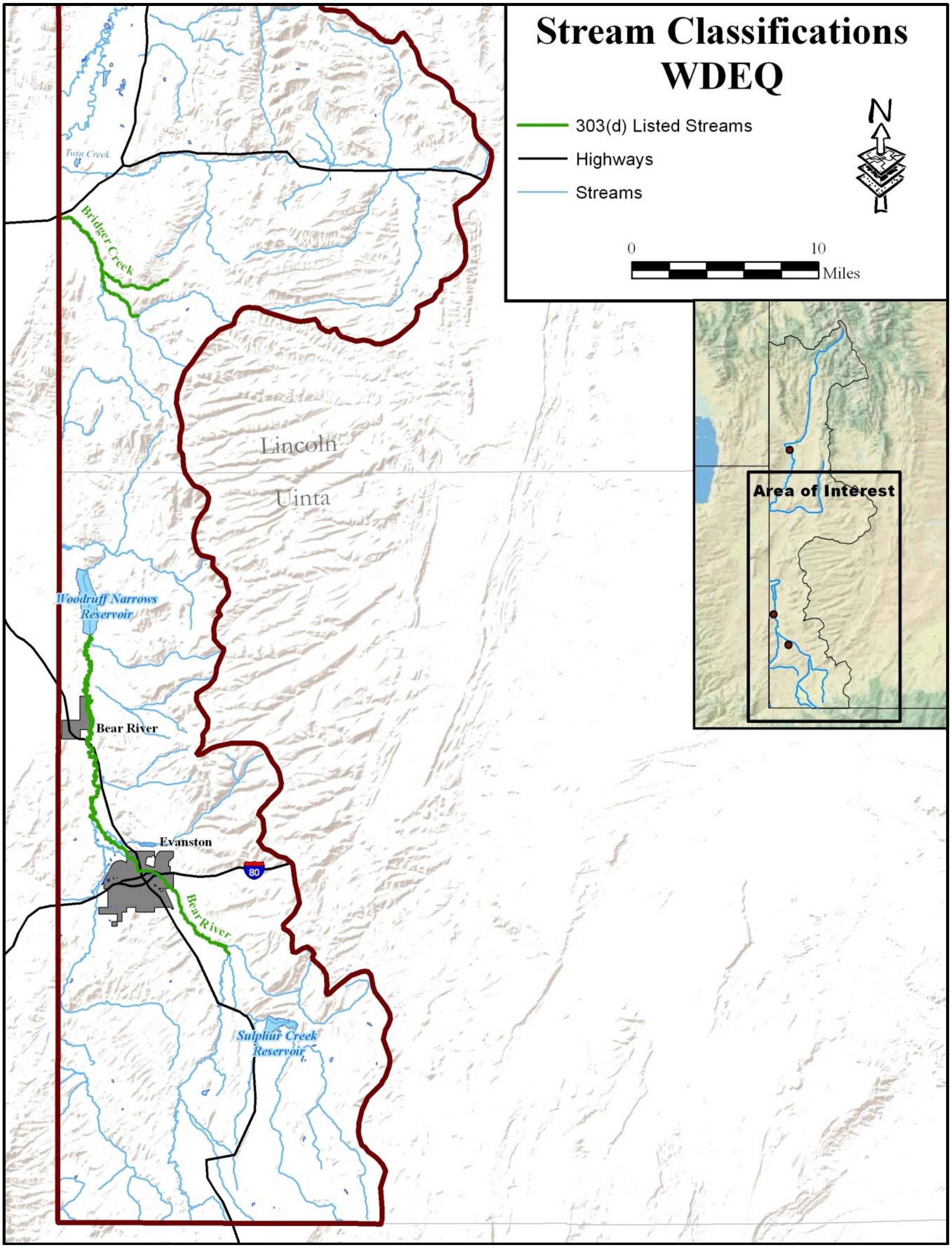

Figure 4-3: Wyoming Department of Environmental Quality 303(d) Listed Streams

4.2 GROUNDWATER

The Bear River Basin is situated along the southwestern border of the State of Wyoming, with adjacent portions of the drainage basin located in Idaho and Utah. The topographic and geologic features of the Basin are reflected in the low relief areas that are relatively flat-lying and generally underlain by Cenozoic unconsolidated deposits and bedrock formations. The steeper mountain uplifts and ridges are commonly cored by the older Paleozoic and Mesozoic bedrock formations.

The hydrogeologic units are various aquifers and confining units within the Basin and include unconsolidated sedimentary deposits and consolidated (lithified) bedrock formations ranging in age from Quaternary to Precambrian. The hydrogeologic units vary widely in lithology and water-bearing properties. Aquifers are described as occurring in four major aquifer groups based on geologic time and the stratigraphic columns for the Basin areas.

The large regional aquifer systems discussed in the 2001 Bear River Basin Plan, were reevaluated for this study and redefined, including combining some of the separate units from Appendix O – Ground Water Resource Investigation (Forsgren Associates, Inc., 2000). Major aquifers and confining units located within the Basin were grouped on the basis of the four geologic eras: the Cenozoic, Mesozoic, Paleozoic, and Precambrian, from youngest to oldest. Therefore, four major regional aquifer groups have been identified in the Bear River Basin. The major aquifer groups are shown on Figure 4-4 by hydrogeologic unit, in descending geologic order:

- Cenozoic aquifer group;
- Mesozoic aquifer group;
- Paleozoic aquifer group; and
- Precambrian aquifer group.

The Precambrian aquifer group is not shown on the figure since it does not surface in the Wyoming portion of the Bear River Basin. Precambrian rocks underlie the Basin but at depths that limit its potential as an aquifer.

This comprehensive major aquifer group classification, based on the geologic eras, allows any geologic unit to be included in one (or more) of these four major systems. This approach is applicable across the State of Wyoming, although there will be some discrepancies based on combinations of geologic time-transgressive units. For example, combined units are mapped such as Paleozoic-Mesozoic rocks, and other formations cross time boundaries like Permian-Triassic or Pliocene-Pleistocene. In these cases, a geologic evaluation of the thickest portion of the formations was conducted to assign a combined or geologic time-transgressive unit to an aquifer system corresponding to the majority of the geologic unit's thickness.

The classification of the four major aquifer groups is also applicable to the geologic units of other adjoining states (Idaho and Utah) with adjoining hydrogeology. A geologic map and discussions of the geologic units of the Bear River Basin are included as an appendix to the groundwater technical memorandum (Volume 2, Tab: V (2011)).

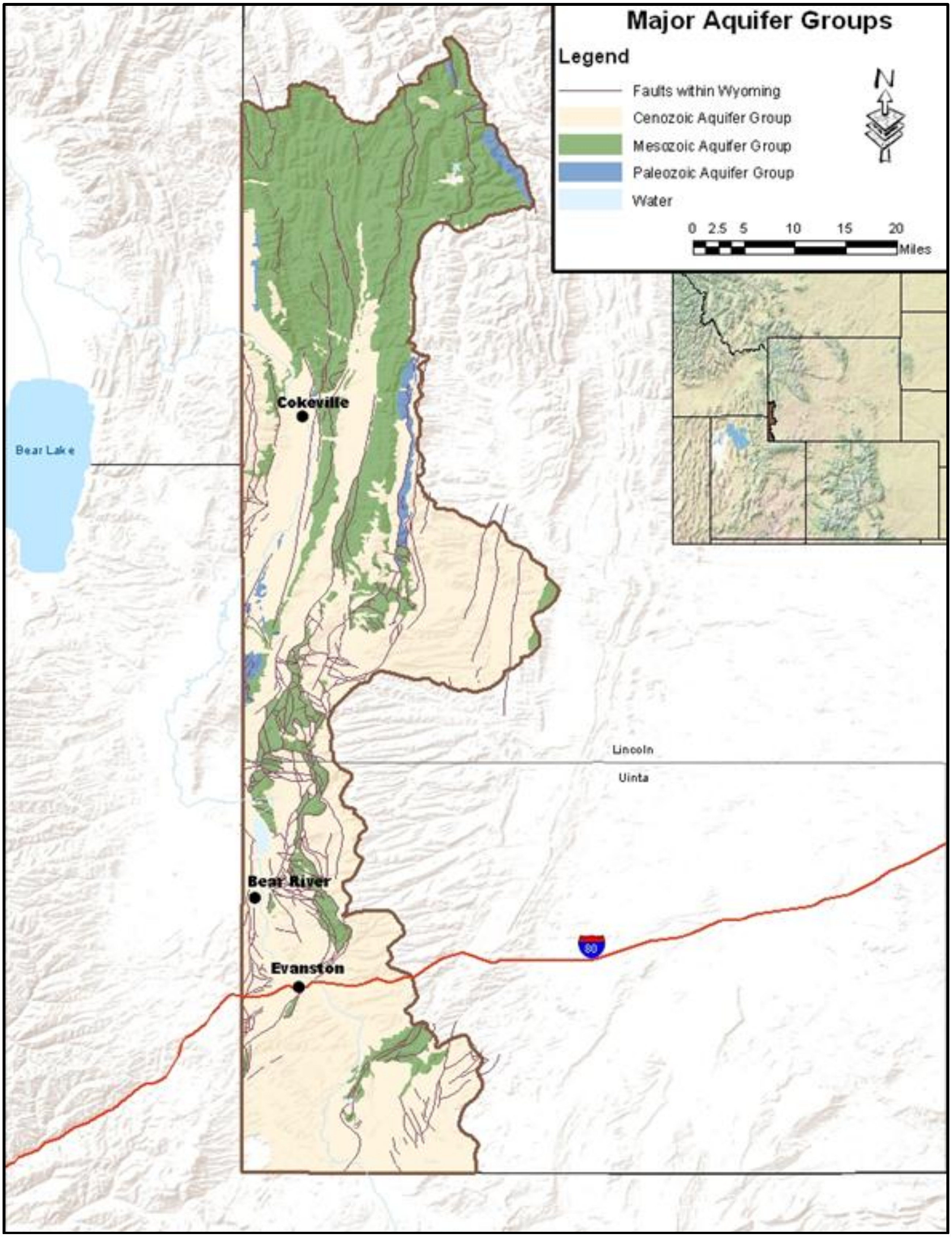

Figure 4-4: Major Aquifer Groups of the Bear River Basin

In the Bear River Basin, the Quaternary unconsolidated deposits and most of the Tertiary bedrock formations (Cenozoic aquifer group) are relatively flat-lying and unconformably overlie the older, intensely deformed Mesozoic and Paleozoic bedrock formations. The contact between the relatively flat-lying geologic units with the underlying formations is commonly an erosional and angular unconformity. The structurally deformed Mesozoic and Paleozoic bedrock formations generally act as fault-severed, fault-bounded, and structurally controlled groundwater compartments. However, in some local fold-fault structures, the fracture-enhanced permeability of the bedrock can greatly increase the yield of wells in these formations. The most heavily used aquifer within the Bear River Basin consists of the Quaternary alluvial deposits located along the Bear River Valley and the associated unconsolidated deposits. The second most heavily used aquifer includes the Tertiary formations, especially the extensive Wasatch Formation.

Complex recharge-discharge interactions occur between the surface water and groundwater within some areas of the Bear River Basin. Surface water infiltrates permeable geologic units and groundwater discharges from the subsurface to surface water through springs and as underflow directly into stream drainages.

The inferred regional groundwater flow patterns would generally flow from the higher elevation areas towards the lowest local topographic elevations located along the Bear River Valley and associated tributary streams.

4.2.1 GROUNDWATER QUANTITY

The SEO groundwater supply report (1973) calculated the total quantity of groundwater available in the saturated portion (aquifer) of the alluvial deposits of the Bear River Basin to be approximately 4,250,000 acre-feet. If a specific yield is assumed as 18% for these deposits, then the total quantity of groundwater in storage within the alluvial aquifer (Cenozoic aquifer group) is approximately 765,000 acre-feet in the Bear River Basin (4,250,000 acre-feet x 18% = 765,000 acre-feet).

In order to calculate the amount of groundwater available in the bedrock aquifers (Mesozoic and Paleozoic aquifer groups) of the Bear River Basin, start with 1-square mile section in the basin, and assume the ground surface is level and a useable aquifer extends down 1,000 ft deep. The surface area of the section is 27,878,400 square ft, and the volume is 27,878,400 square ft x 1,000 ft = 27,878,400,000 ft^3 (27.9 billion ft^3). If the static water level ("water table" or groundwater surface) is assumed to be at 50 ft below the ground surface, the water saturation is 95% (950 feet) of the 1,000 ft deep section.

The porosity of bedrock formation aquifers is widely variable (from 0 to 30+ %) and with an assumed average 10% porosity. Using the average 10% porosity value, the acre-feet per square mile can be calculated:

27,878,400,000 ft^3 x 95% saturation x 10% porosity
= 2,648,448,000 ft^3 of water in aquifer storage x 7.48 gallons/ft^3
= 19,810,391,000 gallons (325,851.43 gallons/acre-ft)
= 60,796 acre-ft per square mile in storage

If 60,796 acre-feet per square mile is used for groundwater contained in a 95% saturated aquifer (10% porosity) down to a depth of 1,000 ft deep (approximate depth limit for acceptable groundwater quality), and take the whole mapped area of the Wyoming Bear River Basin (1,500 square miles), the maximum volume of groundwater contained within the aquifers of the Basin can be estimated:

Groundwater of 60,796 acre-ft/square mile x 1,500 square miles
= **92,194,000 acre-feet of groundwater in maximum aquifer storage**.

This maximum quantity of 92.2 million acre-feet includes both recoverable and non-recoverable groundwater. Not all water that is contained within a geologic unit (unconsolidated deposit or bedrock formation) can be removed from that unit. The "specific yield" of an aquifer is considered to be the "effective permeability" of an aquifer, or another way of stating it is that it is the volume of groundwater that can be recovered by pumping a well per unit volume of that aquifer. Assuming an average specific yield for bedrock formations of approximately 18.5% [ranges from 12 to 27 % (Johnson, 1967)], the amount of water available to pumping wells can be calculated:

91,194,000 acre-feet maximum groundwater volume x 18.5% specific yield
= **16,870,890 acre-feet of groundwater is available to pumping wells**.

If approximately 16.9 million acre-feet of groundwater is the total amount of groundwater available to wells in the Bear River Basin and the amount of groundwater available in the alluvial aquifers is subtracted (765,000 acre-feet; SEO, 1973):

16,870,890 acre-feet (groundwater available) – 765,000 acre-feet (alluvial aquifers)
= **16,105,890 acre-feet of groundwater is available in bedrock aquifers.**

In summary, for this update of the Bear River Basin Plan, these calculations show that there are approximately:

- 91,200,000 acre-feet of maximum volume of groundwater contained within the geologic units of the Bear River Basin (maximum aquifer storage = recoverable and non-recoverable water), but not all of this water is available to be extracted by pumping wells.
- 765,000 acre-feet of groundwater available in alluvial aquifers to wells (SEO, 1973);
- 16,100,000 acre-feet of groundwater available in bedrock aquifers to wells; and
- 16,800,000 acre-feet total groundwater available in aquifers of the Bear River Basin to wells (effective aquifer storage).

Based on these assumptions and calculations, approximately 16.1 million acre-feet of groundwater may be available (recoverable) for development from wells constructed in the saturated bedrock formations of the Bear River Basin of Wyoming. This very large estimated quantity of groundwater available in the bedrock formations greatly exceeds the current use of groundwater within the Basin which is approximately 3,125 acre-feet per year.

As to an estimate of the annual water recharge to the aquifers of the Bear River Basin, WWC Engineering (2007) and Forsgren Associates (2001) estimated the total quantity of annual recharge to the aquifers in the Basin to be 14,000 acre-feet/year. This annual recharge estimate was based on the assumption that aquifer recharge was equal to 2% of the average annual precipitation in the Basin (WWC Engineering, 2007). This 14,000 acre-feet/year quantity is likely a very conservative estimate and it is probably an underestimate or a low-end estimate for river basin planning purposes. Earlier, the amount of annual natural recharge to solely the alluvial aquifer in the Bear River Basin was estimated to be 50,000 acre-feet/year of groundwater during an average year, excluding artificial recharge from irrigation water (SEO, 1973).

These two estimated annual groundwater recharge quantities ranging from 14,000 acre-feet/year for all aquifers (WWC Engineering, 2007) to 50,000 acre-ft/yr to only the alluvial aquifers (SEO, 1973) should conservatively be considered the maximum annual limit of groundwater use that could be safely developed in the Basin for a long-term sustainable yield. With the current annual groundwater use estimated at 3,125 acre-feet/year, there is sufficient room for the future development of additional groundwater resources in the Bear River Basin. This Basin update report recommends that actual field investigations of groundwater recharge in the Bear River Basin be conducted to help determine a realistic and accurate estimate of annual recharge quantities for the Basin aquifers.

4.2.2 GROUNDWATER QUALITY

The quality of the groundwater available in the Bear River Basin is widely variable and ranges from very good to very poor. Groundwater quality generally depends on the geochemistry of the soils, sediments, and bedrock that the water encounters while traveling to the aquifer storing the water and also of the geochemistry of the aquifer host. Groundwater tends to increase in total dissolved mineral content the farther distances and deeper depths that the water travels while in contact with soluble chemicals (minerals) as earth materials (soils and rocks). Time is another factor affecting groundwater quality because the longer the water remains in contact with soluble chemicals, the higher the total dissolved solids of the water becomes.

Overall, shallow groundwater tends to be of the calcium-sulfate-type of water chemistry and deeper groundwater tends to be of the sodium-bicarbonate-type. Groundwater in the Preuss Sandstone (Preuss Redbeds), or other formations that are in close hydrologic connection with this geologic formation, may contain elevated levels of sodium chloride (table salt) because of the rock salt (evaporite minerals) deposits contained within parts of the formation.

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5.0 CURRENT WATER USE

5.0 CURRENT WATER USE

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5.0 CURRENT WATER USE

5.1 AGRICULTURAL WATER USE

Agriculture is the largest consumer of water in the Bear River Basin. The majority of agricultural water is used for flood irrigation of crops. Most irrigation is surface water with a small amount of groundwater used as a supplemental supply. Another part of agricultural water use is contributed by livestock. Livestock water consumption is a small percentage (approximately 0.4%) of the overall agricultural use and comes from both surface and groundwater.

5.1.1 AGRICULTURAL SURFACE WATER USE

Flood irrigation of crops makes up the majority of surface water use in the Basin. Understanding the consumption of surface water irrigation depends upon the amount of water being diverted; the diversion, conveyance and application efficiency; the type of crops being irrigated; and the total acreage of each crop. For this update, there were no changes from the 2001 Plan (Forsgren Associates 2001) to the crop consumptive use determination methodology, irrigated acreage, key ditches, crop types, or irrigation practices. In addition, the same consumptive use model, Colorado's StateCU, was used to further evaluate supply limited consumptive use in the Basin and the full supply diversion requirement calculation. The hydrologic period of record was updated and the method of determining wet, normal and dry years was changed as discussed in Chapter 4 Section 4.1.

5.1.1.1 DIVERSIONS

Updated diversion records (1998 – 2008) provided by the Bear River Commission and the SEO Hydrographer Reports were compiled in spreadsheets. Tables 5-1 and 5-2 show the key ditch systems for the Upper and Central Divisions respectively in an upstream to downstream order. The average annual diversions for the period 1971 through 2008 are shown. These values are not based on the hydrologic conditions. The data used to develop the tables were further analyzed and categorized into three hydrologic conditions: dry, normal, and wet. A spreadsheet model was developed for each of these conditions. The updated diversion data were categorized as dry, normal, and wet based upon the condition assigned to the stream gage data upstream of the particular diversion. A detailed explanation of the analysis can be found in Diversion Operation Technical Memorandum (Volume 2 Tab: II) for this update.

It should be noted that the diversion amount is not the actual amount of water that irrigates the crops. There is an efficiency factor for diversion, conveyance, and application method that is multiplied by the diversion amount. The efficiency patterns used in the 2001 Plan were used for this update. The water lost to efficiency calculations later reenters the system as return flows. The amount remaining after the efficiencies are applied is the amount of water available to the crop.

Table 5-1: Upper Division Key Ditch Systems

Key Ditch Systems	Average Diversion (AFY)
Hilliard East Fork	2,799
Lannon and Lone Mountain	3,137
Hilliard West Side	4,242
Bear Canal	8,358
Crown and Pine Grove	3,935
McGraw	3,972
Lewis	1,147
Myers No 2	1,022
Myers No 1	846
Myers Irrigation	941
Booth	2,542
Anel	1,298
Evanston Water Supply	930
Evanston Water Ditch	3,331
Rocky Mountain Blythe	2,297
John Sims	2,719
SP	2,490
Chapman	18,139
Morris Brothers	807
Tunnel	2,784
Francis Lee	6,122
Bear River Canal	8,727
Pixley Dam	7,445
BQ Dam	13,886
TOTAL	***103,916***

Table 5-2: Lower Division Key Ditch Systems

Key Ditch Systems	Average Diversion (AFY)
Quinn Bourne	1,225
Button Flat	592
Emelle	2,000
Cooper	1,214
Covey	14,540
VH Canal	2,761
Goodell	1,776
Whites Water	5,063
S. Branch Irrigating	3,610
Alonzo F. Sights	2,677
Oscar E. Snyder	3,832
Cook Brothers	8,746
TOTAL	***48,036***

5.1.1.2 CROPS AND MAPPING

The irrigated acreage, crop types, and irrigation practices were not changed from the 2001 Plan. During this study, the SEO began working to update the irrigated acreage mapping in the Basin, and to assign a one-to-one relationship between the irrigated land and the source of supply. These updated data, however, were not complete by the end of this update.

Irrigated acres in the Upper Division and Central Division are shown in Table 5-3. The majority of irrigation in the Basin is for hay or pasture. In the 2007 Statewide Framework Water Plan (WWC, 2007), approximately 92.2% of cropland was reported as being used for grass hay and pasture, with the remaining 7.8% being used to grow alfalfa for hay and forage. These percentages are roughly equivalent to 58,916 acres and 4,984 acres respectively.

Table 5-3: Irrigated Acreage in the Bear River Basin, Wyoming[1]

Location	Irrigated Acreage
Upper Division	40,400
Central Division	23,500
Total	***63,900***

1. This table is taken from the 2001 Bear River Basin Plan

5.1.1.3 Irrigation Water Requirements and Supply Limited Consumptive Use

The StateCU model developed in the 2001 Plan was updated and used to evaluate irrigation water requirement and supply limited consumptive use. The irrigation water requirement (IWR) is calculated by subtracting the monthly effective precipitation from the crop consumptive use (CU). CU is the amount of water the crop would use if it had a full water supply. Supply limited consumptive use is what the crop actually uses from the diverted water. The following tables (Tables 5-4 and 5-5) compare the IWR and supply limited CU between the 2001 Plan and this update. The increase in IWR and decrease in supply limited CU is consistent with drier conditions and less water supply during the most recent drought period in the early 2000's.

Table 5-4: Average Annual Irrigation Water Requirements

Location	2001 Basin Plan (AFY)	2011 Basin Plan Update (AFY)
Upper Division	64,300	65,042
Central Division	32,600	34,362
Total	***96,900***	***99,404***

Table 5-5: Average Annual Supply-Limited Crop Consumptive Use Estimates

Location	2001 Basin Plan (AFY)	2011 Basin Plan Update (AFY)
Upper Division	62,600	58,671
Central Division	31,600	32,538
Total	***94,200***	***91,209***

5.1.1.4 Livestock Consumptive Water Use

Livestock consumptive water use is a small percentage of the total consumptive use in the Basin. The livestock CU is estimated to be 350 acre-feet for this update compared to 528 acre-feet calculated in the 2001 Plan. The methodology used to determine livestock CU for the update is the same as was used in the 2001 Plan. The 2001 Plan used permitted animal-units-month (AUM) for the allotments in the Basin to calculate this consumptive use. The methodology is described in the following excerpt taken from Appendix Q of the Bear River Basin Plan http://waterplan.state.wy.us/plan/bear/techmemos/futureconditions.html:

> *In order to standardize the analysis in terms of livestock forage levels, county level livestock inventories were converted to "Animal Units." This metric is equal to the sum of cattle inventories divided by two and sheep inventories divided by five, and represents a measure of the average livestock inventory.*

> *In order to scale the analysis from the county to the basin level, estimated trends are applied to Basin-specific allotment data, obtained from the BLM, on the stocking capacity of each allotment within the Basin as measured in animal unit months (AUMs). AUMs are then converted to Animal Units by dividing by the average length of time that livestock spend grazing on public rangeland (3.59 months).*

The Bureau of Land Management (BLM) Kemmerer Field Office provided a map of the allotments in Uinta and Lincoln Counties. The map included the allotment's total acreage and the percentage of private and public land within the allotment. With the use of GIS, the allotments were clipped to the Bear River Basin boundary and that information was used to define the acreage of each allotment within the Basin. It was assumed that the percentage of public and private lands in each allotment were proportionate for the full allotment and its clipped allotment. With the Basin's allotments defined, the BLM's Rangeland Administration System (RAS) website was used to obtain the authorized use for each allotment. The RAS provided the AUMs permitted for each allotment and the amount of private and public land therein. The RAS data is for 2011; attempts to get 2008 data were unsuccessful, however, allotment use is fairly static so the 2011 data is applicable to this analysis. The AUMs were converted to AUs following the above method and a factor of 0.02 acre-feet per animal unit was used to calculate the livestock CU. The 0.02 factor is calculated by assuming that an AU consumes 17.5 gallons daily as taken from the 2001 Basin Plan.

5.1.2 AGRICULTURAL GROUNDWATER USE

Predominant agricultural groundwater use in the Bear River Basin includes irrigation and livestock watering. A total of 42 active SEO permitted irrigation wells located within the Basin, including 24 wells with yields ranging from 500 to 4,150 gallons per minute (gpm) and 18 wells with yields from 10 to 400 gpm (SEO, 2009). Most of these irrigation wells are less than 300 feet deep and are constructed into Quaternary unconsolidated alluvial and associated unconsolidated deposits of Quaternary and Tertiary ages and part of the Cenozoic Aquifer Group.

Crop consumptive use from groundwater was estimated to be 1,900 acre-feet in the 2001 Plan, and this estimate is used in this update.

5.1.3 SUMMARY OF AGRICULTURAL WATER CONSUMPTIVE USE

Table 5-6 presents a comparison of the average annual consumptive use for surface water, groundwater, and livestock. Decreased water supply, diversions, and cattle numbers account for the decrease in the overall consumptive water use in the Basin.

Table 5-6: Average Annual Agricultural Consumptive Use Comparison

Source	2001 Basin Plan (AFY)	2011 Basin Plan Update (AFY)
Surface Water	92,300	89,309
Groundwater	1,900	1,900
Livestock	528	350
Total	***94,728***	***91,559***

Note: Groundwater crop consumptive use remains the same as presented in the 2001 Plan.

Table 5-7: Average Annual Percent Shortages

Location	2001 Basin Plan	2011 Basin Plan Update
Upper Division	2.6%	9.9%
Central Division	3.1%	5.3%
Total Bear River Basin	***2.8%***	***8.2%***

5.2 INDUSTRIAL WATER USE

In the 2001 Plan, there were only two self-supplied industrial users in the Basin, Chevron and BP Amoco. These energy companies use water for natural gas processing in the Painter Resource Unit and the Whitney Canyon/Carter Creek Unit.

The Chevron Whitney Canyon/Carter Creek processing plant uses surface water from Woodruff Narrows Reservoir, which is supplied by a pipeline. The BP Amoco plants use groundwater supplies from bedrock aquifer wells. Chevron at the Whitney Canyon/Carter Creek plant uses a water intensive processing method while BP Amoco used a less water intensive processing method for processing natural gas.

The 2001 Plan indicated that 310 acre-feet of surface water and 90 acre-feet of groundwater were used per year for natural gas processing. Natural gas production has decreased in the units and processing has become more water efficient, reducing the amount of water used. In 2002, Chevron changed the manner of processing natural gas at their facility and now only needs 5% as much water as before (Matthews, 2009). They are now using between 22 and 37 acre-feet of water per year for natural gas processing. Additionally, BP Amoco closed their Whitney Canyon/Carter Creek processing facility in the fall of 2007 (Villanova, 2009). Chevron now processes both their gas production and the BP Amoco production from that field unit.

From 2000 to 2007, BP Amoco was using about 82 acre-feet of groundwater per year for natural gas processing at their two plants. In 2008, they used about 5 acre-feet of groundwater for the facilities and gas processing. After the closing of the Whitney Canyon/ Carter Creek facility, an average of only 2.6 acre-feet are used annually to maintain the plant. Currently their Painter plant also uses about 2.6 acre-feet of water annually.

Currently there are approximately 22 to 37 acre-feet of surface water and about 5 acre-feet of groundwater being used for industrial production annually in the Basin.

5.3 MUNICIPAL USE

5.3.1 DATA TECHNIQUES AND METHODS

Municipal water use is an important component to all river basin planning efforts. As is the case across Wyoming, municipal use in the Bear River Basin is not the largest use. However, it is important and depends on an uninterrupted supply. This section of the report outlines the origin of the data used to calculate current municipal use and the methods used to calculate the results presented in the report.

5.3.1.1 POPULATION ESTIMATES AND PROJECTIONS

Municipal water use is directly tied to population. To get an accurate understanding of how water use has changed across the Bear River Basin since 2001, population estimate data were collected from the AIEAD. Population estimates are available on the AIEAD's website for every year since the completion of the first Bear River Basin Plan. See Tables 5-8 and 5-9 for municipal population data from the 2001 Plan and 2009 Population Data from AIEAD.

Table 5-8: Municipal Water Systems Population (2001 Basin Plan Data)

Location	Lincoln County 2001	Uinta County 2001	Total 2001
Evanston	--	12,200	12,200
Cokeville	497	--	497
Rural Domestic	480	2,000	2,480
Total Basin	***997***	***14,200***	***15,177***

Table 5-9: Municipal Water Systems Population (2009 AIEAD Estimate)

Location	Lincoln County 2001	Uinta County 2001	Total 2001
Evanston	--	11,773	11,773
Cokeville	501	--	501
Bear River[1]	--	162	162
Rural Domestic	358	2,284	2,642
Total Basin	***859***	***14,219***	***15,078***

1. Service area population is calculated. The municipal population is estimated to be 513.

Most population data are available by either municipality or by county. This presented a minor problem because county boundaries don't match hydrologic boundaries. To determine the population of the Basin, WenLin Liu, an AIEAD economist, was asked to calculate the Basin specific population for 2007, 2008, 2009, and 2010. The Basin's projected population for 2030 was also provided. The information that Liu provided was used to compare the recent population estimates to the high and low growth projections from the previous plans. Figure 5-5 shows the population growth projections from the 2001 Plan and the estimated population for 2007, 2008, 2009, 2010, and 2030.

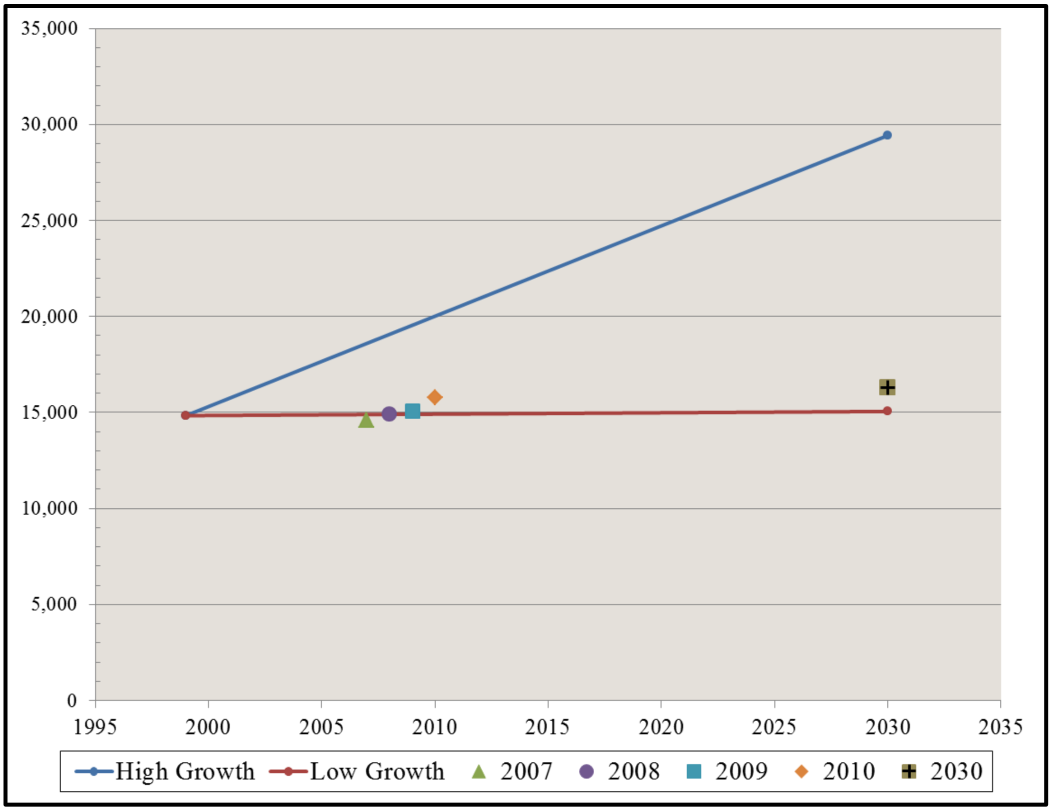

Figure 5-1: Bear River Basin Population and Projections

5.3.2 MUNICIPAL WATER USE DATA

Data were gathered from several sources for the analyses completed in this section of the report. One primary source of data was the 2009 Water System Survey Report (WDC, 2009) http://wwdc.state.wyu.us/watsys/2009/raerept.html. In addition to the data used from the Water System Survey Report, phone calls were made to each of the three municipalities in the Basin. Municipalities were asked various questions about their water systems including peak day demand, winter non-irrigation demand, number of connections to the water system, and waste water treatment plant return flows.

Not all data from the water system survey report were accurate. Where inaccurate data were found, data were corrected from other sources, such as phone call data or other WDC reports. Inaccuracies in data reported from the Town of Bear River illustrate this point. Data in the 2009 Water System Survey report was incorrect for the town, therefore data gaps were filled in from a memo provided by Sunrise Engineering for the Level III Regional Pipeline construction project (Sunrise Engineering, 2008) as well as phone conversations with town officials.

Water withdrawal was calculated using the municipal populations provided by the AIEAD and the water use rate, and the average gallons per capita per day (gpcpd) was calculated or obtained from the data sources described above.

5.3.2.1 EVANSTON MUNICIPAL WATER USE

There have been a few changes to the Evanston municipal water system since the 2001 Plan was completed. One is the addition of a new 18-hole golf course. Also, the 2001 Plan reported that Evanston had 3,782 connections to its municipal system. In 2009, the municipality reported 4,200 connections which is an increase of 418. However, despite the increase in municipal water connections, the service area population used in the 2001 Plan was 12,200, and the service area population in 2009 was 11,773.

The difference in population numbers is most likely due to the release of data from the 2000 Census, which was not available when the 2001 Plan was being drafted. The 2000 Census reported the actual population of Evanston to be 11,507. This is approximately 700 people less than the estimates used in the 2001 Bear River Basin Plan. Evanston's surface water withdrawals, based on population and average daily water use, are shown in Table 5-10.

Table 5-10: Evanston Municipal Water Withdrawals

Year	Municipal Population	Avg. Day (gpcpd)	Peak Day (gpcpd)	Avg. Day (MGD)	Peak Day (MGD)	Withdrawal (AFY)
2001	12,200	316	--	--	--	4,300
2007	11,483	266	644	3.05	7.40	3,416
2008	11,443	310	804	3.55	9.20	3,974
2009	11,773	310	780	3.65	9.20	4,088

Using the information provided in the 2009 Water Systems Survey, and information gathered from phone calls to city staff (personal communication, Hansen, 2009), Evanston's consumptive use was calculated (see Table 5-11).

Table 5-11: Evanston Consumptive Water Use

Year	Municipal Population	Avg. Day (gpcpd)	Avg. Day (MGD)	Surface Water Withdrawal (AFY)	Avg. Annual Wastewater Discharge (AFY)	Surface Water Consumed (AFY)
2001	12,200	316	3.86	4,300	1,547	1,000
2009	11,773	310	3.65	4,088	1,680	2,408

Specific information describing how consumptive use was calculated for Evanston in the 2001 Plan was not available, and therefore, a direct comparison of the current consumptive use estimate and that provided in the 2001 Plan is not possible. The 2001 Plan presented a consumptive use estimate of 1,000 acre-feet per year. If consumptive use is calculated for 2001 using the current method, Evanston's consumptive water use would have been 2,753 acre-feet per year.

5.3.2.2 COKEVILLE MUNICIPAL WATER USE

The 2001 Plan reported 160 connections to the town of Cokeville's water system. In 2009, the number of connections was reported to be 172. The increase in municipal water connections did not, however, correspond to a commensurate increase in service area population. The estimated population increased between 2001 and 2009 by only 5 people.

Cokeville's gpcpd use estimates are considerably higher than the other municipalities in the Basin. The primary reason for this is that their water system has historically been a "flow through" system. Cokeville's original water supply was from springs and the water was gravity fed to town. With very little reason for restricting use, water was left to continually flow through the system. Because of this, not all of the water lines in town were buried below frost depth, and as a result this practice has continued to prevent water lines from freezing. Cokeville's current water withdrawal can be seen in Table 5-12.

Table 5-12: Cokeville Municipal Water Withdrawals

Year	Municipal Population	Avg. Day (gpcpd)	Peak Day (gpcpd)	Avg. Day (gpd)	Peak Day (gpd)	Groundwater Withdrawal (AFY)
2001	497	1,440	--	--	--	810
2007	468	988	2,113	462,384	989,116	518
2008	491	1,361	2,015	668,251	989,116	749
2009	501	1,334	1,974	668,334	989,116	749

As with Evanston, data were gathered from the 2009 Water Rates Survey and phone calls to the town to calculate Cokeville's municipal consumptive use. Cokeville's flow through system in conjunction with its low, flat rate billing structure explains the high estimated consumptive use per capita when compared to Evanston (see Table 5-11) (personal communication, Walker, 2009).

Table 5-13: Cokeville Consumptive Water Use

Year	Municipal Population	Avg. Day (gpcpd)	Avg. Day (gpd)	Groundwater Withdrawal (AFY)	Avg. Annual Wastewater Discharge (AFY)	Groundwater Consumed (AFY)
2001	497	1,440	715,680	810	143	40
2009	501	1,334	668,334	749	84	665

Specific information describing how consumptive use was calculated for Cokeville in the 2001 Plan was not available so a direct comparison of the current consumptive use estimate and that provided in the 2001 Plan is not possible. The 2001 Plan presented a consumptive use estimate of 40 acre-feet per year. If consumptive use is calculated for 2001 using the current method, Cokeville's consumptive water use would have been 667 acre-feet per year, only 2 acre-feet more than the 2009 estimate.

5.3.2.3 BEAR RIVER MUNICIPAL WATER USE

The Town of Bear River was incorporated in June 2001after the completion of the 2001 Plan. As a result there is no information about the town of Bear River in the 2001 Plan. Water use for the area was included in the rural domestic category of the 2001 Plan.

Bear River was formed with the incorporation of five subdivisions listed below. The town's 2009 estimated population is 513 people.

- Deer Mountain 1
- Deer Mountain 2
- Hoback Industrial
- Deer Mountain Downs
- El Caballo Road

Only three of the five subdivisions that joined to form the town, Deer Mountain 1 and 2 and Hoback Industrial, are currently on the town's water system. Deer Mountain Downs and El Caballo Road are within the town limits, but have not yet connected to the town's water system. Because only portions of town are receiving water from the system, the municipal population provided by AIEPD was too high to use in the water use calculations. As a result, current water use information was obtained from a memo prepared by Sunrise Engineering (Sunrise Engineering, 2008). The memo was prepared for the regional pipeline construction project discussed later in this report. Table 5-14 presents Bear River's current water use information, which is shown to be the same for all years because of the lack of available data.

Table 5-14: Town of Bear River Municipal Water Withdrawal

Year	Service Area Population	Avg. Day (gpcpd)	Peak Day (gpcpd)	Avg. Day (gpd)	Peak Day (gpd)	Withdrawal (AFY)	
						Surface Water	Groundwater
2001	N/A	--	N/A	N/A	N/A	N/A	N/A
2007	162	285	285	46,129	46,129	0	52
2008	162	285	285	46,129	46,129	0	52
2009	162	285	285	46,129	46,129	0	52

To calculate the Town of Bear River's consumptive use, the average day use data from Sunrise Engineering's memo (2008) was used in conjunction with data obtained from phone calls to the town (personal communication, Rhodes, 2009). The peak day use is the same as the average day use because summer lawn irrigation is met with irrigation canals and wells. The raw water irrigation system currently being used was in place before the town was incorporated.

Additionally, the town of Bear River applied to the WDC for a water supply study in 2001 because their wells were having difficulty keeping up with demands. For the purposes of this plan, an assumption was made that the wells were operating at capacity and that the daily use would remain constant, out of necessity, until the regional pipeline was completed (see Table 5-15).

Table 5-15: Town of Bear River Consumptive Water Use

Year	Service Area Population[1]	Avg. Day (gpcpd)	Avg. Day (gpd)	Groundwater Withdrawal (AFY)	Avg. Annual Wastewater Discharge (AFY)	Groundwater Consumed (AFY)
2001	*These data are unavailable because Bear River was not an incorporated town in 2001. Therefore it was not included as a municipality in the 2001 Plan.*					
2009	162	285	46,129	52	25	27

1. The actual municipal population is estimated to be 513. The "Service Area Population" refers to the estimated population being served by the municipal water system.

5.3.3 REGIONAL WATER SYSTEMS

Before the town of Bear River was incorporated, the area was included in the North Uinta County Improvement and Service District. Grant funding was authorized by the WDC for a Level I master plan for the district in 1999 and the report was completed in 2000 (Forsgren Associates, 2000). The Level I master plan outlined the condition of the existing system, and recommended solutions for system deficiencies. One issue identified by the Level I master plan was the lack of an adequate water supply. The recommended long term solution for this issue was to implement a regional water system with the city of Evanston.

Following completion of the Level I study, a Level II study was conducted by the WDC to provide a detailed analysis of the regional water supply alternatives, including conceptual level designs and cost estimates. The Level II report was completed in 2005 (Sunrise Engineering, 2005). Construction grant funding was appropriated in 2006 through the WDC Water Development Program. Construction of the regional system was completed in early 2010. Figure 5-2 shows the regional water system.

In order to meet their projected demand, the town of Bear River must acquire additional water sources. According to the Level II study (Sunrise Engineering, 2005), there is water available for use under the original 1958 Bear River Compact. The availability of water allocated under this compact is not affected by the level of Bear Lake. As a result, this option was identified as a preferred alternative for the town's future water supply needs. Of the original 1958 Compact allocation, 4,100 acre-feet of storage were allocated to the Smiths Fork Reservoir Project, which has not yet been built. In recent years the Cokeville Development Company has been working with the WDO's Dam and Reservoir Division to build a reservoir to meet their water demands. The Cokeville Development Company's proposed project would use the 4,100 acre-feet of water initially allocated to the Central Division by Wyoming from its Original Bear River Compact storage allocation. Because there is a need in the town of Bear River, the SEO has given the Cokeville Development Company until December 31, 2015 to make significant progress toward use of the water identified in the compact (see Technical Memorandum I, Storage Summary (Volume 2 Tab: IV). Allocations from several smaller un-built projects were transferred to meet Bear River's present day demand (Sunrise Engineering, 2005).

Installation of the Evanston Bear River Regional Pipeline, 2009

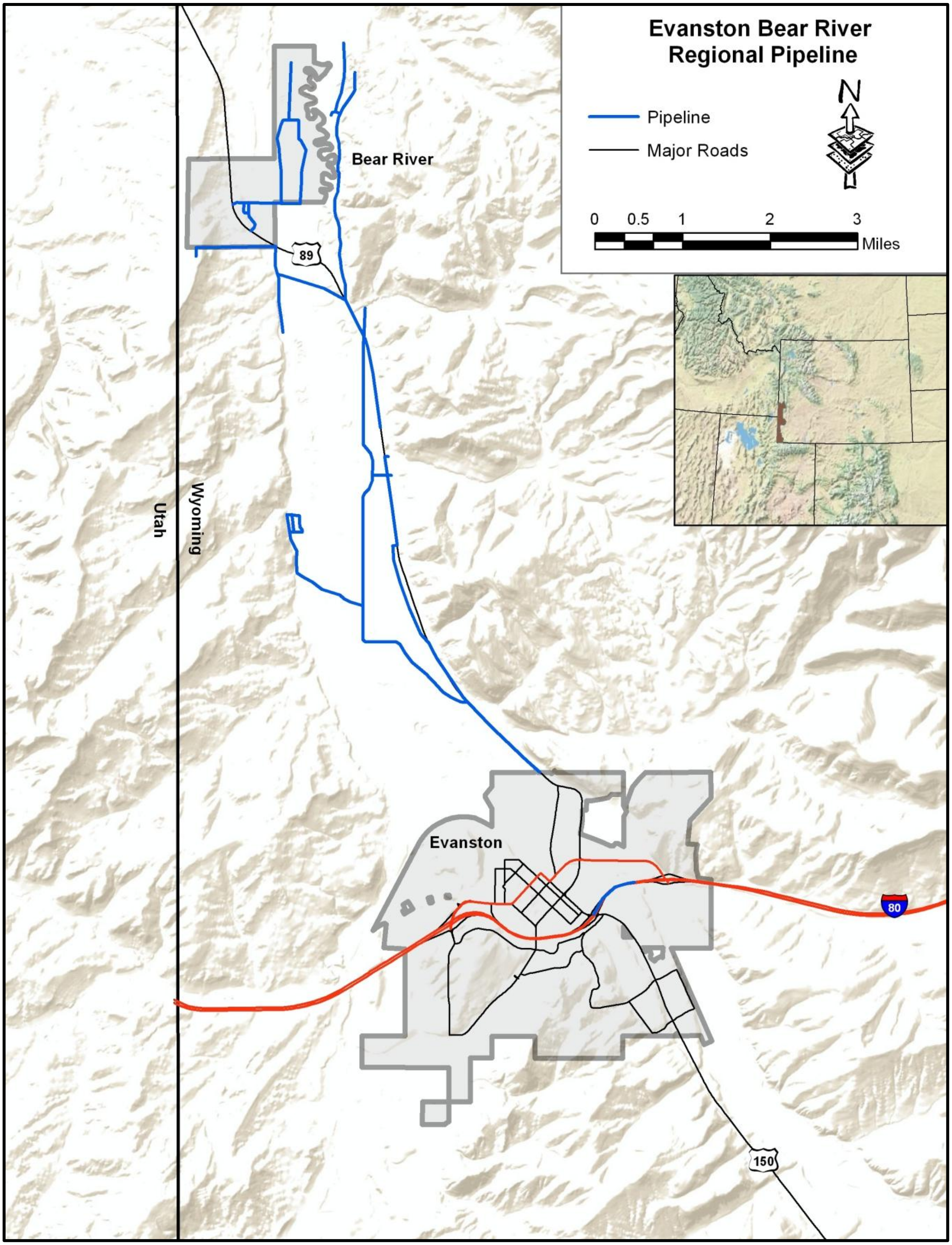

Figure 5-2: Evanston Bear River Regional Pipeline

5.3.4 MUNICIPAL USE TOTALS AND SEASONAL CHANGES

Municipal demand varies greatly from summer to winter. The differences in summer peak day demand and winter demand are highlighted in Figure 5-3.

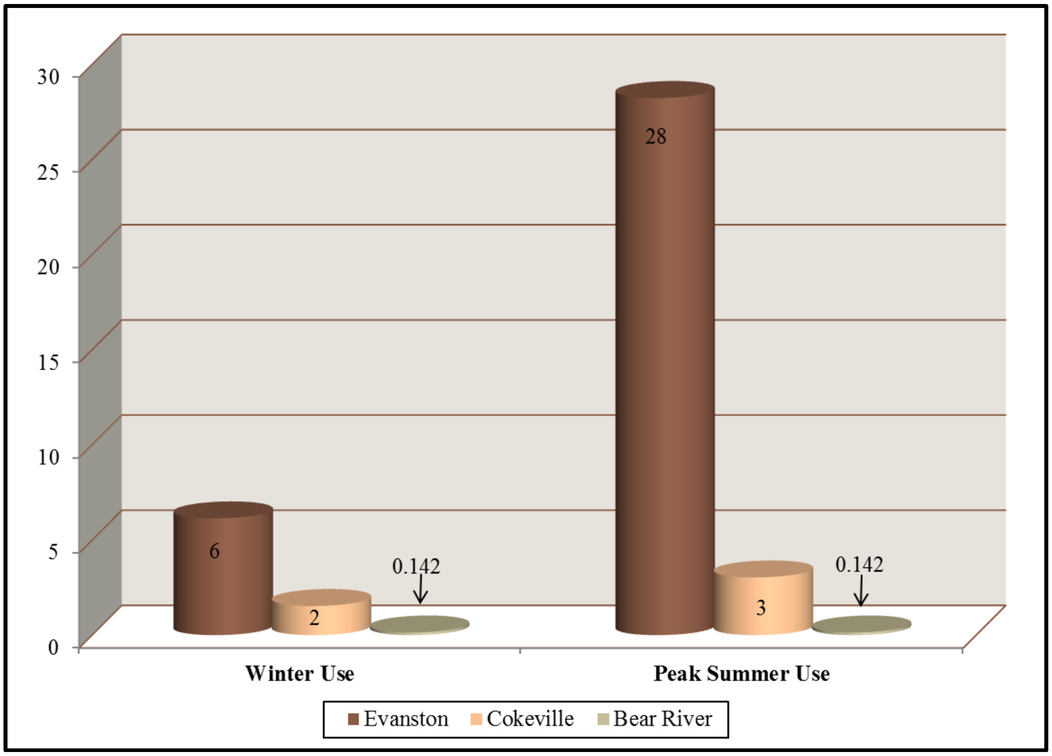

Figure 5-3: Winter Water Use versus Peak Summer Water Use (Acre-Feet/Day)

Although Evanston's peak summer water use is significantly higher than its winter use, it is important to note that both Bear River and Cokeville have unusual circumstances in their seasonal water use. The citizens of Bear River use canals and groundwater wells for their summer lawn irrigation, and Cokeville's per capita demand is much higher than the typical average per capita demand due to the nature of their water system. In the winter, the town of Cokeville "bleeds" water to keep their pipes from freezing. In the summer, water is billed at a $30.00 flat rate with no meters, resulting in lawn irrigation that may be beyond actual requirements of the lawn. Figure 5.4 highlights the different per capita water use values for each municipality.

Municipal water withdrawal and consumptive use for Evanston, Cokeville, and Bear River can be seen in Table 5-16 and 5-17.

Consumptive use for 2009 was determined by subtracting the waste water return flows in acre-feet/year from the water withdrawn in acre-feet/year. Water lost from the system was assumed to be part of consumptive use.

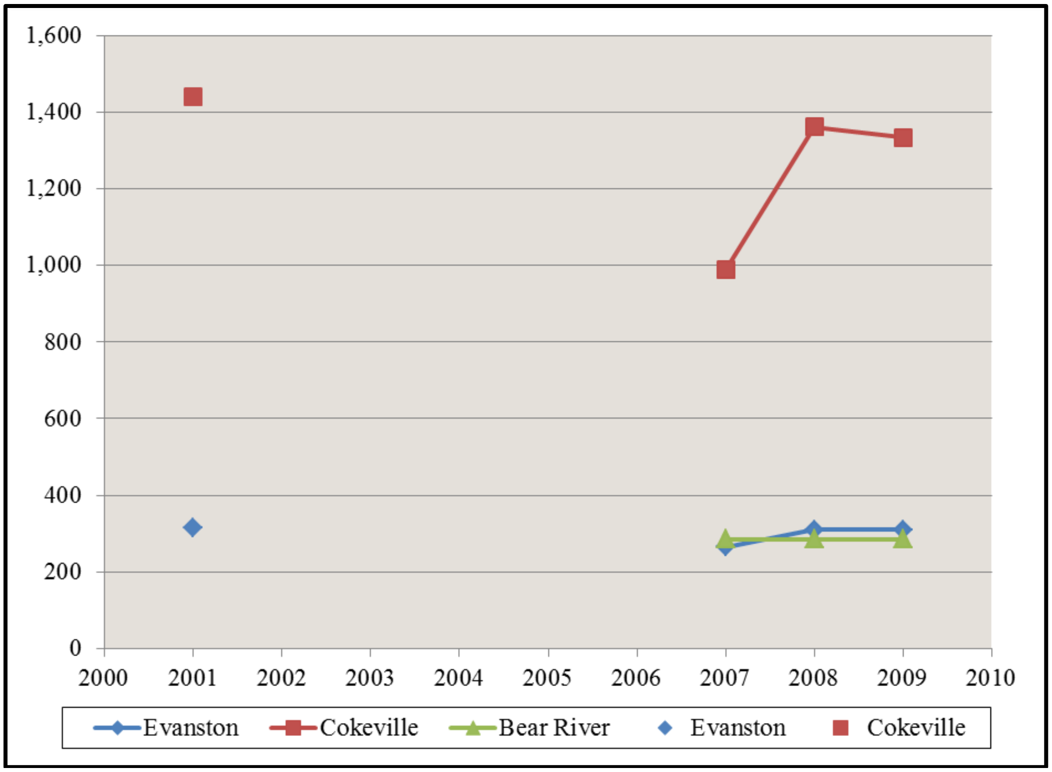

Figure 5-4: Average Gallons Per Capita Per Day Water Use

Table 5-16: Current Water Withdrawal

City/Town	2009 Withdrawal (AFY)	
	Surface Water	Groundwater
Evanston	4,088	--
Cokeville	--	749
Bear River	--	52
Rural Domestic	--	533

Table 5-17: Current Consumptive Water Use

City/Town	2009 Withdrawal (AFY)	
	Surface Water	Groundwater
Evanston	2,408	--
Cokeville	--	665
Bear River	--	27
Rural Domestic	--	533
Total	***2,408***	***1,224***

5.4 RURAL DOMESTIC USE

Rural domestic water use was calculated using the Basin specific and municipal populations provided by AIEAD for 2007, 2008, 2009 and 2030. The municipal populations were subtracted from the Basin specific population to obtain the number of county residents living outside of the municipalities.

The exception is the town of Bear River. The municipal population for Bear River is estimated to be approximately 500. However, a memo produced by Sunrise Engineering (2008) for the Bear River Regional Level III project indicated that the actual service area is much smaller. So the population was determined using phone call data and the data provided in the memorandum.

Rural domestic water use in the Bear River Basin is primarily supplied by individual wells. Consumptive use by the Basin's rural domestic water users was calculated using the Basin specific population not served by a municipal water system, and an average day per capita demand estimate.

The 2001 Plan assumed an estimated water withdrawal of 180 gallons per capita per day. Using this rate, water consumption was calculated as shown in Table 5-18. Additionally, Figure 5-5 compares total municipal water consumptive use to rural domestic water use.

Table 5-18: Rural Domestic Consumptive Water Use

Rural Domestic		Avg. Day (gpcpd)	Avg. Day (gpd)	Groundwater Withdrawal (AFY)	Groundwater Consumed (AFY)
Year	Population				
2001	2,480	180	446,400	500	500
2007	2,463	180	443,340	497	497
2008	2,842	180	511,560	573	573
2009	2,642	180	475,560	533	533

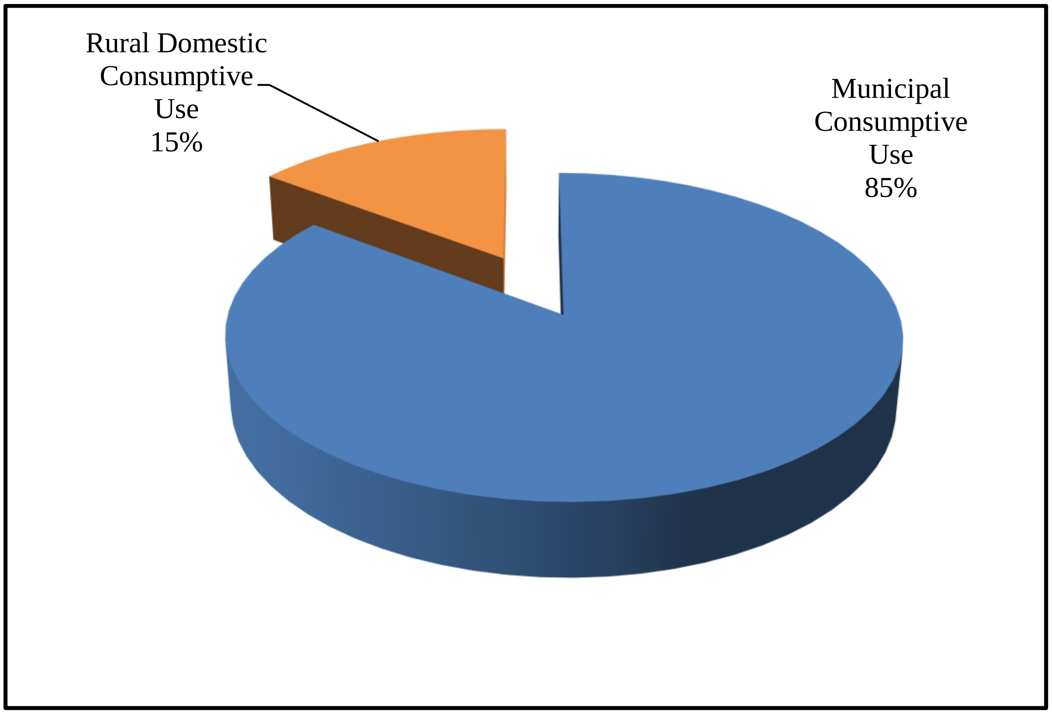

Figure 5-5: Municipal versus Rural Domestic Consumptive Water Use 2009

5.5 ENVIRONMENTAL WATER USE

For this update, all environmental topics have been updated. Several new environmental programs have been implemented since the 2001 Plan and are discussed. Table 5-19 illustrates the previous and new items considered.

Table 5-19: Environmental Topics Comparison

2001 Basin Plan	2011 Basin Plan Update
Instream Flows	Instream Flows
Wetlands Mapping	Environmental Projects and Programs
Minimum Reservoir Conservation and Bypass Requiements	*Minimum Reservoir Conservation Pools and Bypass Requirements*
Cokeville National Wildlife Refuge	*Wyoming Wildlife and Natural Resources Trust*
	Trout Unlimited
	Wyoming Landscape Conservation Initiative
	Cokeville Meadows Refuge
	Wyoming Game and Fish Crucial Habitat Areas
	Lower Bear River Watershed Crucial Habitat Area
	Bear River Tributaries
	Aquatic Invasive Species Protection
	National Wetlands Inventory
	Threatened, Endangered, Candidate, and Sensitive Species

5.5.1 ENVIRONMENTAL PROJECTS AND PROGRAMS

5.5.1.1 INSTREAM FLOW FILINGS

There are 17 instream flow filings within the Bear River Basin. This is the same number of filings as in the 2001 plan (Forsgren Associates, 2001). These filings have since been permitted by SEO and are currently in the process of being adjudicated (see Figure 5-6).

5.5.1.2 WYOMING WILDLIFE AND NATURAL RESOURCE TRUST

In 2005, the Wyoming Legislature created the Wildlife and Natural Resources Trust (WNRT). The trust is funded by a legislative appropriation, donations, and interest earned on the Wildlife and Natural Resources Trust Account. The purpose of the WNRT is to enhance and conserve wildlife habitat and natural resource values throughout the state by way of awarding funds through the trust (WNRT, 2010). The WNRT is an independent state agency governed by a nine-member citizen board appointed by the governor. Oversight is provided by a legislative committee composed of three state senators and three state representatives. Projects have been funded in all 23 counties in the state, and eight projects have been funded and completed in the Bear River Basin (see Figure 5-6).

5.5.1.3 MINIMUM RESERVOIR CONSERVATION POOLS AND BYPASS REQUIREMENTS

The information on Minimum Reservoir Conservation Pools and Bypass Requirements has not changed from the 2001 Plan and has been inserted below for reference.

3.5.2 Minimum Reservoir Conservation Pools and Bypass Requirements

In general, conservation pools are intended to provide the minimum volume of water necessary to maintain the existing aquatic life in the reservoir. Because on-stream reservoirs disrupt the natural flow in a stream, minimum bypass requirements are often dictated during the permitting process to provide the minimum flow downstream required to maintain existing fisheries. ***Table 12*** *shows the conservation pools and minimum releases for Sulphur Creek and Woodruff Narrows Reservoirs.*

Table 12:
Minimum Reservoir Pools and Releases

Reservoir	*Conservation Pool (acre-feet)*	*Minimum Release (cfs)*
Sulphur Creek Reservoir	*4,180*	*9*
Woodruff Narrows Reservoir	*4,000**	*10*

**Temporary storage account of 4,000 acre-feet was set up to accommodate an agreement between the Reservoir Company and the Utah Department of Fish and Game to supply the 10 cfs winter minimum release for the fishery purpose.*

Sulphur Creek Reservoir, 2009

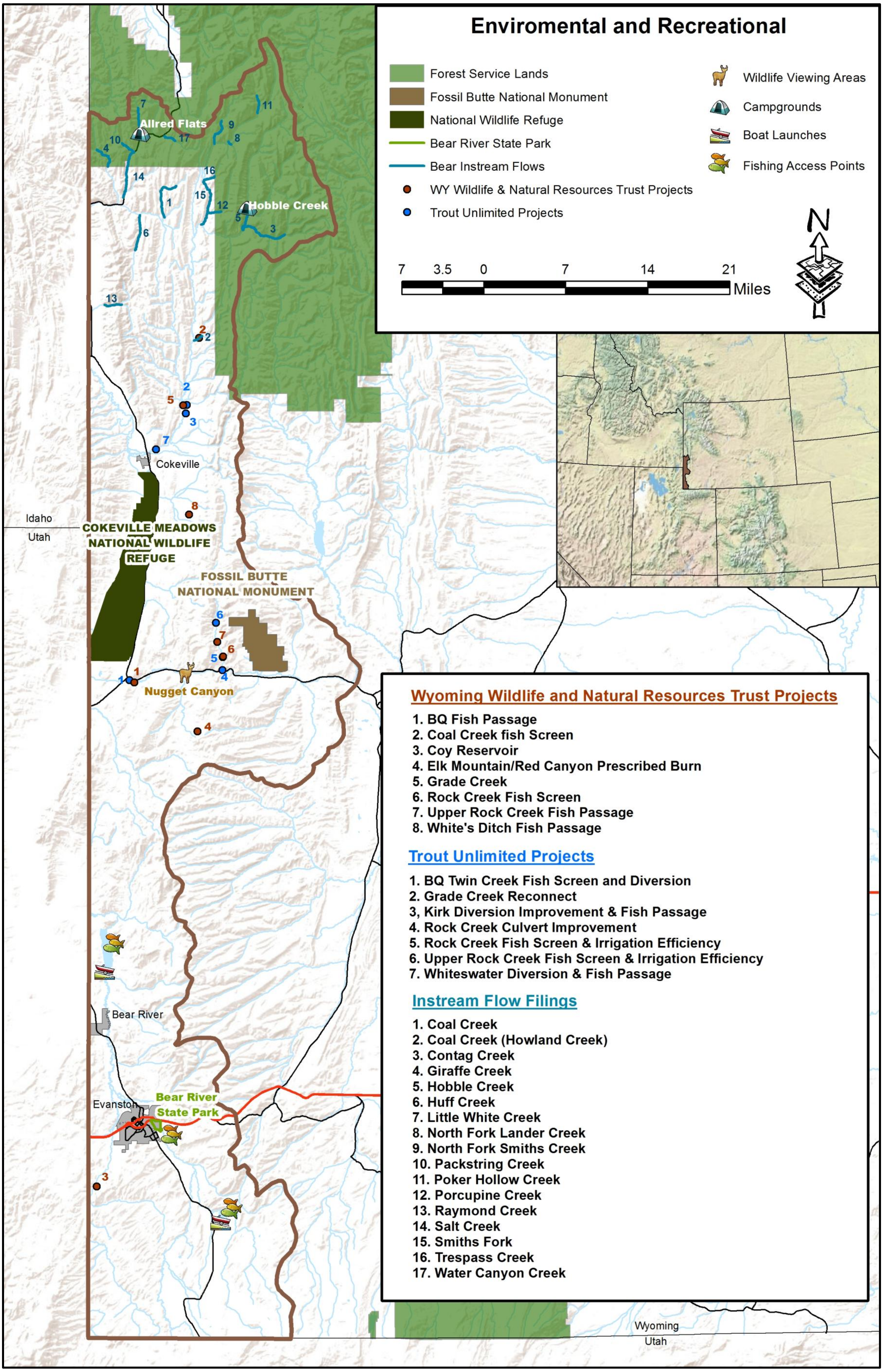

Figure 5-6: Environmental and Recreational Map

5.5.1.4 TROUT UNLIMITED PROJECTS

Trout Unlimited's (TU) Wyoming Water Project Team has completed several projects in the Bear River Basin. Projects include diversion structures, fish passages, fish screens, culvert improvements, and the Grade Creek Reconnect Project (Figure 5-6).

The Grade Creek Reconnect project reconnected Grade Creek to the Smiths Fork near Cokeville. Irrigation upstream had prevented the creek from completing its natural course. TU worked with the landowner to install a new "fish friendly" diversion structure and a more efficient sprinkler system. This project will provide access to spawning and rearing habitat for native Bonneville cutthroat trout (Trout Unlimited, 2010).

5.5.1.5 PARTNERS FOR FISH AND WILDLIFE PROGRAM

The U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program (PFW) was developed in the mid-1880s with the mission to achieve voluntary on-the-ground habitat restoration on private lands through financial and technical assistance. One of eight designated focus areas for Wyoming, the Bear River Watershed habitat activities have concentrated on working with conservation partners to restore and enhance wetland habitat for migratory birds and fish passage/reconnection projects for native fishes. On-the-ground habitat enhancement projects include repairing and replacing existing irrigation infrastructure to improve water management, construction of shallow water wetlands, diversion and culvert replacement for fish passage, and stream restoration. To find out more about PFW activities in Wyoming, visit www.fws.gov/mountain-prairie/pfw/wy/ (Hogan, 2012).

5.5.1.6 WYOMING LANDSCAPE CONSERVATION INITIATIVE

"The Wyoming Landscape Conservation Initiative (WLCI) is a long term science based effort to assess and enhance aquatic and terrestrial habitats at a landscape scale in Southwest Wyoming, while facilitating responsible development through local collaboration and partnerships" www.wy.blm.gov/jio-papo/jio/presentations/grazing-grouse08/FundingSources.pdf. The WLCI is implemented by the following agencies:

- U.S. Bureau of Land Management (BLM),
- U.S. Fish and Wildlife Service (USFWS),
- U.S. Geological Survey (USGS),
- U.S. Forest Service,
- National Park Service,
- U.S. Bureau of Reclamation,
- Wyoming Department of Agriculture,
- Wyoming Game and Fish Department (GFD),
- Local conservation districts, and
- Local counties.

The WLCI partners exchange data with each other, industry, and stakeholders to improve habitat conditions at a landscape scale. Funding for the WLCI was provided by the USGS, USFWS, and BLM totaling $4.25 million (WLCI Fact Sheet, Revised 2-15-2008). Additional information, including a projects list can be found on the WLCI website at http://wlci.gov

5.5.2 COKEVILLE MEADOWS NATIONAL WILDLIFE REFUGE

The Cokeville Meadows National Wildlife Refuge (Refuge) was established in 1993 by the USFWS. The Refuge is centered on a 20-mile stretch of the Bear River and is located south of Cokeville, Wyoming (Figure 5-6). It has not been open for public use; however, the USFWS issued notice of intent to develop a new Comprehensive Conservation Plan, a Hunt Plan, and an Environmental Assessment for the Refuge. Public meetings were held in November 2009 to solicit public comment. The planning process was started in the fall of that same year and is expected to take two years to complete (Federal Register, 2009).

5.5.3 WYOMING GAME AND FISH CRUCIAL HABITAT AREAS

There are two crucial habitat areas within the Bear River Basin: the Lower Bear River Watershed Crucial Habitat Area and Bear River Tributaries. These Crucial Habitat Areas were identified in the GFD Strategic Habitat Plan as revised in December 8, 2008 (GFD, 2008).

5.5.3.1 LOWER BEAR RIVER WATERSHED CRUCIAL HABITAT AREA

The Lower Bear River Watershed Crucial Habitat Area was selected as a crucial habitat area because it supports a conservation population of Bonneville cutthroat trout, a diverse assemblage of native aquatic species, and terrestrial species (GFD, 2008). The Bonneville cutthroat trout population in this area has high-quality genetics and is distributed throughout much of the watershed.

The importance of this watershed to multiple species requires that management efforts focus on overall watershed health (GFD, 2008). As a result, GFD recommends emphasizing the following management practices for the area:

1. Restore, enhance, and maintain a diverse, healthy, productive, and sustainable ecosystem.
2. Prevent/reduce competition between Bonneville cutthroat trout and non-native trout.
3. Emphasize and support U.S. Forest Service management prescriptions that maintain high quality vegetation communities.
4. Prevent oil and gas development impacts.
5. Prevent impacts from proposed reservoir projects.
6. Evaluate and adjust livestock grazing management.

5.5.3.2 BEAR RIVER TRIBUTARIES

The Bear River tributaries were selected as a crucial habitat area because they provide habitat for the following species:

- Bonneville cutthroat trout,
- Leatherside chubs,
- Mountain whitefish,
- Mountain suckers, and
- Northern leopard frogs.

These species are experiencing population declines throughout their native range as a result of hybridization, competition with non-native species, habitat degradation, and habitat loss (GFD, 2008). The GFD recommends the following actions throughout this crucial habitat area:

1. Advocate sound livestock grazing practices throughout the watershed.
2. Advocate sound water management practices that improve habitat conditions for the fishery.
3. Evaluate habitat conditions to identify possible improvement projects.
4. Advocate habitat protection in this area, and attempt to minimize habitat impacts created by future energy development and production activities.
5. Evaluate the direct impacts to fish populations from water withdrawals. Both from loss of habitat and direct loss of fish.

5.5.4 AQUATIC INVASIVE SPECIES PROTECTION

Aquatic Invasive Species (AIS) are non-native organisms that are introduced into a new ecosystem (GFD, 2009). Following direction given by the 2010 Legislature, the GFD implemented regulations to protect Wyoming's waters from AIS. Species included in the regulation are:

- Zebra mussel,
- Quagga mussel,
- Rusty crayfish,
- Bighead carp,
- Silver carp,
- Black carp, and
- Viral hemorrahagic septicemia.

Primary species of concern currently are Quagga and Zebra mussels. Quagga and Zebra mussels are originally from the Black and Caspian Sea Drainages in Eurasia. Both mussel species are invasive freshwater mollusks that encrust hard surfaces (GFD, 2010). Once introduced into an ecosystem these mussels can spread rapidly and have significant impacts on power plants, municipalities, irrigation systems, and native aquatic species. Quagga and Zebra mussels are filter feeders that remove plankton from the water. Plankton is the primary food of forage fish, which in turn are the primary food of sport fish.

In the last two years, these invasive mussels have spread out of the Great Lakes Region and into the plains states. Neighboring states, including Colorado, Utah, and Nebraska have detected the presence of invasive mussels.

One key source for the spread of these mussels and other AIS is on boats or in water contained in them. As a result GFD has implemented inspection and decontamination procedures for boats. To fund this effort, the GFD requires boaters to purchase decals for both motorized and non-motorized boats.

5.5.5 NATIONAL WETLANDS INVENTORY

The National Wetlands Inventory was updated by the USFWS in September of 2009. A revised wetlands map is presented as Figure 5-7.

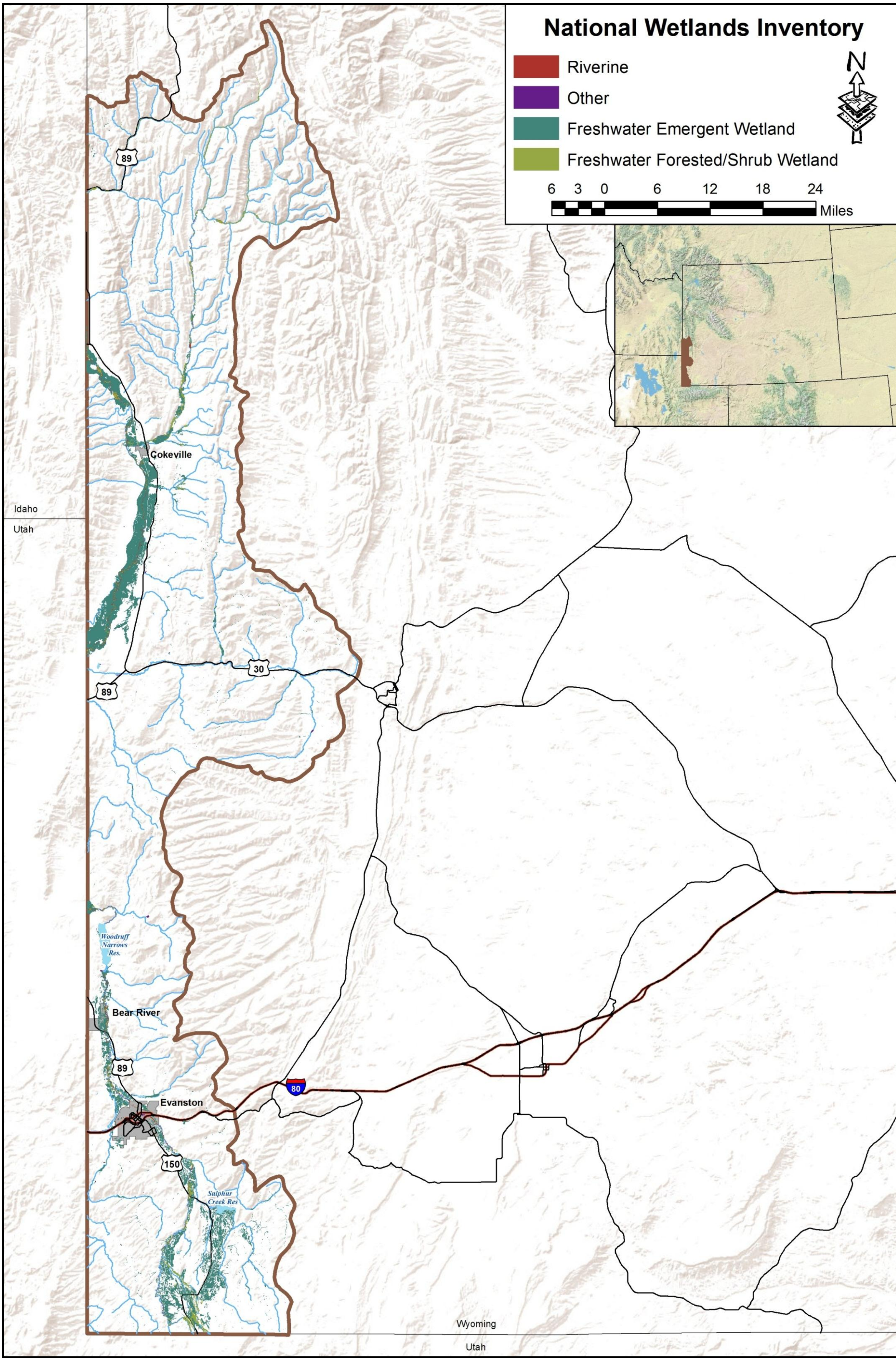

Figure 5-7: National Wetlands Inventory Map

5.5.6 THREATENED, ENDANGERED, CANDIDATE, AND SENSITIVE SPECIES

Species management plays an important role in today's water resources industries. There are four important species classifications that will be discussed in this report. They are listed below with their descriptions. The first four definitions were taken from the Fish and Wildlife Service's website at the following address, http://www.fws.gov/endangered/esa-library/pdf/glossary.pdf The last definition was taken from Wyoming Game and Fish website at the following address, http://gf.state.wy.us/web2011/wildlife-1000407.aspx

> *Endangered: An animal or plant species in danger of extinction throughout all or a significant portion of its range.*
>
> *Threatened: An animal or plant species likely to become endangered within the foreseeable future throughout all of a significant portion of its range.*
>
> *Candidate: A plant or animal species for which FWS or NOAA Fisheries has on file sufficient information on biological vulnerability and threats to support a proposal to list as endangered or threatened.*
>
> *Experimental/Non-essential: A population (including its offspring) of a listed species designated by rule published in the Federal Register that is wholly separate geographically from other populations of the same species. An experimental population may be subject to less stringent prohibitions than are applied to the remainder of the species to which it belongs.*
>
> *Species of Greatest Conservation Need: Species whose conservation status warrants increased management attention, and funding, as well as consideration in conservation, land use, and development planning.*

The Fish and Wildlife Service is responsible for species classification. They have provided a listing of the Threatened, Endangered, and Candidate Species on their website. The species lists are broken down by county and listed in Tables 5-20 and 5-21.

Table 5-20: Uinta County Federally Classified Species

Species[1]	Status
Black-footed Ferret	Endangered
Blowout Penstemon	Endangered
Ute Ladies' Tresses	Threatened
Greater Sage-grouse	Candidate
Yellow-billed Cuckoo	Candidate

1. The Colorado River Fish were omitted from this table even though they showed up in the Uinta County list on the Fish and Wildlife Service's website because this plan focuses on the Bear River Basin.

Table 5-21: Lincoln County Federally Classified Species

Species[1]	Status
Black-footed Ferret	Endangered
Blowout Penstemon	Endangered
Canada Lynx	Threatened
Gray Wolf	Experimental/Non-essential
Grizzly Bear	Threatened
Ute Ladies-tresses	Threatened
Greater Sage-grouse	Candidate
North American Wolverine	Candidate
Whitebark Pine	Candidate
Yellow-billed Cuckoo	Candidate

1. The Colorado River Fish were omitted from this table even though they showed up in the Lincoln County list on the Fish and Wildlife Service's website because this plan focuses on the Bear River Basin.

The fourth category of species classification, Species of Greatest Conservation Need, was provided by the GFD. More information is provided in the 2010 Wyoming State Wildlife Action Plan for the Bear River Basin. The action plan is available on the GFD website at the address listed above. The species for the Bear River Basin are listed below in Table 5-22.

Table 5-22: Species of Greatest Conservation Need in the Bear River Basin

Fish
Bluehead Sucker
Bonneville Cutthroat
Northern Leatherside Chub
Mountain Whitefish
Crustaceans
Pilose Crayfish
Mollusks
California Floater Mussel
Western Pearlshell Mussel

5.6 RECREATIONAL WATER USE

Outdoor recreation and water use are very important in Wyoming and the Bear River Basin is no exception. This section identifies water related recreational uses within the Basin. The Basin has experienced changes since the 2001 Plan, and the changes in recreational water use have been updated. Additionally, there have been several new topics added. Table 5-23 illustrates the differences in the two plans. One difference, the 2001 Plan included information on swimming and boating; these topics could not be updated because no data was found.

Table 5-23: Recreational Topics Comparison

2001 Basin Plan	2011 Basin Plan Update
Boating	Recreational Destinations
Fishing – Angler Days	*National Forest Service*
Water Fowl Hunting	*National Park Service*
Swiming	*USFWS National Wildlife Refuge*
Recreational Destinations	*BLM*
Cokeville Meadows	*State Park – With hiking trails*
Bear River State Park	*Fishing Access Points*
Bridger Teton National Forest	*Camping Sites*
BLM	*Boat Launches*
	State Park Visitation
	Fisherman Data
	Water Fowl Hunting
	Game and Fish Stream Classifications

5.6.1 RECREATIONAL DESTINATIONS

There are several recreation areas within the Bear River Basin. Global Positioning System (GPS) locations were obtained from the U.S Forest Service, Department of State Parks and Cultural Resources, and the GFD for many of the public access points. Fishing access points, camping spots, and boat launches are shown on Figure 5-6. Additional information on BLM recreation sites can be found on the BLM website http://www.blm.gov/wy/st/en/field_offices/Kemmerer/recreation.html.

Additionally, data for Bear River State Park, including location information for the walking trails, were provided by the Wyoming Department of State Parks and Cultural Resources. This information has been included in the updated Geographic Information System (GIS) database and is shown on Figure 5-8.

The Wyoming Department of State Parks and Cultural Resources provided updated visitation data for the walking trails and visitor center for Bear River State Park (Figure 5-9).

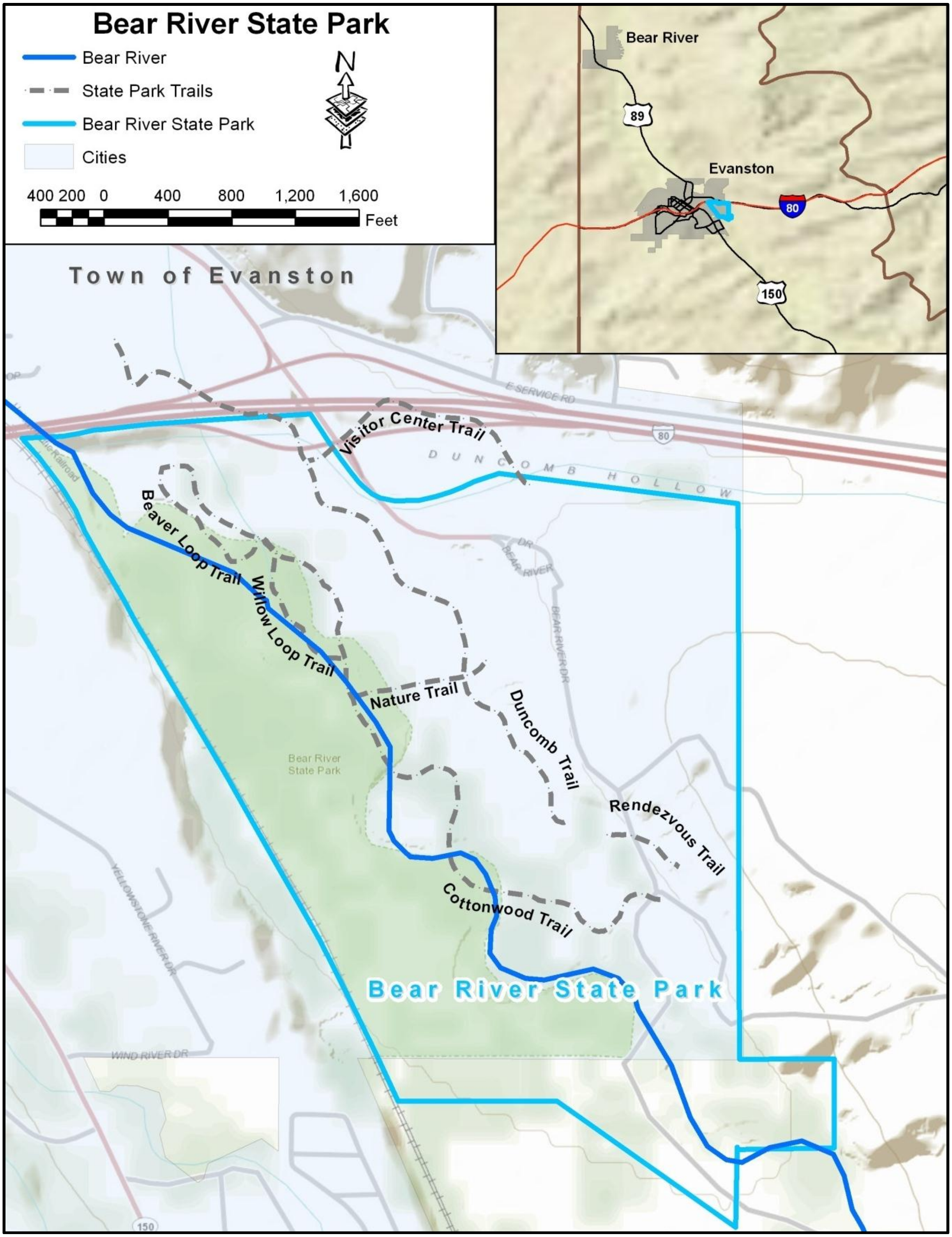

Figure 5-8: Bear River State Park

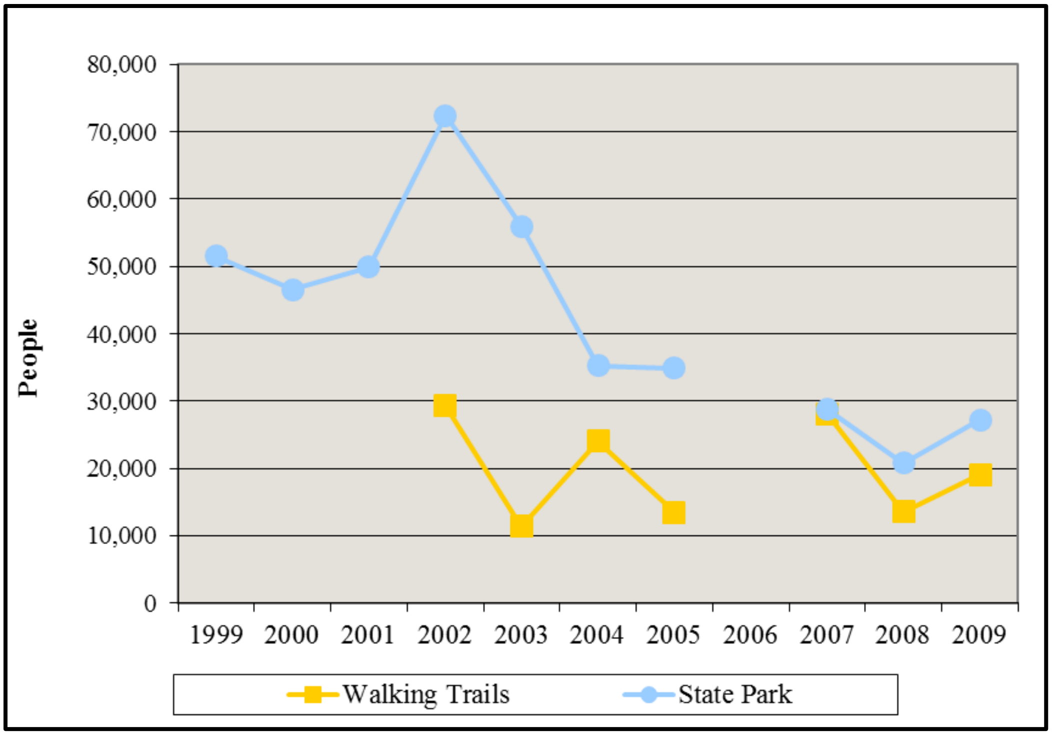

Figure 5-9: Bear River State Park Visitation Information

5.6.2 FISHERMAN DATA

Angler day's data has not been updated since before the 2001 Plan (Keith, 2009). However, data on the estimated daily expenditures by fisherman do show an increase. Using new information, an estimate of annual revenue generated in the Bear River Basin economy by fisherman was developed (see Table 5-24). For comparison, Table 5-25 includes the information developed in the 2001 Bear River Basin Plan.

Table 5-24: Estimated Annual Revenue from Fishermen – 2009

Water Type	Angler Days Annually	Per Day Expense 2009	Estimated Yearly Revenue
Lakes	7,400	$68.00	$503,200.00
Streams	9,400	$68.00	$639,200.00
Total	***16,800***	***$68.00***	***$1,142,400.00***

Table 5-25: Estimated Annual Revenue from Fishermen – 2009

Water Type	Angler Days Annually	Per Day Expense 2001	Estimated Yearly Revenue
Lakes	7,400	$53.00	$392,200.00
Streams	9,400	$53.00	$498,200.00
Total	***16,800***	***$53.00***	***$890,400.00***

5.6.3 WATER FOWL HUNTING

Updated data on duck and goose hunting were provided by GFD (GFD website, 2009). As in the 2001 Plan, data for 2002 to 2007 were provided for the number of hunters, the number of days, and the total harvest (see Figures 5-10 and 5-11).

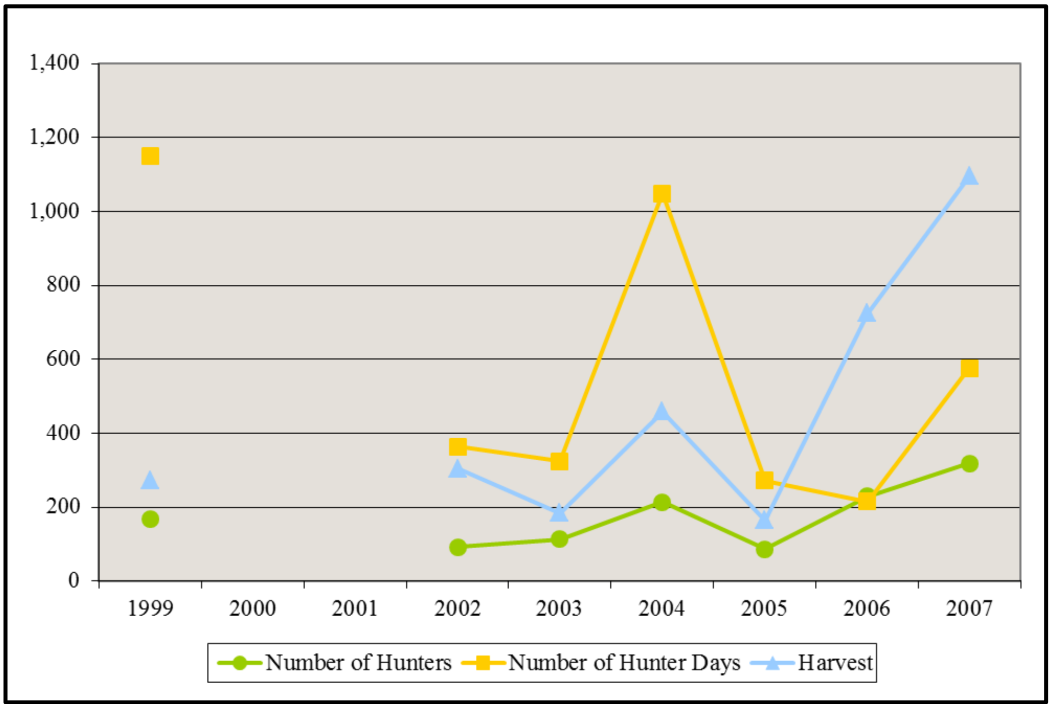

Figure 5-10: Wyoming Bear River Basin Goose Hunter Data

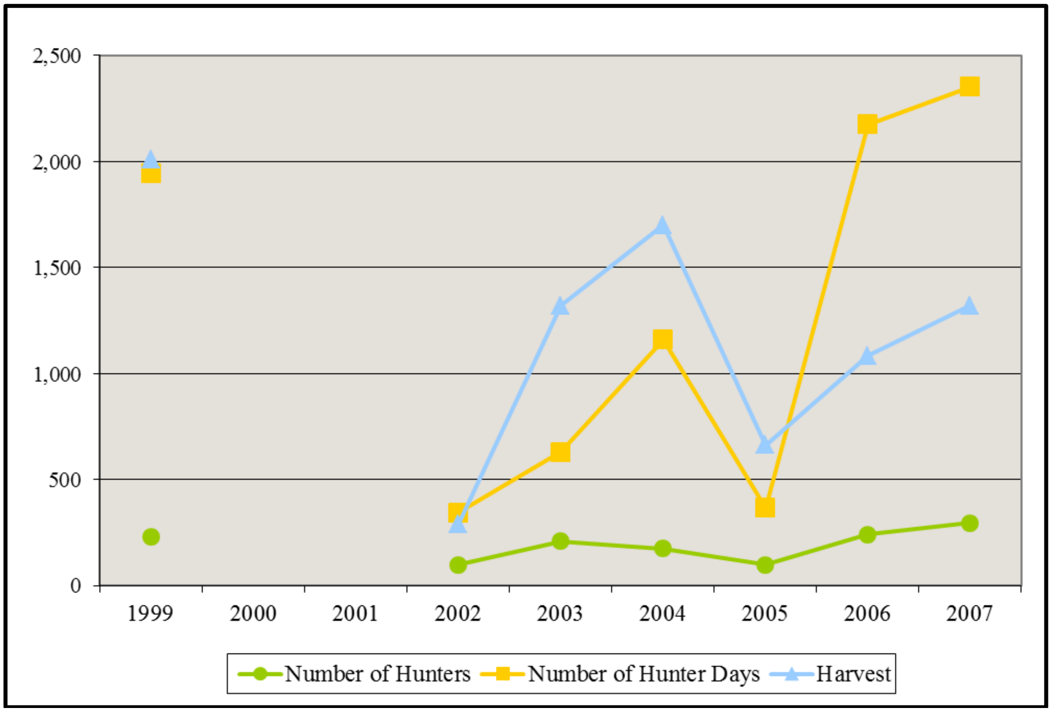

Figure 5-11: Wyoming Bear River Basin Duck Hunter Data

Figure 5-10 shows that with the exception of 2005, the number of goose hunters and the number of geese harvested have been increasing since 2003. Figure 5-11 shows a small decrease in the number of hunters, and a large contraction in the number of ducks harvested in 2005. In both figures, after a decline in 2005, the following two years showed an increase in hunters and harvest.

5.6.4 WYOMING GAME AND FISH STREAM CLASSIFICATIONS

The GFD has redefined their stream classification system since the 2001 Plan. Their reasons were in part due to the following two items:

- The previous stream ranking system relied on attributes that were highly subjective, and may not be easily defined or defended (Annear, 2006).
- The previous system created significant confusion with the classification system used by the Department of Environmental Quality (Annear, 2006).

The new classification system is based on the pounds of sport fish present per mile of stream (Robertson, 2010). The categories for the new classification system are listed below:

- Blue ribbon > 600 lbs produced,
- Red ribbon 300 – 600 lbs produced,
- Yellow ribbon 50 – 300 lbs produced,
- Green ribbon 1-50 lbs produced,
- Orange ribbon – Any cool/warm water species present, and
- Clear – No trout present.

The Basin has mostly green ribbon segments that indicate low productivity for fish. There are five yellow segments, one red segment, and five clear segments (see Figure 5-12). The Smiths Fork drainage basin has the most productive fisheries in the Wyoming portion of the Bear River Basin (all of the yellow ribbon streams and the only red ribbon stream).

Trout Unlimited Fish Screen Project, Coal Creek, 2009

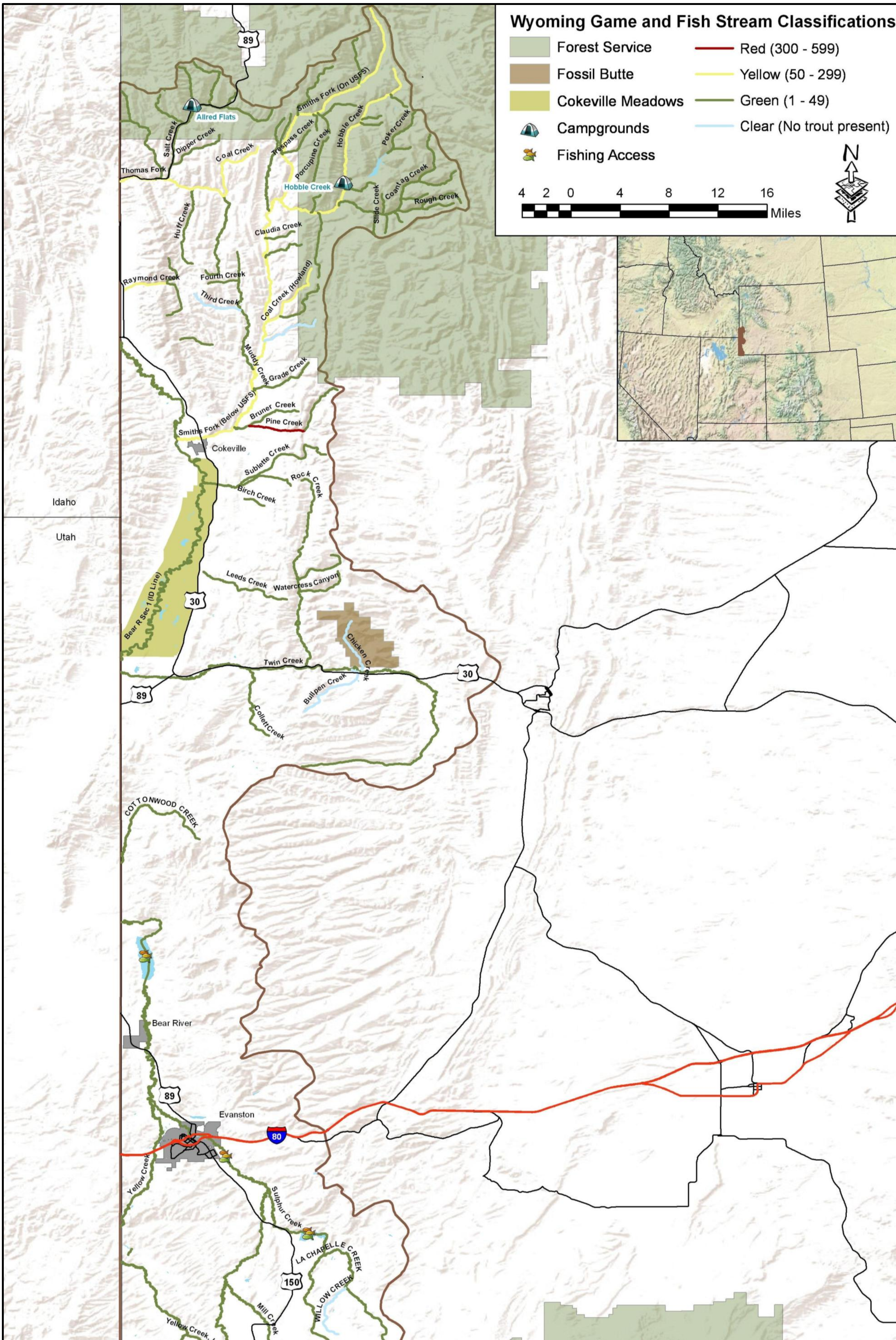

Figure 5-12: Wyoming Game and Fish Stream Classification Map

5.7 ENVIRONMENTAL AND RECREATIONAL WATER USE ANALYSIS

In order to better understand how environmental and recreational water uses fit into the overall water use profile of the basin, protected uses, complementary uses and competing uses were examined. These three uses were defined by Harvey Economics in work on the Environmental and Recreation Level I Study commissioned by the WDO, which is currently in progress.

- Protected Uses: Protected uses have a senior water rights holder in such a location as to guarantee water availability, or as in the case of the instream flow filings, have a permit for protection from the State of Wyoming.
- Complementary Uses: Complementary uses are those without explicit protection. Their existence has continued by virtue of their location. An example is any US Forest Service sponsored campground around the state. Campgrounds are often located around lakes or streams. They are not however guaranteed a flow rate or water level by virtue of this location. Nevertheless because diversions are rare in the high elevation, federally managed forests water is typically available for the enjoyment of the public.
- Competing Uses: Competing uses are in a location that other traditional diverters may constrain or eliminate. These environmental and recreational uses are incidental and may be eliminated by present or future water rights holders.

5.7.1 IRRIGATED LANDS AND WETLANDS

To begin the analysis, a comparison was made between the National Wetlands Inventory (NWI) coverage and the irrigated lands GIS coverage. The number of irrigated acres recorded in the Basin GIS coverage is 63,636. The irrigated lands coverage for the Bear River Basin was clipped to include only those lands within Wyoming. As a result, the total number of irrigated acres may differ slightly from the totals reported in other sections of the report. The NWI lands and irrigated lands were compared to show areas where they overlapped. The area of overlap was calculated and summarized by wetland type (see Table 5-26).

Table 5-26: Irrigated Land and National Wetland Inventory Overlap Areas

Wetland Type	Acres
Freshwater Emergent	28,210
Freshwater Forested Shrub	1,159
Freshwater Pond	202
Lake	0
Other	6
Riverine	108
Total	***29,684***

When the total area of overlapping lands was compared to the area of irrigated lands within the Wyoming portion of the Bear Basin, the percentage of irrigated lands that are considered wetlands by the NWI is 47%. It is worth noting that since the irrigated lands coverage has been field verified by the SEO personnel, two likely reasons for some of the overlap is the method used to gather the NWI information (interpretation of 1:24,000 scale aerial photos) and the common nature of flood irrigation in the Basin. Additionally, areas of pond, lakes and riverien wetlands that are considered irrigated lands may be the result of inaccuracies inherent to the GIS map coverages.

5.7.2 DIVERTIBLE VERSUS NON-DIVERTIBLE USES

To help identify the environmental and recreational uses that are protected, complementary and competing, the divertible and non-divertible uses in the Basin were identified (see Table 5-27).

Table 5-27: Divertible versus Non-Divertible Water Uses

Divertible	Non-Divertible
Irrigation Diversions	Instream Flow Filings
Municipal Diversions – Evanston, Bear River	Trout Unlimited Projects
Industrial Diversions	Wyoming Wildlife and Natural Resources Trust Projects
Cokeville Meadows	Habitat Uses
	Fishing
	Boating

The divertible water uses provided in Table 5-27 are all protected by Wyoming water law, thus they would fall into the protected category. Cokeville Meadows is unique because it could be considered an environmental water use; however, their water rights are for agricultural irrigation and fall into the protected category. The only non-divertible uses listed above that are protected with a water right under Wyoming law are the instream flow filings. The remaining uses could either fall into the competing or complimentary categories. At this time, without a better understanding of priority dates for irrigation water rights in the Basin, it is not possible to make a comparison between the remaining non-divertible uses described above. Further research to analyze these interactions should be pursued.

5.8 RESERVOIR EVAPORATION

Reservoir evaporation is not a conventional consumptive use like agriculture or industry; however, it is considered a consumptive use and is the second largest use of water in the Basin. There are five main reservoirs that are either greater than 1,000 acre-feet, or considered significant for the purposes of this study (see Technical Memorandum; Reservoir Evaporation, Volume 2, Tab XI). There are other reservoirs in the Basin that might not be considered significant but, because evaporation is the second largest use of water, have been included in evaporation calculations.

Five reservoirs are described in the technical memorandum: Sulphur Creek, Woodruff Narrows, Ben, Broadbent, and Whitney Reservoirs. In the 2001 plan, Sulphur Creek and Woodruff Narrows Reservoirs' evaporation were calculated in the model as was also done for this update. Other reservoirs identified in various river basin planning databases were also evaluated and included in the final evaporation estimates. Those reservoirs are Martin, Crompton, Painter, Quealy, and Larson.

Evaporation calculations require three variables: pan evaporation rate, precipitation, and water body surface area. WRDS staff gathered the evaporation and precipitation data, while the surface area acreage for each reservoir was acquired from data in the SEO's water right permits.

The nearest station having daily pan evaporation data is the National Weather Service COOP station at Green River, which is located in the Green River Basin. Data for this station were gathered from the High Plains Regional Climate Center's http://ww.hprcc.unl.edu. CLIMOD program. The data collection period was from 1971 to 2010.

The precipitation data were taken from the Water Resources Data System's Water and Climate Map Server http://www.wrds.uwyo.edu/sco/gis/IMS.html. This web mapping application allows a user to obtain monthly and annual precipitation values for any point in the state using spatially gridded data from the PRISM Climate Group, Oregon State University, http://www.prismclimate.org. Precipitation values were taken from an approximately 4km x 4km grid cell that best represented the precipitation at each reservoir. The monthly values for the period of record were averaged to come up with representative monthly precipitation. Because gridded PRISM data were used, a precipitation value could be obtained for the actual location of the reservoir.

Evaporation and precipitation data were calculated as monthly averages, and precipitation was subtracted from the evaporation to derive the average net evaporation for each month. This monthly value was then converted to acre-feet and multiplied by the reservoir's surface area to obtain total evaporation for the year. The evaporation estimate from the 2001 Plan was 5,280 acre-feet, compared to the 5,361 acre-feet calculated in this update.

5.9 SUMMARY OF CONSUMPTIVE WATER USE

Agriculture is the largest water use in the Basin consuming 91,559 acre-feet annually; a decrease of less than 1% from the previous plan (92,300 acre-feet).

Reservoir evaporation is the second largest use in the Basin at 5,361 acre-feet. Evaporation is water lost to the atmosphere and, with increased storage, there will be increased evaporation.

Municipalities are the third largest water users in the Basin. Evanston's consumptive use equals 2,408 acre-feet per year; Cokeville's consumptive use is 665 acre-feet per year; and the town Bear River's consumptive use equals 27 acre-feet annually. It should be noted that the town of Bear River's water usage has shifted from groundwater to surface water supplied through the regional system. Rural domestic consumptive water use within the Basin is estimated to be 533 acre-feet per year.

Industrial water use, ranked fifth in the Basin, has decreased from 410 acre-feet per year to approximately 42 acre-feet per year. This decrease has occurred primarily due to changes in natural gas processing that do not require large amounts of water.

Environmental and recreational water uses are important in the Basin but are considered non-consumptive. There seems to be increasing environmental and recreational water demands within the Basin, and these demands may impact future water use and development. There may also be opportunities to use and develop water in ways that maintain or improve environmental and recreational water uses.

As shown in Table 5-28, the 100,595 acre-feet of consumptive water use presented in this update is comparable with the 2001 Plan estimate of 99,300 acre-feet. The difference is likely due to drier hydrologic conditions during the early 2000's, changes in basin water use, and the different methods used for estimating wet, normal and dry years.

Table 5-28: Bear River Consumptive Water Use by Sector

Sector	Surface Water	Groundwater	Total
Agricultural	89,659	1,900	91,559
Industrial	37	5	42
Municipal	2,408	692	3,100
Rural Domestic	0	533	533
Environmental	0	0	0
Recreation	0	0	0
Reservoir Evaporation	5,361	0	5,361
Total	***97,465***	***3,130***	***100,595***

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6.0 WATER USE PROJECTIONS

6.0 WATER USE PROJECTIONS

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6.0 WATER USE PROJECTIONS

This chapter discusses current water use and future water demand projections for the six water use sectors: agriculture, industrial, municipal, rural domestic, environmental, and recreation. A comparison is made between the future projected demands and the available water supply. The effects of conservation on water demand projections and water supply are presented. Future water use opportunities are also discussed.

Demand projections and future water use opportunities were presented in the 2001 Bear River Basin Plan, Chapter 6 (Forsgren Associates, 2001) and Appendix Q, Technical Memoranda, Future Economic and Demographic Scenarios and Future Water Demand Projections (BBC Research and Consulting, 2000). Results from the 2001 Plan are reviewed here and compared with information and data collected as part of this Plan Update. The analyses presented in the plan and Appendix Q are detailed and a good presentation of the economic and demographic conditions of the Basin as well as presenting projections of future conditions. The data and information presented in this report are used for comparison purposes and no attempt has been made to repeat the analyses conducted as part of the 2001 Plan.

6.1 ECONOMIC AND POPULATION PROJECTIONS

Economic growth and activity in the Basin were based on four sectors including agriculture, energy, tourism and manufacturing (Forsgren Associates, 2001). These sectors best reflected the economics of the Basin during the analysis. Discussions for this report focus on six water use sectors, which are agricultural, industrial, municipal, rural domestic, environmental and recreation. These water use sectors will be compared to the four economic sectors to provide a basis for the review and evaluation. To compare economic growth and activities to water use sectors, agricultural will represent agriculture, industrial will represent energy and manufacturing, and environmental and recreation will represent tourism. Dynamics in municipal and rural domestic populations will be used to help explain changes in economic activity in all sectors since populations grow as economies expand.

Population estimates are made annually by AIEAD. Figure 6-1 illustrates the changes in population from 1999, and shows two population growth projections made in the 2001 Plan: a low growth projection of 15,100 people and a high growth projection of 29,000 people. The Figure also shows that the estimated population has been very close to the low growth projection. The 2010 census shows some increase over the low growth projection with a population of 15,796. An estimated population growth scenario prepared by AIEAD shows the population increasing to 16,274 by 2030. This increase is greater than the low growth scenario but much less than the high growth or the mid growth scenario of 21,500 persons proposed in the Statewide Framework Water Plan (WWC, 2007). The AIEAD 2030 population projection was used to make municipal and rural domestic water use projections for this update. The labor market was not analyzed, but the overall population data and other water use sector data does not indicate a significant change in the labor market.

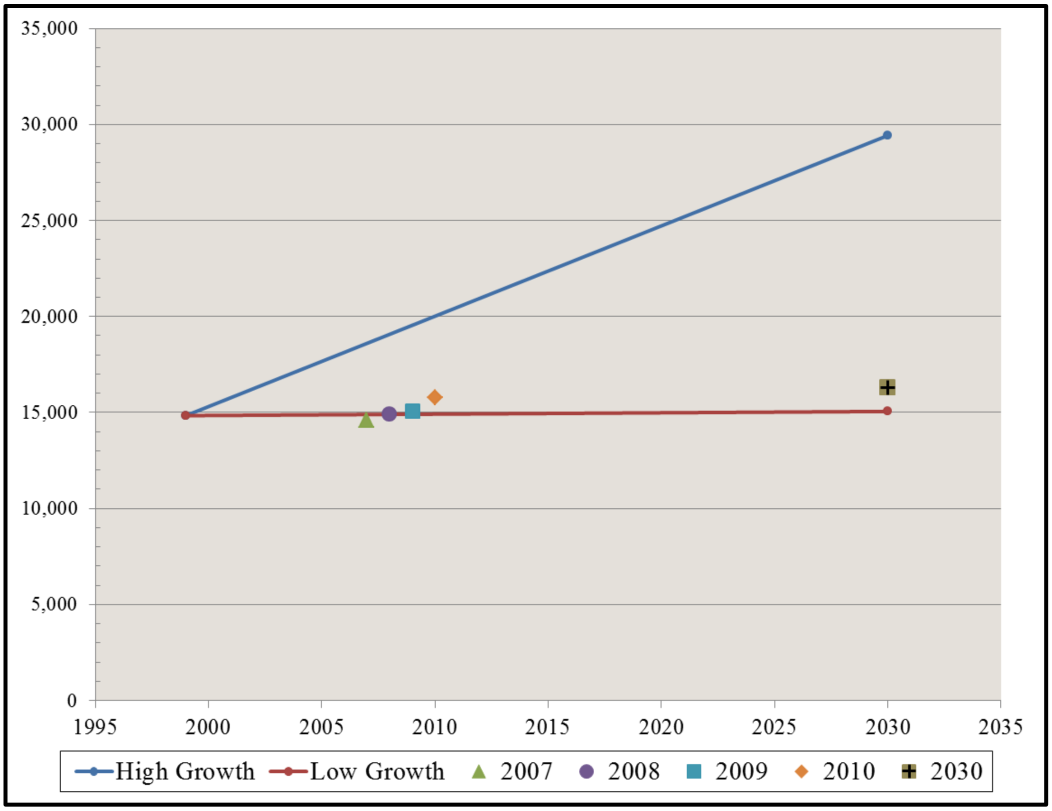

Figure 6-1: Bear River Basin Population and Population Projections

6.2 AGRICULTURAL WATER USE

In the 2001 Plan, two scenarios were developed to project future agricultural water use for livestock and irrigation. The scenarios focused on low and high growth projections. For this update, current use was estimated based on the newest available data and plotted to compare the current use to the projected uses developed in the 2001 Plan.

6.2.1 IRRIGATION

Water supply, water use efficiency, irrigation methods, availability of groundwater, storage, and crop types all impact water use. As water supply increases, land owners are able to deliver more water to their crops. Diversion, conveyance and application efficiencies have an effect on consumptive use because more efficient water delivery means the crop will have more supply to satisfy the crop irrigation requirement. In some cases, such as sprinkler irrigation, the diverted water more efficiently meets the crop's needs, resulting in decreased return flows. Much of the agricultural irrigation in the Wyoming Bear River Basin depends on return flows to meet the crop's water demands. Changes to the types of crop planted also have an effect on water use. When economic conditions are favorable for growing a more valuable crop, a change in overall consumptive use of water may occur, depending on the new crop's needs.

The assumptions made for the irrigated acreage, crop types, and irrigation practices were not changed from the 2001 Plan. Irrigated acreage projections to the year 2030 are presented in Figure 6-2. Along with Idaho and Utah, the SEO recently began a project to improve the quality of the irrigated lands mapping throughout the Basin. This information, once completed, will provide a more accurate picture of irrigation and water rights in the Basin.

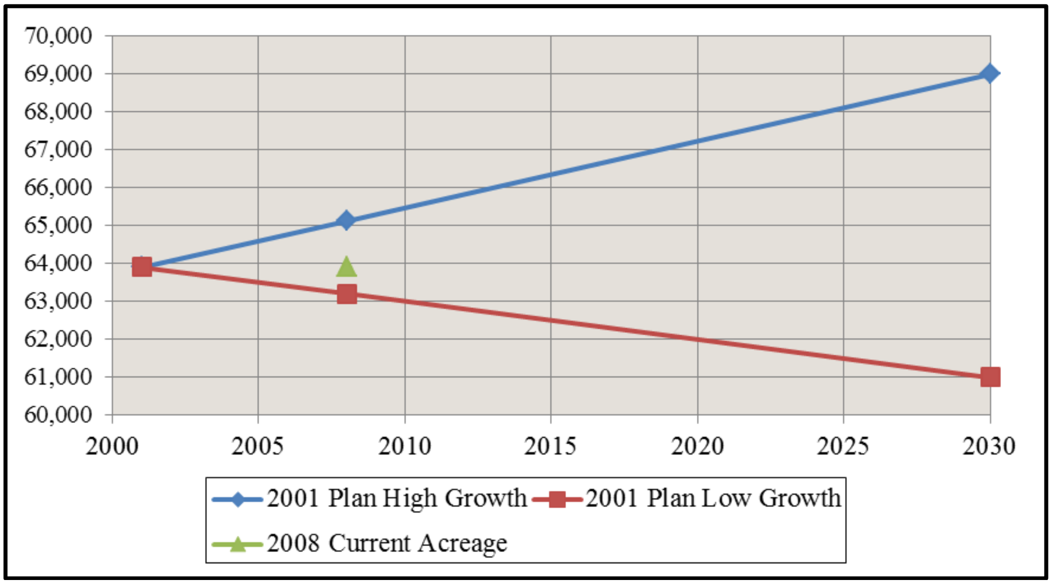

Figure 6-2: 2001 Irrigated Acreage Projections and 2008 Irrigated Acreage

Diversion totals decreased and fell below the low growth projection made in the 2001 Plan. Both inflows and diversions decreased due to drier climatic conditions from 2001 to 2004. Diversion amounts are expected to increase as wetter conditions have been observed over the last two years (2010 and 2011). The amounts shown in Figure 6-3 are the head gate diversion amounts. Efficiencies, irrigation water requirements and crop consumptive use all factor into these values.

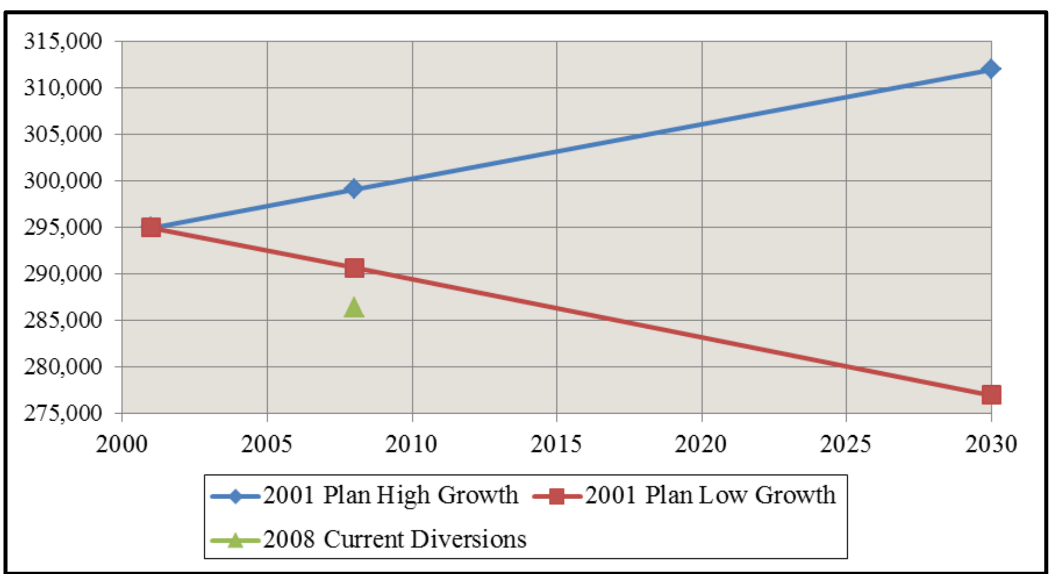

Figure 6-3: 2001 Diversions Projections versus 2008 Diversions

Table 6-1shows a comparison of the total inflows and diversions for dry, normal and wet conditions (May through September) from the 2001 Plan and this update. The period May through September was chosen in order to remain consistent with the model output tables shown in Chapter 7, section 7.1.3. The total diversions in Table 6-1 represent the model diversion data input, which is different than the model diversion summary. The difference is the model's diversion summary does not use the diversion input in every case due to the internal balancing of the water budget. For example, when a diversion (from the diversion input) is greater than the calculated available flow at a node, the model ignores the input data and sets the diversion value to zero to ensure there will not be a negative flow at the node. Note that the volume of diversions exceeds the inflow for every case. This is indicative of the amount of water returning to the system for downstream use. Framework Table 5-3, presented in Appendix A, represents January through December values.

Table 6-1: Inflow and Diversion Comparison, May-September

Description	2001 Plan	2011 Plan Update	2001 Plan	2011 Plan Update	2001 Plan	2011 Plan Update
	Dry Conditions (AF)		Normal Conditions (AF)		Wet Condition (AF)	
Inflow Gage 10011500	66,868	63,399	124,011	110,857	193,738	174,274
Inflow Gage 10015700	1,118	2,398	3,889	7,108	10,490	16,646
Inflow Gage 10032000	46,407	45,093	110,470	97,211	165,423	167,829
Ungaged gains or losses	3,582	-32,268	128,850	68,322	361,263	189,789
Total Inflows	***117,976***	***78,622***	***367,220***	***283,498***	***730,913***	***548,538***
Total Diversions	***336,055***	***271,958***	***607,887***	***519,593***	***897,801***	***794,987***

Difference in values between the 2001 Plan and this update are due in part to different methodologies used to discern hydrologic conditions. In the 2001 Plan, the hydrologic conditions for a specific gage were determined by the locations of "natural breaks" in the ranked flow values for the period of record. For this plan, the 20 % dry and 20 % wet years were used to define dry and wet years, as was recommended for basin planning in the Guidelines for Development of Basin Plans (States West Water Resources Corporation, 2001). Because of the difference in approach, comparisons are only for informational purposes. Future basin plans should follow the analysis in the guidance document so that comparisons can be based on the accepted approach.

IWR is calculated by subtracting the monthly effective precipitation from the CU. The supply limited consumptive use is the amount of diverted water the crop actually uses. Tables 6-2 and 6-3 compare the IWR and supply limited CU between the 2001 Plan and this update. The increase in IWR and decrease in supply limited CU is consistent with drier conditions and a limited water supply.

Table 6-2: Average Annual Irrigation Water Requirements

Location	2001 Basin Plan (AFY)	2011 Basin Plan Update (AFY)
Upper Division	64,300	65,042
Central Division	32,600	34,362
Total Bear River Basin	***96,900***	***99,404***

Table 6-3: Average Annual Supply-Limited Crop Consumptive Use Estimates

Location	2001 Basin Plan (AFY)	2011 Basin Plan Update (AFY)
Upper Division	62,600	58,671
Central Division	31,600	32,538
Total Bear River Basin	***94,200***	***91,209***

These values are expected to fluctuate depending on supply and crop type. The majority of irrigation in the Basin is for hay or pasture, with approximately 92% of cropland being grass hay and pasture, and the remaining 8% being used to grow alfalfa for hay and forage. The crops grown, and the percentages, were assumed to have remained the same as in the 2001 Plan.

6.2.2 LIVESTOCK

The number of cattle and sheep in the Basin were obtained from the United States Department of Agriculture (USDA), National Agriculture Statistics Service (USDA, 2008 and 2011). Lincoln and Uinta Counties data were downloaded and plotted to look at the general trends for those counties. The 2001 Plan estimated that 25% of the livestock reported to be in Lincoln and Uinta Counties can be attributed to the Bear River Basin. Using the USDA National Agriculture Statistics Service data and assumptions from the 2001 Plan, the number of cattle and sheep in the basin were estimated and plotted. The number of sheep was not available for the years 2004 through 2007.

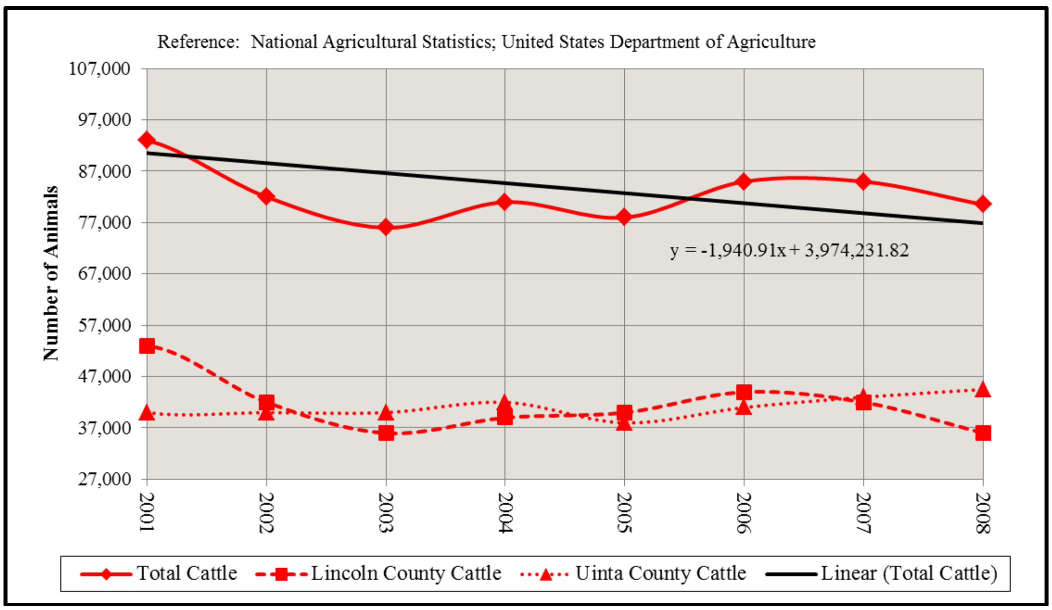

Figure 6-4: Lincoln and Uinta County Cattle Numbers, 2001-2008

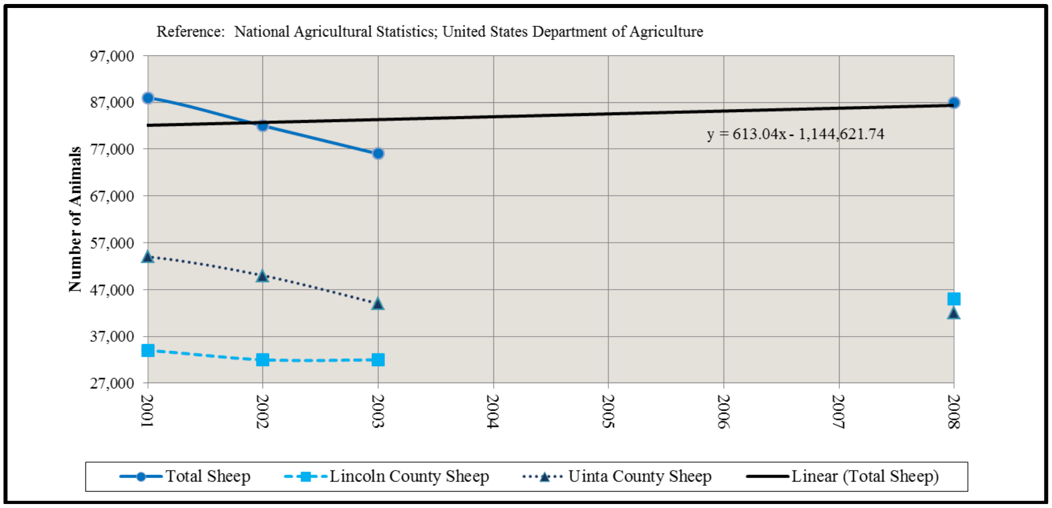

Figure 6-5: Lincoln and Uinta County Sheep Numbers, 2001-2008

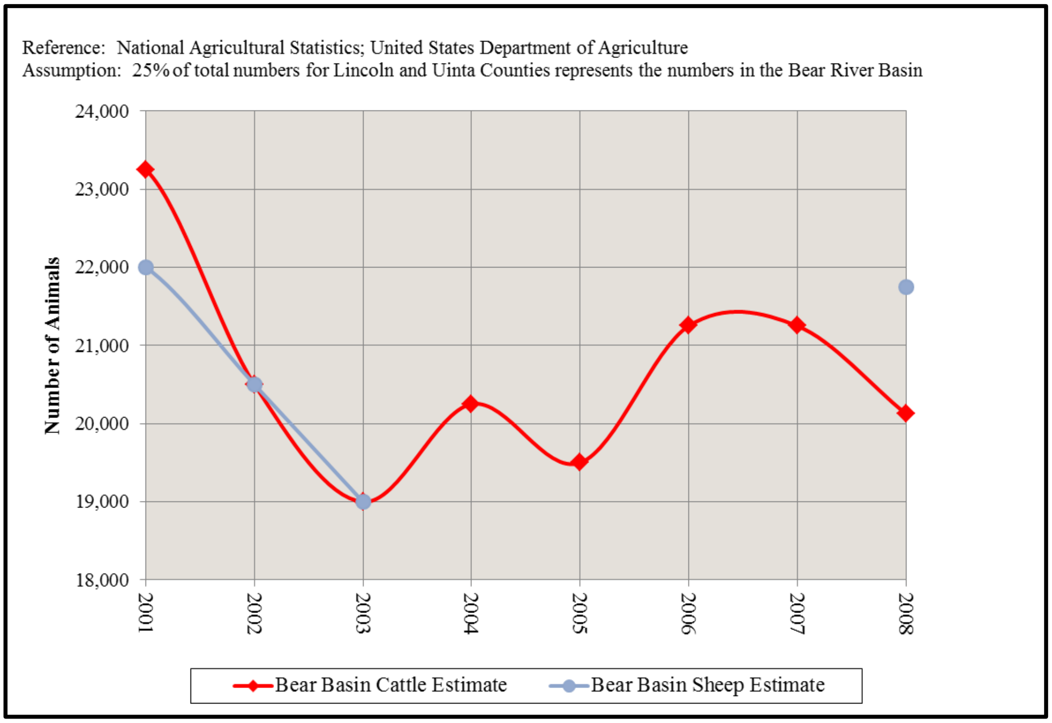

Figure 6-6: Bear River Basin Cattle and Sheep Estimates, 2001-2008

The county cattle numbers show an average decline of 20% from the number in the 2001 plan, with declines in both Lincoln and Uinta Counties being comparable. The number of sheep increased slightly overall with a slight decline in Uinta County and an increase in Lincoln County. The 2001 Basin Plan's low growth scenario stated that the BLM may expand its no conversion of sheep to cattle grazing policy, which would reduce the number of AUMs in the Basin. A separate analysis to determine consumptive use of livestock showed a significant decrease in the AUMs.

The 2001 Plan used permitted AUMs for allotments in the Basin to determine the consumptive use for livestock. The same methodology was applied for this update and the results mirrored the data from USDA National Agriculture Statistics Service. The BLM's RAS website was used to obtain the "authorized use" for each allotment. The RAS provided the AUMs permitted for each allotment and the amount of private and public land therein. The RAS data is for the year 2011. Attempts to obtain 2008 data were unsuccessful. Allotment use is fairly static; therefore, the 2011 data is applicable for this analysis. The AUMs were converted to AUs following the method described in Chapter 5, section 5.1.1.4. The decrease in AUMs also fell below the low growth projection from the 2001 Plan. The 2001 Plan's high growth livestock consumptive use estimates were 528 acre-feet for 2001, 548 acre-feet for 2008, and 610 acre-feet or 2030. Calculated for this update, the estimated livestock consumptive use for 2011 is 345 acre-feet.

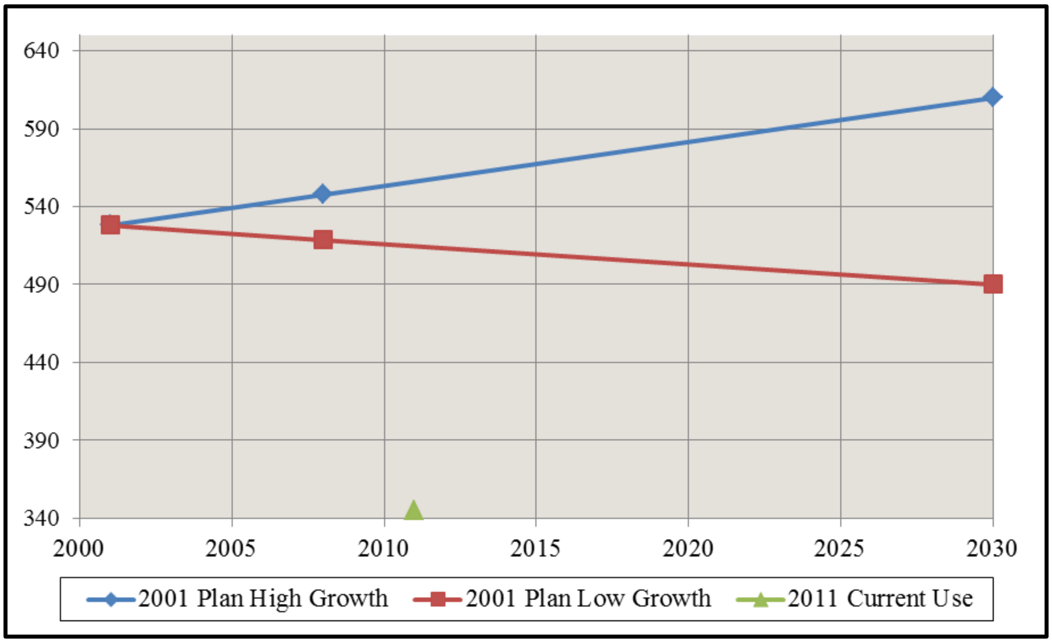

Figure 6-7: Livestock Consumptive Use Projections to 2030 (AFY)

6.3 INDUSTRIAL WATER USE

Natural gas production and processing was the only self-supplied water consuming industry in the Basin during development of the 2001 Bear Plan. That plan presented two growth scenarios for natural gas processing water use within the Basin, a high scenario and a low scenario. The high growth scenario estimated that natural gas production and processing would increase by 15% over the 30-year planning period. This increase would raise the consumptive water use to approximately 460 acre-feet per year.

The low growth scenario indicated that natural gas production and processing in the Basin would cease by 2027, three years before the end of the planning period. This would eliminate water use for gas processing. Figure 6-8 shows the water use as projected in the 2001 Plan.

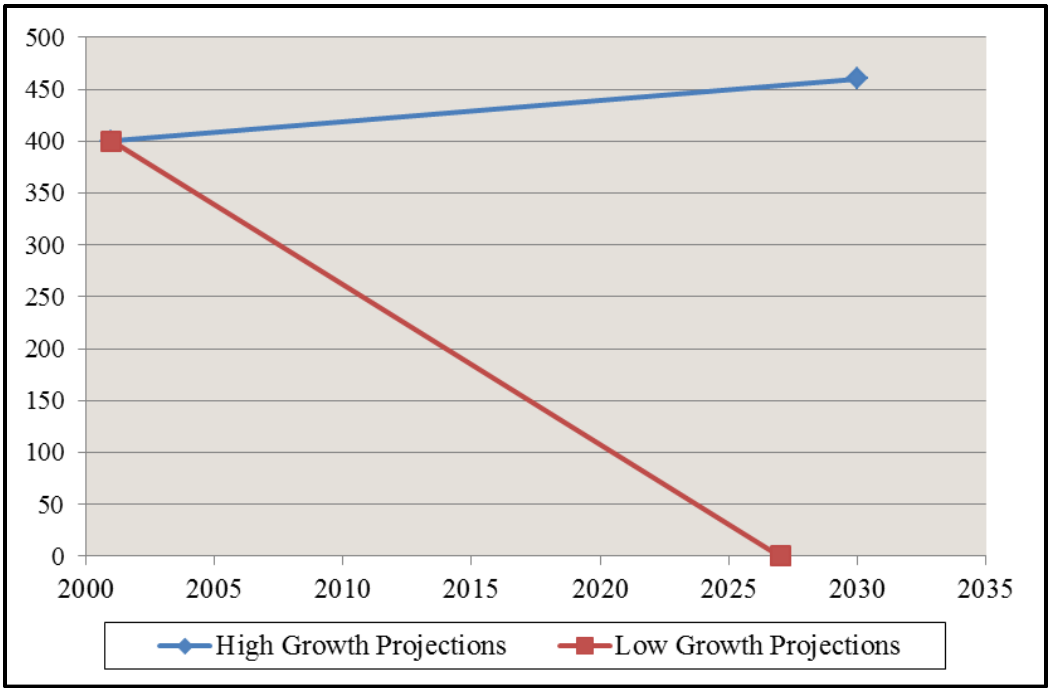

Figure 6-8: 2001 Bear River Basin Plan Industrial Water Use Trends (AFY)

During this review, it was found that there are no new industrial water uses within the Basin. As in the 2001 Plan, the only industry supplying its own water was the natural gas processing plants. These processing plants have become more water efficient and now only use a fraction of the water previously required. Both BP America (formerly BP Amoco) and the Chevron Corporation operate gas processing plants in the Basin. BP America reduced its groundwater use for gas production from approximately 90 acre-feet per year to approximately 5.2 acre-feet per year. This was the result of reduced production and the closing of their Whitney Canyon plant. Chevron now processes their natural gas as well as BP America's production from the Whitney Canyon/Carter Creek Unit. Formerly, Chevron used a water intensive natural gas processing procedure, using 310 acre-feet of surface water annually from Woodruff Narrows Reservoir. They have improved their gas processing water efficiency and now only use between 22 and 37 acre-feet per year. These reductions in water use have resulted from some reduced natural gas production, but mainly from improvements in processing and the closing of one processing plant.

Future natural gas production in the Basin is uncertain. Mr. Matthews of Chevron Corporation indicated that the Painter Field Unit is still viable but production has decreased (personal communication, Matthews, 2009). He also indicated the East Painter Field and the Whitney Canyon/Carter Creek Field both have ten years of production remaining. The availability of natural gas reserves, production and processing technology, and energy demands will influence production within the existing Basin fields and the potential development of other natural gas resources in the Basin.

It would seem that the high growth projection for industrial water use of 460 acre-feet annually presented in the 2001 Plan would be very high, unless a new industry requiring large quantities of water was established in the Basin. At this time, it seems a continued low industrial water demand of between 27 and 42 acre-feet annually will continue for the next 10 to 20 years.

It is difficult to predict economic changes and demands for products over an extended planning period. Therefore, to provide a comparison of current industrial water use with potential future industrial development and increased water use, a low growth, mid growth and high growth scenario were developed. The low growth scenario corresponds to the closing of the natural gas processing plants within the Basin by 2030 and no further water intensive industrial development occurring during the planning period. The mid growth scenario estimates a 100% increase in industrial water use and the high growth scenario anticipates a 200% increase in water use (see Figure 6-7). The low growth scenario goes to zero industrial water use by 2030 as the natural gas processing ceases. The mid growth scenario would increase water use to 84 acre-feet annually, and the high growth scenario would increase to 126 acre-feet per year. These are modest increases compared to the projections in the 2001 Plan but provide a point of comparison for looking at potential future water uses.

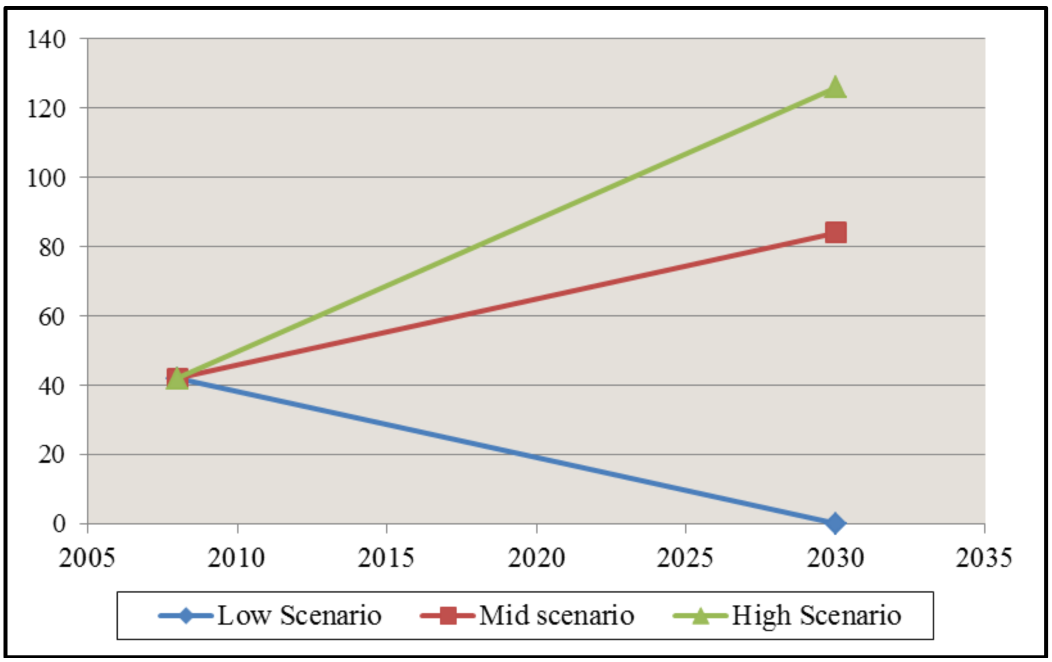

Figure 6-9: Industrial Water Use Projections by Scenario

The ratio of surface water use compared with groundwater use is estimated as the current surface water and groundwater use ratio. Currently, about 5 acre-feet of groundwater is used in natural gas processing and a maximum of 37 acre-feet of surface water is used. The ratio is 88% surface water and 12% groundwater. In the mid growth scenario, about 74 acre feet of surface water and 10 acre-feet of groundwater would be used. Under the high growth scenario, 111 acre-feet of surface water and 15 acre-feet of groundwater would be used. The low growth scenario show that water use goes to zero by 2030 as natural gas production ceases.

6.4 MUNICIPAL AND DOMESTIC WATER USE

Table 6-4 presents municipal consumptive water use for 2009 and projected use for 2030. The information presented in the table was calculated using the 2030 population estimates provided by AIEAD and the average per capita daily demands outlined in Table 6-5. It was assumed that the average gallons per capita per day use values would not change from the numbers reported in the 2009 phone call data with water managers (personal communications, Hansen 2009, Rhodes 2009, and Walker 2009). The average per capita daily demands are calculated for each municipality and rural domestic users.

Table 6-4: Updated Municipal and Rural Domestic Water Use Projections

City/Town	2009 Consumed (AFY)		2030 Consumed (AFY)	
	Surface Water	Groundwater	Surface Water	Groundwater
Evanston	2,408	--	2,610	--
Cokeville	--	665	--	861
Bear River	--	27	93	--
Rural Domestic	--	533	--	465
Total	***2,480***	***1,224***	***2,703***	***1,326***

Table 6-5: Updated Per Capita Water Withdrawal Estimates for 2009 and 2030

Municipality	2009 Est. Population	2030 Est. Population	Avg. Day (gpcpd)	2009 Withdrawals (AFY)		2030 Withdrawals (AFY)	
				Surface Water	Groundwater	Surface Water	Groundwater
Evanston	11,773	12,760	310	4,088	--	4,431	--
Cokeville	501	649	1,334	--	749		970
Bear River	162	557	285	--	52	178	--
Rural Dom.	2,642	2,308	180	--	533	--	465
Total	***15,078***	***16,274***		***4,088***	***1,334***	***4,609***	***1,435***

The average day use values (see Table 6-5) for Evanston and Bear River were collected through personal correspondence with the municipalities. The average day use value listed for the town of Cokeville was calculated from the annual water use data submitted by Cokeville for the 2009 Water System Survey (WDC, 2009).

The 2001 Plan reported the projected municipal water use for the year 2030. Data from the 2001 Plan has been included in Table 6-6 for comparison to the water consumption estimates reported above in Table 6-4. The town of Bear River did not incorporate until after the 2001 report was published. As a result, the town of Bear River's water use was included with rural domestic water use.

Table 6-6: 2001 Bear River Basin Plan Projected Consumptive Water Use Data

Location	High Growth 2030 (AFY)		Low Growth 2030 (AFY)	
	Normal Demand	High Demand	Normal Demand	High Demand
Evanston	4,678	5,885	2,352	2,959
Cokeville	513	516	364	365
Rural Domestic	959	959	504	504
Total	***6,150***	***7,360***	***3,220***	***3,828***

Note: Normal Demand corresponds to an average water year, and High Demand corresponds to dry hydrological conditions.

Data from Table 6-4 shows that municipal consumptive use for 2009 was 3,632 acre-feet per year for surface and groundwater sources combined. The 2030 projected use for surface and groundwater sources from Table 6-4 is 4,029 acre-feet per year. The updated 2030 estimates are similar but slightly higher than the low growth scenario developed for the 2001 Plan (see Table

6-6). The difference could be due in part to the average per capita use values used for each of the municipal systems. These values were calculated from local data, and in some cases, they are higher than those used in the previous plan.

6.5 ENVIRONMENTAL

With little quantitative data available for this sector, the ability to project growth for environmental water uses is limited. There is, however, one component of the environmental water use sector with enough available information to discuss in this chapter. According the USFWS website, Cokeville Meadows National Wildlife Refuge has an approved acquisition boundary of 26,657 acres. To date, however, they have only purchased 8,106 acres. Land acquisition is expected to continue from willing sellers (USFWS, 2011). As a result, it is anticipated that the acreage within the refuge will continue to expand. A communication from the Water Division IV Superintendent (Henderson, 2011) indicated land purchases for the refuge should not change the water use if the USFWS continues to operate the irrigation water rights as they were under agricultural production. However, a "crop" change from hayed ground to more cattails, and expansion to higher dikes, excavated ponds, and longer impoundments has been noted.

6.5.1 ENVIRONMENTAL SUMMARY

Most of the environmental water uses are concentrated in the Central Division, including all of the Basin's instream flow filings (see Figure 5-6). Several efforts have been undertaken to improve Bonneville cutthroat trout habitat in the Central Division. Additionally, Cokeville National Wildlife Refuge is the largest environmental use in the Basin and it is split between the Upper and Central Divisions.

These data help demonstrate the fact that despite limited numerical data, environmental uses are significant in the Bear River Basin and should be considered in any future projects.

6.6 RECREATION

There are several trends that can be reported to explain growth in the recreational sector. Data were collected for the following recreational water use components:

- Leisure and hospitality sales and use tax for Uinta County,
- Duck and goose hunter days,
- State park visitation trends, and
- Phone call survey data from county planners.

One way that recreational water use can be tracked is by looking at sales and use tax data. Figure 6-10 shows the leisure and hospitality sales and use tax data for Uinta County from 2004 to 2010 (AIEAD, 2011). In 2004, the data were restructured from Services to Leisure and Hospitality. As a result of this restructuring, data before 2004 cannot be compared. The data show a positive trend in leisure and hospitality revenues, especially for 2008 and 2009.

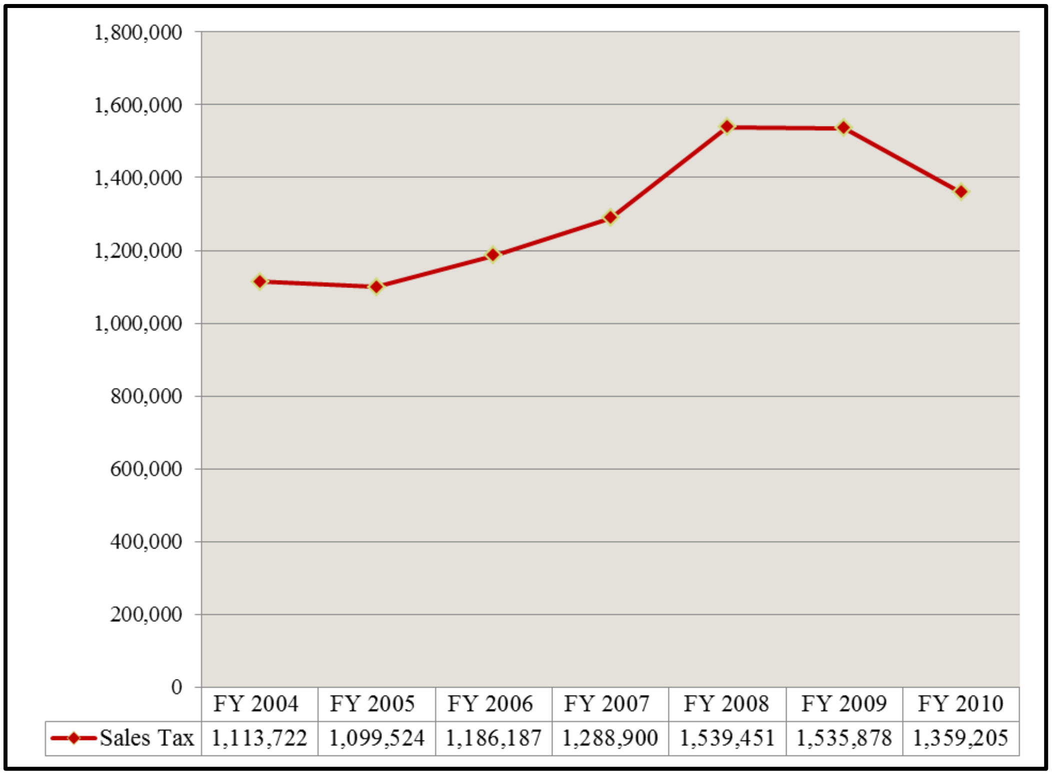

Figure 6-10: Uinta County Leisure and Hospitality Sales Tax in Dollars

Phone calls were made to the county planners for Lincoln and Uinta Counties. The planners gave further clarification on the peak sales and use tax figures for 2008 and 2009. During that time frame, construction began on a large interstate natural gas pipeline. This resulted in a large transient population in the Evanston area. When the pipeline construction in the Evanston area was completed, many of the workers followed their employer to other states to work on construction in other areas (personal communication, Williams, 2011). However, even with the data from 2008 and 2009 removed, the leisure and hospitality taxes are still trending upward (see Figure 6-11).

Additional data provided by the GFD can be used to track trends in duck and goose hunting (see Chapter 5, section 5.6.3). Graphs of number of hunters show a positive trend (see Figure 6-12).

The Wyoming Department of State Parks and Cultural Resources provided visitor data for walking trails and the visitor center at Bear River State Park (see Chapter 5, section 5.6.1). In general, the number of visitors using the park appears to be decreasing from 1999 to 2009, with an increase in use only in 2002. Given the other trends described above, it is possible that this is a localized phenomenon. Further analysis would be required to determine the reasons for this trend.

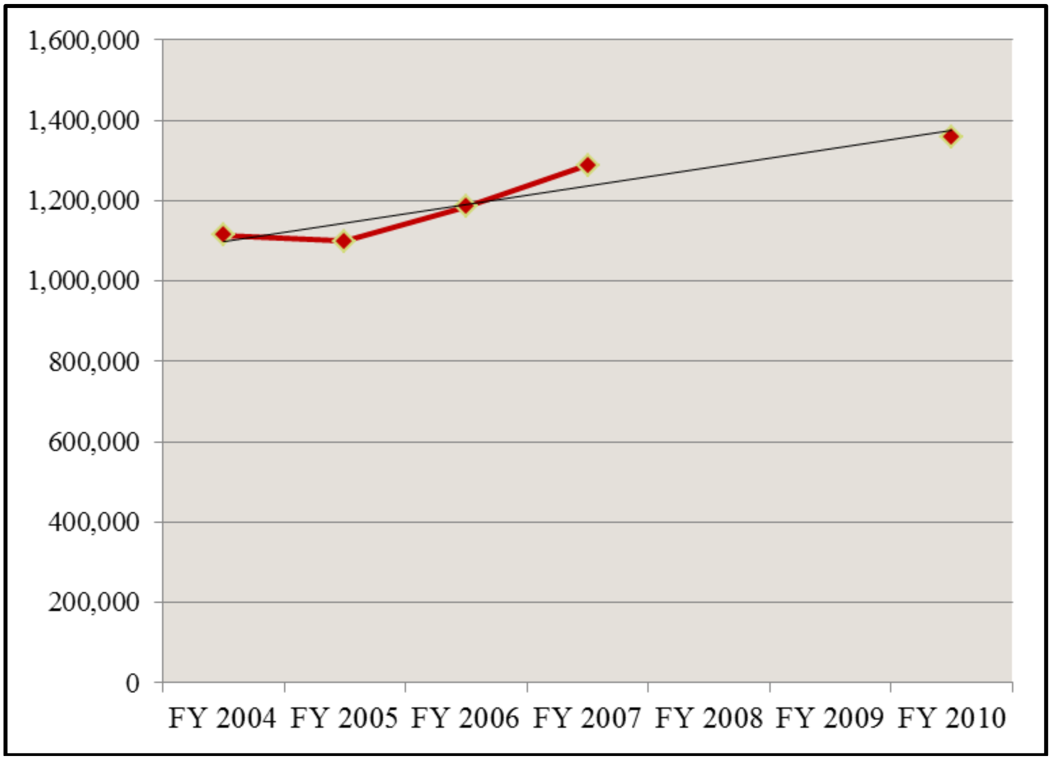

Figure 6-11: Leisure and Hospitality Sales Tax Trends in Dollars

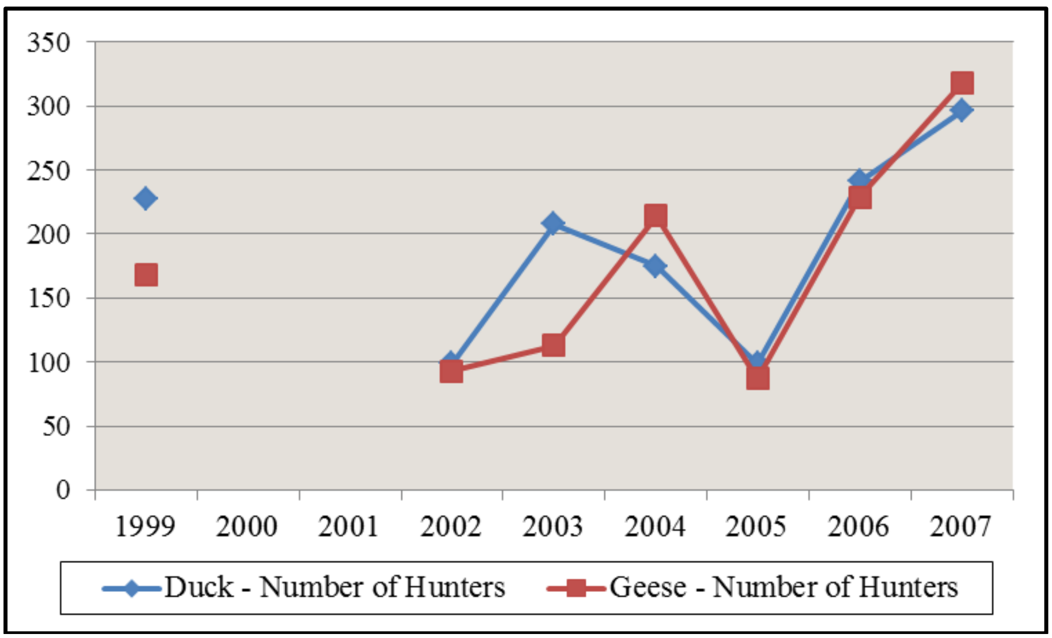

Figure 6-12: Number of Waterfowl Hunters within Bear River Basin

6.6.1 RECREATIONAL WATER USE SUMMARY

Recreational data gathered for this report generally show an upward trend. Specifically, sales tax, duck hunter, and goose hunter data are all trending upward. Visitation data for the park for the same timeframe shows a downward trend.

One conclusion that can be drawn from this data is that recreational uses are important to the Basin and should be considered in any future project completions.

6.7 RESERVOIR EVAPORATION

Reservoir evaporation is not a conventional consumptive use like agriculture or industrial; however, it is considered a consumptive use in these analyses and is the second largest use of water in the Basin. Projected changes to evaporation are difficult to predict due to the variables used to calculate evaporation. The variables are temperature, precipitation, pan evaporation, and the surface acreage of each water body. Temperature, precipitation, and pan evaporation are a part of the climate which is variable and difficult to predict, one variable does not necessarily correlate with or influence the other. In addition, reservoir capacity is dependent on snow pack and precipitation and the operation of the reservoir. Reservoir operation data are very limited in the Basin, which means estimates of water elevations must be assumed, and this can have a large effect on evaporation.

The 2001 Basin Plan estimated the total evaporation to be 5,280 acre-feet. This update estimates 5,361 acre-feet of evaporation for current conditions. To project evaporation over the planning period, temperature, precipitation, and pan evaporation was assumed to remain relatively consistent over the planning period. With this assumption, the reservoir surface acreage is the only variable that changes simplifying the calculations.

6.8 SUMMARY OF PROJECTED WATER USE

Table 6-7 provides a comparison of the consumptive water uses from the 2001 Plan and this update. Much of the decrease in consumptive water use between the 2001 Plan and this update is due to decreases in irrigation water use. Municipal and rural domestic consumptive uses have increased but not enough to offset the decreases in irrigation, industrial and livestock water uses.

A full economic analysis was not undertaken for this update, and therefore, the growth projections follow simple estimates of increased water use to 2030. Additionally, only mid and low growth scenarios are presented. There is no indication of large expansions in agricultural (primarily irrigation) or industrial water use, that would drive large water use increases and help create a high growth potential. Data available from the AIEAD indicates only slow population growth to 2030 and these data were used to develop the growth scenarios. Table 6-8 presents the growth scenarios developed for this update.

Table 6-7: Comparison of Consumptive Water Use between the 2001 Plan and 2011 Update under Normal Hydrologic Conditions

Source	Sector	2011 Basin Plan Update (AFY)	2001 Basin Plan (AFY)
Surface Water	Irrigation	89,309	92,300
	Livestock	345	528
	Industrial	37	310
	Municipal	2,408	2,304
	Reservoir Evaporation	5,361	5,280
	Subtotal	*97,460*	*100,722*
Groundwater	Irrigation	1,900	1,900
	Industrial	5	90
	Municipal	692	505
	Rural Domestic	533	500
	Subtotal	*3,130*	*2,995*
	Total	***100,590***	**103,717**

Table 6-8: Low and Mid Growth Consumptive Water Use Projections to 2030

Source	Sector	Low Growth Scenario (AFY)	Mid Growth Scenario (AFY)
Surface Water	Irrigation	89,309	92,300
	Livestock	345	528
	Industrial	0	74
	Municipal	2,435	2,703
	Reservoir Evaporation	5,361	5,361
	Subtotal	*97,450*	*100,966*
Groundwater	Irrigation	1,900	1,900
	Industrial	0	10
	Municipal	665	861
	Rural Domestic	533	465
	Subtotal	3,098	3,326
	Total	***100,548***	***104,202***

Assumptions used to develop the two growth scenarios are presented below.

<u>Low Growth Scenario:</u>

- Irrigation consumptive water use remains at 89,309 acre-feet even though hydrologic conditions and water availability improve over the projected time period. Additionally, groundwater irrigation use remains the same over the period.
- Livestock consumptive water use remains at 345 acre-feet over the projected time period.
- Industrial consumptive water use goes to zero during the projected time period as the natural gas fields are taken out of production.
- Municipal water use remains flat over the projected time period.
- Reservoir evaporation remains the same over the projected time period.
- Rural domestic consumptive water use remains constant over the projected time period.

<u>Mid Growth Scenario:</u>

- Irrigation consumptive water use increases as hydrologic conditions improve and more water is available over the period to the level estimated in the 2001 Plan (92,300 acre-feet), and groundwater irrigation water use remains at 1,900 acre-feet.
- Livestock numbers increase to levels estimated in the 2001 Plan and consumptive water use returns to 528 acre-feet annually.
- Industrial consumptive water use increases over the time period to 84 acre-feet as production is spurred by improved technologies and increased demand for natural gas. Seventy-four acre-feet of use would be from surface water and 10 acre-feet would be from groundwater.
- Municipal water use increases to match the projected population growth through the projected time period.
- Reservoir evaporation remains constant over the projected time period at 5,361 acre-feet per year.
- Rural domestic consumptive water use decreases from 533 to 488 acre-feet annually as more households are included within cities and towns or as they are included in regional water systems. It should be noted that the estimated population growth for the Basin was greater for cities and towns than for rural areas in the AIEAD analysis.

Figure 6-13 illustrates the projected changes of water use to 2030. Because of the low population growth projections and slow economic development, there is not a significant change in water use over the period. The mid growth projection shows a slight increase in water use above the 2001 Plan estimated water use.

The mid growth scenario may be the most likely water use scenario, since the major decrease in water use between the 2001 Plan and the 2011 update was due to the drought related decrease in agricultural water use. As the drought subsides and water is more available, agricultural water use may return to more normal conditions as shown in the 2001 Plan.

Also of importance are the environmental and recreational water uses. These uses are considered non-consumptive but can play an important role in the economy and in future water use and development. These variables should be further evaluated and considered in any future project planning process.

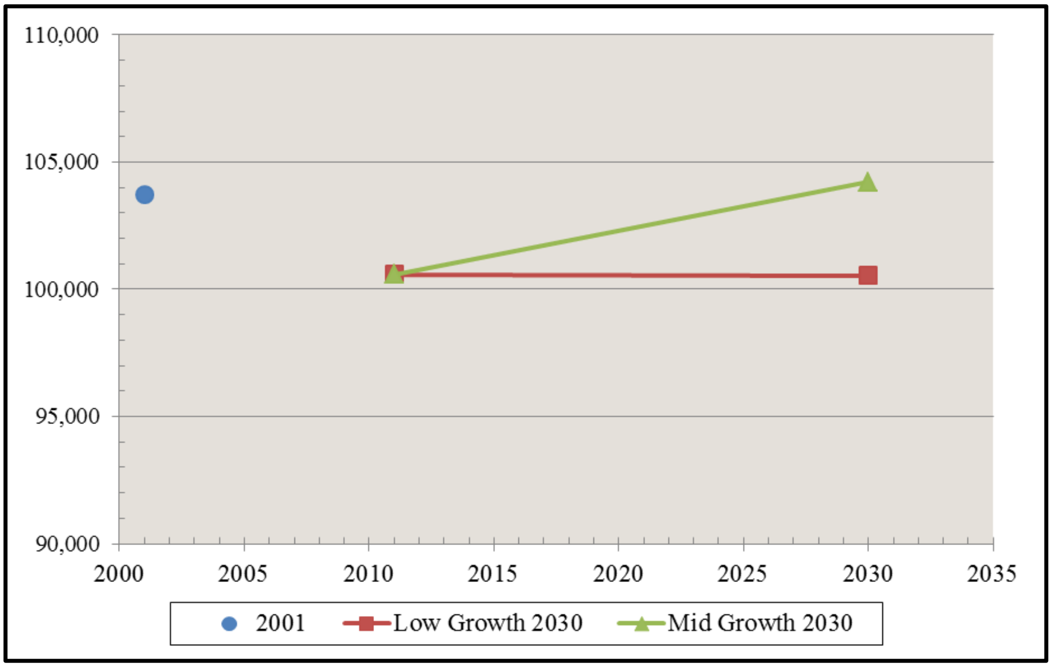

Figure 6-13: Consumptive Water Use Projections for the Low and Mid Growth Scenarios

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7.0 WATER AVAILABILITY

7.0 WATER AVAILABILITY

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7.0 WATER AVAILABILITY

7.1 SURFACE WATER

The amount of surface water available for future use in the Basin is a product of the spreadsheet models output for wet, normal and dry years. The models are driven by an estimation of the amount of water that can be put to beneficial use under the general hydrologic and consumptive use conditions. Estimates of available water are location specific because they are calculated at the bottom of each reach within the model. This method of determining availability does not take into account any legal entitlements to downstream users; rather it is assumed that the legal water use is reflected in the hydrologic and diversion records.

7.1.1 SURFACE WATER MODELING

The methodology used to develop the water availability spreadsheet models in the 2001 Plan was also employed for this update. The only changes made within the spreadsheet models were updates to USGS stream gage data, diversion data, and reservoir evaporation variables. Each spreadsheet model provides a "snapshot" of water use and availability, dependent upon yearly hydrologic conditions at the representative gages and diversion data. For more information on these models, refer to Chapter 5 of this report and the technical memoranda from the 2001 Plan http://waterplan.state.wy.us/plan/bear/techmemos/techmemos.html

When comparing the hydrology of the 2001 Plan to this update, all three hydrologic conditions show a decrease in the amount of water entering the system due to drier years in the extended period of record. Stream gage and diversion data were classified into corresponding dry, normal, and wet condition values. The dry, normal, and wet conditions used to define the diversion data corresponded to the hydrologic condition of the gage upstream of a particular diversion. For example, if gage 100 had dry year conditions for 1970, 1972, 2006, and 2008, then these years were used to determine the dry year diversions for the diversions immediately downstream of gage 100.

The average annual (January-December) normal hydrologic condition inflow for the Basin is 391,981 acre-feet for this update, versus 525,000 acre-feet for the 2001 Plan. However, the months of May through September were the focus of the water availability output of the spreadsheet models because there is insufficient diversion data for the other months.

Table 7-1 presents a comparison of the total inflows and diversions (May through September) of the 2001 Plan and this update. The total diversions in the table represent the model diversion data input which is different than the model diversion summary table. The difference between the two is that the model diversion summary does not use the diversion input in all cases, due to the internal balancing of the water budget. For example, when a diversion from the diversion input is greater than the calculated available flow at a node, the model sets the diversion to zero so there will not be a negative flow at that node. Note that the volume of diversions exceeds the inflow for every case. This is indicative of the amount of water returning to the system for downstream use.

Table 7-1: Inflow and Diversion Comparisons, May-September

Description	2001 Plan (AF)	2011 Update (AF)	2001 Plan (AF)	2011 Update (AF)	2001 Plan (AF)	2011 Update (AF)
	Dry		Normal		Wet	
Inflow Gage 10011500	66,868	63,399	124,011	110,857	193,738	174,274
Inflow Gage 10015700	1,118	2,398	3,889	7,108	10,490	16,646
Inflow Gage 10032000	46,407	45,093	110,470	97,211	165,423	167,829
Ungaged gains (+) or losses (-)	3,582	-32,268	128,850	68,322	361,263	189,789
Total Inflow	***117,976***	***78,622***	***367,220***	***283,498***	***730,913***	***548,538***
Total Diversions	***336,055***	***271,958***	***607,887***	***519,593***	***897,801***	***794,987***

7.1.2 AVAILABLE SURFACE WATER DETERMINATION

Water availability is an estimation of the amount of water that can be put to beneficial use under the general hydrologic and consumptive use conditions that drive the models. The values represented in the model are useful for an initial investigation of potential future water developments. It is advised that further research and modeling be done before making final decisions on where and how much water can be developed at any given location.

Tables 7-2 and 7-3 are direct output from the updated models and show water allocation calculations and potential water emergencies for the normal hydrologic condition in both the Upper and Central Divisions, respectively. Details describing the development of the tables and the output for the dry and wet conditions can be found in the Available Surface Water Determination Technical Memorandum, Volume 2, Tab: IX. All values are in acre-feet unless otherwise noted. A water emergency exists, in the Upper Division, if the total divertible flow is less than 1,250 cfs. A water emergency exists, in the Central Division, if the total divertible flow is less than 870 cfs or if flow at the Border gage is less than 350 cfs.

Tables 7-4 and 7-5 represent the total available flow for the months of January through December, taking into account compact requirements for the Upper and Central Divisions, respectively. Because the model calculations are for the months of May through September, the divertible flows for the remaining months are set to zero. This is consistent with the 2001 Plan. According to the updated models, there appears to be developable water for all non-irrigation months; however, there is a lack of diversion data for those months. Therefore, this conclusion should be carefully investigated when considering water development. Available water during the non-irrigation months could be used for reservoir storage.

Table 7-2: Normal Year Upper Division Water Allocation Calculations

May	Jun	Jul	Aug	Sep	
352	773	544	315	113	Upper Utah Section Diversion (1) (Havorka and Hatch)
11,091	24,165	18,561	8,527	6,165	Upper Wyoming Section Diversion
3,631	(13,621)	(8,570)	(1,845)	(849)	Woodruff Narrows Reservoir Change in Storage Water
38,228	64,346	26,350	4,576	5,836	Lower Utah Section Diversions
6,668	12,353	3,390	176	187	Lower Wyoming Section Diversions
22,015	24,155	17,401	6,100	3,528	Bear River Below Pixley Dam
81,985	112,171	57,676	17,847	14,980	**Total Upper Division Divertible Flow (ac-ft)**
1,333	1,885	938	290	252	**(cfs)**
No W.E.	**No W.E.**	**W.E.**	**W.E.**	**W.E.**	
		346	107	90	Upper Utah Section Allocation
		28,434	8,799	7,385	Upper Wyoming Allocation
		23,359	7,228	6,067	Lower Utah Section Allocation
		5,537	1,713	1,438	Lower Wyoming Section Allocation

NOTE: (1) Upper Utah Division is not modeled explicitly in this model. Diversion data are included here for computation of Compact allocations.

Is Total Upper Division Divertible Flow less than 1250 cfs?If so, Water Emergency (**W.E.**) exists.

Table 7-3: Normal Year Central Division Water Allocation Calculations

May	Jun	Jul	Aug	Sep	
10,182	22,911	20,217	10,858	5,276	(1) Wyoming Diversions
15,027	25,359	14,104	6,943	6,542	(2) Idaho Diversions
58,533	46,112	29,681	11,966	8,249	(3) Rainbow Inlet Canal plus Bear River Main Stem Flow below Stewart Dam
83,743	94,381	64,002	29,767	20,067	Total Central Division Divertible Flow (ac-ft)
1,362	1,586	1,041	500	337	(cfs)
			W.E.	**W.E.**	
58,284	58,377	35,012	13,396	9,661	Flow of Bear River at Border Gaging Station (ac-ft)
980	981	569	225	162	(cfs)
			W.E.	**W.E.**	
			12,800	8,629	Allocation in the State of Wyoming
			16,967	11,438	Allocation in the State of Idaho

Is Total Divertible Flow (2) < 870 cfs? If so, Water Emergency (**W.E.**) exists.

Is Flow at Border < 350 cfs?If so, Water Emergency (**W.E.**) exists.

Table 7-4: Upper Division Water Availability (AF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1. Flow below Pixley Dam (AF)													
Dry	1,078	841	3,059	2,110	238	1,173	2,402	1,007	752	1,356	1,745	1,407	17,168
Normal	2,663	2,619	6,469	13,724	22,015	24,155	17,401	6,100	3,528	3,185	3,427	3,031	108,317
Wet	5,414	5,950	17,292	33,145	57,170	61,520	31,946	13,704	12,078	10,038	8,743	6,711	263,711
2. Total Divertible Flow (AF)													
Dry					41,930	62,770	26,956	9,741	6,724				148,121
Normal					81,985	112,171	57,676	17,847	14,980				284,659
Wet					103,105	180,292	89,751	26,959	24,602				424,709
3. Min. Compact Flow Required (AF)					76,861	74,381	76,861	76,861	74,381				379,344
(cfs)					1,250	1,250	1,250	1,250	1,250				6,250
4. Available Flow for WY (AF)													
Dry	1,078	841	3,059	2,110	0	0	0	0	0	1,356	1,745	1,407	11,596
Normal	2,663	2,619	6,469	13,724	5,124	37,790	0	0	0	3,185	3,427	3,031	78,032
Wet	5,414	5,950	17,292	33,145	26,244	105,911	12,890	0	0	10,038	8,743	6,711	232,339

Notes:

1. Flow below Pixley Dam is gage 10028500 Bear River below Pixley Dam. This constitutes the flow out of the Upper Division.
2. Total Divertible Flow is combined diversions (*present development*) of Wyoming and Utah in Upper Division including flow below Pixley Dam (1,250 cfs limit).
3. Minimum Compact Flow is minimum of flow above 1,250 cfs (Total Divertible Flow, including Pixley Dam release) or zero for non-irrigation season.
4. Available Flow is *physically available flow,* based on present development, above required Compact flows, which is flow in item 1 during non-irrigation season or flow in item 2 minus item 3 in irrig. season.

Table 7-5: Central Division Water Availability (AF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1. Flow at WY/ID Border Gage (AF)													
Dry	7,441	6,474	11,598	10,073	11,819	12,809	8,906	4,673	3,856	7,626	8,702	7,960	101,937
Normal	11,255	11,103	19,960	37,507	58,284	58,377	35,012	13,396	9,661	11,766	12,745	12,062	291,128
Wet	16,489	17,841	42,333	70,599	126,688	163,428	67,594	29,607	23,870	24,617	22,902	18,760	624,728
2. Flow below Stewart (AF)													
Dry					245	313	239	224	0				1,020
Normal					607	908	833	786	0				3,133
Wet					944	10,763	5,985	564	0				18,256
3. Total Divertible Flow (AF)													
Dry					31,416	39,699	24,846	14,849	10,208				121,018
Normal					83,743	94,381	64,002	29,767	20,067				291,960
Wet					164,981	205,313	99,112	48,639	35,505				553,550
4. Min. Compact Flow Required (AF)	21,521	19,438	21,521	20,827	53,495	51,769	53,495	53,495	51,769	21,521	20,827	21,521	411,199
(cfs)	350	350	350	350	870	870	870	870	870	350	350	350	6,800
5. Available Flow for WY (AF)													
Dry	7,441	6,474	11,598	10,073	0	0	0	0	0	7,626	8,702	7,960	59,874
Normal	11,255	11,103	19,960	37,507	30,248	36,856	10,507	0	0	11,766	12,745	12,062	194,009
Wet	16,489	17,841	42,333	70,599	105,167	142,601	45,617	0	0	24,617	22,902	18,760	506,926

Notes:

1. Flow at WY/ID Border Gage is gage 10039500 Bear River at Border, above Idaho diversions. One of the Compact flow limitations/triggers is a flow of 350 cfs at this gage.

2. Flow below Stewart Dam reported by PP&L, is referenced in compact as part of other minimum of 870 cfs in item 4 (other part is Total Divertible Flow). Information not available for Jan-Apr and Oct-Dec.

3. Total Divertible Flow is combined diversions (*present development*) of Wyoming and Idaho in the Central Division plus flow below Stewart Dam.

4. Minimum Compact Flow is minimum of flow above 350 cfs at Border Gage or flow above 870 cfs (Total Divertible Flow, including Stewart Dam release).

5. Available Flow is *physically available flow,* based on present development, above required Compact flows, which are minimum of flow in item 3 above 870 cfs or flow in item 1 above 350 cfs.

7.2 GROUNDWATER

The quantity of groundwater resources available in the Bear River Basin is dependent on the three-dimensional physical extent, water saturation, and permeability of the various geologic units located within the Basin. Groundwater is generally available in most of the geologic units although the quantity available for use from wells may range from very low to very high yields. The most heavily used aquifers in the Bear River Basin are first the Quaternary unconsolidated deposits located in the valley areas of the Basin, followed by the relatively flat-lying Tertiary bedrock formations as the second most heavily used aquifers (Ahern et al., 1981). The Quaternary unconsolidated deposits and the Tertiary bedrock are part of the Cenozoic aquifer group.

From information and calculations presented in Chapter 4 of this report, approximately 16.8 million acre-feet of groundwater are available in the Wyoming portion of the Basin. There is estimated to be 765,000 acre-feet available in the Cenozoic aquifer group and 16.1 million acre-feet available in the Mesozoic and Paleozoic aquifer groups. It was estimated in the 2001 Plan, that groundwater recharge equaled 14,000 acre-feet annually (Forsgren Associates, 2001). Although this estimate may be conservative, it demonstrates that the annual sustained yield of groundwater would be much less than the storage capacity.

Overall, future development of groundwater resources within the Basin is considered favorable for both the unconsolidated deposits and bedrock formations. Access to groundwater via new wells is generally good depending on the quantity and quality of the groundwater required for a beneficial use. Current groundwater use is estimated to be 3,098 acre-feet annually and is projected to be 3,259 acre-feet annually in 2030 under the mid-growth scenario.

7.3 DISCUSSION OF WATER AVAILABILITY AND PROJECTED USE

Water is available for development and growth in Wyoming's Bear River Basin. However, allocation under the Amended Bear River Compact must be considered when evaluating the amount of water available for development. Table 7-6 presents surface water flow into the Basin, current consumptive uses, and flow leaving the state. In many basins, flow leaving the state minus compact or decree flow requirements is the water available for development. In the Bear River Basin, the amount of water available for development is set by the amended compact as discussed in the SEO report to the Bear River Commission (Lowry, 1992).

The Amended Bear River Compact of 1980 allowed Wyoming 13,000 acre-feet in additional depletions annually and 35,000 acre-feet of additional storage within the Basin. However, storage of the 35,000 acre-feet can only occur when the water storage level in Bear Lake is above 5,911 feet in elevation. Of the 35,000 acre-feet allocated, approximately 14,451 acre-feet have been developed, leaving approximately 20,549 acre-feet to develop. Wyoming has 4,100 acre-feet of pre-compact storage remaining and this water storage is not subject to restrictions under the compact. This storage has been designated by the SEO for the Central Division and specifically to the Smiths Fork.

Table 7-7 presents water availability under dry hydrologic conditions and the mid-growth scenario to 2030. Once again, Wyoming's share of the Bear River water is governed by the compact and is limited to approximately 9,790 acre-feet. In wet and perhaps normal years, water may be available to a current year water right. However, given the short supply of water during the irrigation season under water emergency situations (e.g. dry year conditions), a current year priority water right may not provide a firm water yield.

Table 7-6: Wyoming Bear River Basin Surface Water Resources and Current Depletions – Normal Hydrologic Conditions (AFY)

Surface Water Resources (Normal Conditions)	**391,981**
Current Water Depletions:	
Irrigation	89,309
Livestock	345
Industrial	37
Municipal	2,408
Reservoir Evaporation	5,361
Total Depletions	**97,460**
Surface Water Leaving Wyoming	291,128
Wyoming's Remaining Share Under Compact[1]	**9,790**

1. Calculated from data presented in the SEO Report to the Bear River Commission (Lowry, 1992).

Table 7-7: Wyoming Bear River Basin Projected Surface Water Depletions, Mid Growth Scenario to 2030 (AFY)

Surface Water Resources (Dry Conditions)	**202,790**
Mid Growth Water Depletions	
Irrigation	92,300
Livestock	528
Industrial	74
Municipal	2,703
Reservoir Evaporation	5,361
Total Depletions	**100,966**
Surface Water Leaving Wyoming	101,937
Wyoming's Remaining Share Under Compact[1]	**9,790**

1. Calculated from data presented in the SEO Report to the Bear River Commission (Lowry, 1992).

Wyoming has water storage rights that could help provide water for new depletions. Storage would be the best way to address new, large water uses. However, there are several issues that need to be considered. First, depletions in the Basin cannot exceed 9,790 acre-feet, including reservoir evaporation from new reservoirs. The second issue relates to the timing of water storage; water is available from October through April, but the amount of water available cannot be accurately established because depletions occurring during this period are undetermined (see Tables 7-4 and 7-5). Additionally, water storage under the amended compact cannot occur if Bear Lake is below the elevation of 5,911 feet.

Groundwater could easily be developed to satisfy new water depletions. However, groundwater is considered in the compact, and therefore, new depletions from groundwater and/or surface water cannot exceed 9,790 acre-feet annually.

Considering the Basin's future growth projections, developed as part of this report, it does not appear that growth and development will exceed the allocated depletion amounts in the next 20 years.

7.4 WATER CONSERVATION

At this time and through 2030, if development follows the projected mid growth scenario, there is adequate water to meet the demands within Wyoming's Bear River Basin. Water conservation would allow for more efficient use of the water supplies and would become important if development and consumptive water uses approach or increase above the 9,790 acre-feet allocation threshold.

Irrigated agriculture is the largest water use in the Basin and would benefit most from water conservation. Improvements in diversion and delivery efficiencies could provide more water to fields, and improvements in irrigation methods would make better use of the water delivered to the fields to better meet crop water requirements. Improving irrigation methods presents problems at times since established water rights are based upon the quantity of water diverted. Also, changing or improving irrigation practices can change the timing and quantity of return flows affecting downstream water use and potentially the entire stream system.

Industry has shown the benefits of water use efficiencies by decreasing water use from 400 acre-feet per year, as presented in the 2001 Plan, to 42 acre-feet per year presented in this update. This was accomplished with only slight reductions in natural gas production.

Cities and towns can also benefit from conservation, primarily by reducing the cost of treating water. Municipalities normally encourage conservation through increased fees for higher water use and by imposing landscape watering restrictions. Strict conservation measures are not warranted for the municipalities in the Basin at this time. However, water conservation, reuse and recycling are important strategies for municipalities to reduce costs and stretch water resources. Cokeville could benefit from system upgrades that would reduce water use. Cokeville uses groundwater and continually flows water through the system during the winter months to prevent freezing and broken pipes. Establishing a new distribution system with pipes buried below the frost line would be an option to conserve water. Water conservation improvements can be costly and are only beneficial when demands for water approach or exceed the supply.

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8.0 BASIN ISSUES, STRATEGIES, AND WATER USE OPPORTUNITIES

8.0 BASIN ISSUES, STRATEGIES, AND WATER USE OPPORTUNITIES

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8.0 BASIN ISSUES, STRATEGIES, AND WATER USE OPPORTUNITIES

8.1 REVIEW AND DISCUSSION OF BASIN ISSUES AND STRATEGIES

The Bear River BAG was formed in 1997 to help develop recommendations for citizen involvement in river basin planning. The group completed the Final Report: Bear River Basin Water Planning Advisory Group http://waterplan.state.wy.us/BAG/bear/report / report.html in September 1998. The group was asked to develop a list of issues that were important to the citizens in the Bear River Basin and to river basin planning. These issues were included in the 2001 Bear River Basin Plan and are listed in Table 8-1.

In the summer of 1999, as development of the Bear River Basin Plan started, the BAG was given the opportunity to update their list of issues. The group kept the main categories listed in Table 8-1, but added new issues to the list for each category.

After the completion of the Plan in 2001, the updated issues list was not revisited until 2005 during the development of the Framework Water Plan (WWC, 2007). At that time, the group was asked to select the issues that were most important to them and share their concerns at the Statewide Framework Water Planning meetings. The issues the group selected are highlighted in blue and are listed in Table 8-2. The Framework Water Plan was completed in 2007 and this list is included in Volume II of that report http://waterplan.state.wy.us/plan/statewide/Volume_II.pdf.

The latest updates to the Bear River BAG's issues list were incorporated to coincide with this report (see Table 8-2).

Using the issues developed by the BAG, the Planning Team developed a list of strategies to meet the needs of the Basin. The strategies are listed in Table 8-3.

Bear River South of Evanston at River Crossing for Bear River Regional Joint Powers Board Pipeline Project, 2009

Table 8-1: Issues Identified by 1998 Bear River Basin Advisory Group

Category	Issues
1) Water Allocation	
	a) Current water rights perspective and priorities
	i) Benefits and impacts of current allocations in different uses
	ii) Restrictions and opportunities of the Bear River Compact
	iii) Current law and The Prior Appropriation Doctrine
	iv) Improving existing allocations
	v) Water transfers and marketing feasibility
	vi) Water storage
	vii) Water conservation
	b) Groundwater Definitions
	i) Rights, availability and uses
2) Water Quality	
	a) Water quality impacts and benefits
	i) Municipal
	ii) Agricultural
	iii) Recreational
	iv) Industrial/Mining
	v) Subdivisions and infrastructure developments (roads, highways, etc.)
	vi) Groundwater
	vii) Water flow/quality interaction
	b) Water quality standards and regulation (i.e. TMDLs)
	i) Historical perspective
	ii) Point and non-point source differentiation
	iii) Coordinating standards with neighboring states
	c) Water quality solutions
	i) Locally driven and citizen-based problem solving
	ii) Monitoring activities
	iii) State agencies and local conservation district involvement
3) Future Demands and Growth	
	a) Current allocation patterns
	i) Water rights
	ii) Community heritage
	b) Potential shortages by water use sector
	i) Land and water availability
	c) Opportunities and solutions to meet existing and future shortages
	i) Efficiency
	ii) New technology
	iii) Additional Upper Division storage
	iv) Groundwater
	v) Public education
	d) Miscellaneous growth issues (i.e. floodplains, open space)
4) Habitat, Wildlife, and Fisheries	
	a) Examine impacts and benefits of existing and future water management activities
	i) Habitat benefits or impacts of agriculture
	ii) Impacts and benefits of water storage projects
	b) Compatibility of consumptive and non-consumptive uses of water
	c) Endangered species issues and solutions
	d) Cost sharing opportunities for projects with benefits to habitat, wildlife and fisheries
5) Economics	
	a) Evaluation of economic impacts
	i) Growth and Developments
	ii) Agriculture
	iii) Additional Storage
	iv) New technology and efficiency practices
	v) Water quality improvements & cost/benefit analysis
	vi) Recreation/Tourism
	vii) Marketing water resources
	b) Solution funding
	i) Water conservation incentives
	ii) Industrial partnerships
	iii) Growth financing
	iv) Cost share with other beneficiaries
	v) Water rate structuring
	vi) Taxation
	vii) Water marketing revenues

Table 8-2: Bear River Basin Issues List, 1999-Present

Category	Issues
Water Allocations	
	- Bear River Compact Administration
	- Storage
	- Smiths Fork
	- Compact Allocation
	- Town of Bear River
	- Measuring device installation - info available on Web
	- Conveyance loss study (UW Water Research Program)
	- USCOE Flood Study
	- Groundwater - only compact with groundwater specifically in allocations
	- WWDC Small Water Projects
	- Spring development with NRCS in Cokeville
Water Quality	
	- Joint 3 State WQ Committee affiliated with Bear River Commission
	- Water Quality Task Force - Bear Lake Regional Commission staffs this
	- responsible for reviewing state line standards for compatibility
	- Upper Bear River Watershed Plan (in lieu of TMDL)
	- DEQ 319 Projects
	- Bridger Creek, Thomas Fork
	- AML Phosphate Mine
Future Demands and Growth	
	- Town of Bear River
	- Cokeville spring developments
	- Smiths Fork (storage)
	- Wildlife Refuge land acquisition
	- Woodruff Narrows Reservoir deliveries
	- Compact tie to elevation of Bear Lake
	- Downstream growth pressures on Bear River (Washakie Reservoir in Utah)
Habitat, Wildlife, and Fisheries	
	- Instream flow applications
	- Bonneville cutthroat trout petitioned
	- habitat improvements
	- upgrading measuring devices
	- Smiths Fork Reservoir project
	- Wildlife Refuge
	- Evanston river restoration
	- Upper Bear River Watershed plan
	- Aquatic Invasive Species, ex. Zebra Mussels
Economics	
	- Town of Bear River
	- WWDC Level I Study - Smiths Fork
	- Wind generation - Evanston diversifying
	- Wildlife Refuge development and related tourism impacts
	- WWDC Small Water Project program

Note: Per the meeting held 11-7-2005, the words in blue identify some issues that BAG members wanted to have taken forward to the Framework Water Plan consultant. Issues identified in red were added at the 4-28-2009 Bear BAG Meeting.

Table 8-3: Bear River Basin Identified Issues and Strategies

Category	Strategies
Water Allocations	
	Encourage planning for future growth to properly manage and allocate water resources.
	Strategies to meet the increased municipal and domestic water demands should be evaluated.
	Evaluate methods to meet agricultural water needs.
	Identify opportunities for water conservation, re-use and recycling within the Basin.
	Work to maintain and protect water rights within the Basin.
	Maintain accurate data on water supply and use in the Basin.
	Groundwater resources of the Bear River Basin should be described and evaluated.
Water Quality	
	Use DEQ/WQD watershed plans to protect water quality.
	Participate in the Bear River Regional Water Quality Task Force.
Future Demands and Growth	
	Project future agricultural and municipal water system needs and compare to current and future water availability.
	Use master plans to assess growth potential and establish water and infrastructure needs for municipalities.
	Conduct watershed studies to assess water resources and opportunities for agriculture.
Habitat, Wildlife, and Fisheries	
	Consider non-consumptive and aesthetic water uses and needs in planning (habitat, wildlife, fisheries, environment and recreation).
	Quantify recreational and environmental water demands.
	Aid in the prevention of Aquatic Invasive Species migration by draining, cleaning, and drying watercraft (& other equipment) before use in WY waters.
Economics	
	Encourage planning for future growth to properly manage and allocate water resources.
	Groundwater resources of the Bear River Basin should be described and evaluated.
	Identify and pursue water storage opportunities to improve the reliability of existing late season water supplies.
	Conduct watershed studies to assess water resources and opportunities.

Note: Strategies in black text were taken from the 2001 Bear River Basin Plan. Strategies in red text were added by the planning staff following the 4-28-2009 BAG Meeting.

8.2 FUTURE WATER USE OPPORTUNITIES

8.2.1 RESERVOIR STORAGE OPPORTUNITIES

The 2001 Plan indicated that future water use opportunities would require storage to supply water in dry years. There were a number of studies discussed in the 2001 Plan that looked at water storage in the Basin during the 1980's. Primarily because of poor cost to benefit ratios, none of these projects were constructed. A Level I reconnaissance study (Sunrise Engineering, 2004) reevaluated potential reservoirs on Smiths Fork. Six sites were evaluated with three sites on the main stem considered best locations from an operational stand point; the Lower Teichert/Bagley site, the Upper Teichert/Bagley site and the Smiths Fork site. These reservoirs were proposed to be multipurpose including irrigation, flood control and recreation with the potential for municipal and industrial uses and perhaps hydropower. Once again, the study concluded construction of a reservoir on Smiths Fork did not have a positive cost benefit ratio and no further study was undertaken.

A site on Muddy Creek, a tributary to the Smiths Fork, had a cursory evaluation as part of the Framework Water Plan (WWC Engineering, 2007). This site may have less environmental impacts, and therefore may be more suitable then other on-channel sites. Construction costs were not developed for the report and no economic evaluation was done for the site.

Reservoir studies in the Basin's Central Division have shifted to sites on Sublette Creek, which could be filled from a canal and deliver water back to the canal (RJH Consultants, Inc., 2010). The reservoir would be for supplemental irrigation water and recreation. Studies are continuing on this potential project. This reservoir would allow storage of water allocated to the Central Division by the State Engineer from Wyoming's compact storage rights.

At this time, there are not sufficient needs or economic drivers for reservoir construction in the Basin's Upper Division. Additionally, there are no documented needs or sufficient economic drivers for constructing a large storage reservoir in the Central Division. Construction of a small reservoir on Sublette Creek for supplemental irrigation water and recreation may prove to be feasible; however, further study is needed.

If reservoir storage is determined to be necessary to meet future development needs within the Basin, there are a number of alternative reservoir sites that may be considered. The WDO Dam and Reservoir Division has compiled a summary of the potential sites in the Basin. This summary is entitled "Bear River Basin WY: Summary of Potential Dam and Reservoir Project Literature" and can be found at:
http://wwdc.state.wy.us/dam_reservoir/Bear_DamRes_survey07.pdf

8.2.2 GROUNDWATER USE OPPORTUNITIES

The heavily used Cenozoic aquifer group, including the alluvial deposits, has groundwater available for additional use in the Basin. The Mesozoic and Paleozoic bedrock aquifer groups, particularly the widely used Wasatch Aquifer, are also available for further development. However, groundwater is considered in the Amended Bear River Compact, and therefore, groundwater development and depletions cannot exceed the compact allocations. It was estimated by Lowry (1992) that 9,790 acre-feet of depletions are available annually from both groundwater and surface water within the Wyoming Bear River Basin.

Older and deeper bedrock formations in the Bear River Basin are generally situated in groundwater compartments formed by the geologic structures of the Overthrust Belt. The use of the older and deeper aquifers (Paleozoic and Mesozoic aquifers groups) may require site-specific hydrogeologic investigations to help identify favorable well sites, depending on the desired use for the Basin's groundwater resources.

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9.0 PROGRAM STRATEGIES AND RECOMMENDATIONS

9.0 PROGRAM STRATEGIES AND RECOMMENDATIONS

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9.0 PROGRAM STRATEGIES AND RECOMMENDATIONS

This chapter provides program strategies and recommendations for future planning in the Bear River Basin. Program strategies guide the WDO in planning efforts for the Basin. Recommendations are to help the BAG, the WDO and others in their efforts to efficiently use and develop water within the Basin.

9.1 PROGRAM STRATEGIES

There are three major program elements that should be used to improve the basin planning process for the Bear River Basin. These elements are: outreach and agency coordination, data acquisition, and simulation model development. Strategies for improving these elements are presented in the following discussion.

9.1.1 OUTREACH AND COORDINATION

Conducting BAG meetings to discuss water resource issues with local groups and individuals is an important part of the outreach and educational efforts of the planning process. BAG meetings should be held on a periodic basis. Coordination with federal, state, and local agencies is also an important part of outreach efforts. Outreach and coordination efforts should include federal and local agencies within the Basin to exchange information on water resources management and development. These agencies should be included in the BAG issues identification and discussion process. Close coordination should be developed and maintained between the SEO Interstate Streams Division and the WDO planning team. Additionally, coordination should be maintained with the Water Division IV Superintendent, their field staff, and the planning team. Regular meetings should be scheduled with the Cheyenne SEO and the field offices.

9.1.2 DATA ACQUISITION

Acquiring hydrologic (stream flow), climate, and water use data is key to basin planning efforts. The planning team should work with the USGS, SEO, WRDS and other agencies to acquire accurate datasets for the planning efforts. Understanding which data are readily available and datasets that need improvement will help direct data collection efforts. The planning team supports maintaining USGS and SEO stream gages and installing or reinstalling stream gages in important reaches. Working with the SEO Division IV Superintendent and field staff to obtain diversion and water use data is important, as well as working with SEO office staff to obtain and improve current water rights information and irrigated lands mapping. The SEO should continue to update their irrigated lands and points of diversion GIS products for future modeling efforts. Diversion records need to be digitized in order that they may be more readily used as inputs to models.

The planning team must coordinate and work with local, state, and federal agencies to gather current economic and population data to make population and economic growth projections. These data provide the basis for developing future water use and availability projections.

Recreational and environmental water uses are non-consumptive uses, but may impact other water use and development opportunities. Recently, the WDC commissioned the Basin

Planning, Environmental and Recreation, Level I Study, and it is recommended that the planning team apply the data collection and analysis methods being developed in the study to better understand the impacts of these non-consumptive uses. The datasets developed for this study allow for better evaluation of where environmental and recreation water uses exist and where there may be conflicts with other water development projects or where there are opportunities to improve environmental and recreational uses through water development projects. Collecting data will require coordination with federal, state, and local agencies as well as private groups and organizations.

9.1.3 SIMULATION MODELING

Hydrologic spreadsheet models are tools used to organize and analyze data collected on the different elements of water availability and use or demand. For this update, spreadsheet models were used to predict natural stream flows for the Bear River under dry, normal, and wet hydrologic conditions. In the model, water depletions are estimated and then subtracted from the available supply to determine the physically available stream flow. The legally available flow is then derived from compacts or decrees to provide the amount of water available for development.

To obtain better estimates of natural flows, depletion and water remaining for development, a simulation model should be developed in lieu of the spreadsheet models. A water rights based simulation model along with more complete datasets will allow more accurate estimations of water available for future use and development. A move toward a decision support system for the Bear River Basin should be part of the basin planning process.

9.2 RECOMMENDATIONS

This section addresses the major issues of concern presented by the BAG through the planning process. There have been several meetings where these issues were discussed and refined. This section further discusses information and suggestions developed during this plan update process. The primary issues presented by the BAG members include water allocation, water quality, future water demand and growth, habitat, wildlife and fisheries, and economics.

9.2.1 WATER ALLOCATION

At this time and for population/use projections out to 2030, there is adequate water within the Basin to address the needs and changes in water use. The Basin population is growing at a moderate rate and this is not expected to change in the near term. However, planning for future growth and expansion is important and an evaluation of potential changes in the economy should be part of this planning effort. A full economic analysis was not completed for this update, however the information gathered did not indicate significant changes in the economy.

The major problem with water allocation is availability throughout the entire year. From October to April there is estimated to be more streamflow than is being used and consumed or depleted; thus there are no estimated shortages. Conversely, during the irrigation season from May through September, there can be easily shortages in both the Upper Division and the Central Division.

To finally determine where shortages and surpluses occur, October to April uses and depletions must be determined. Once established, these variables can then be included in a simulation model that will better predict when and where shortages occur and when and where water is available. Management of stored water and increasing the amount of storage through reservoir enlargements or construction of new reservoirs could address the potential shortages. The WDO is planning to develop a simulation model and decision support system in the near future that will help define shortages and strategies to address them.

Groundwater resources in the Basin could also be used to address some of these shortages. Groundwater use is governed by the Bear River Compact (Amended Bear River Compact, 1978) and its use is considered part of the total water allocation. However, groundwater could be available when surface water supplies are short.

Groundwater resources are not heavily used in the Basin. Cokeville depends on groundwater and all rural domestic water use is from groundwater. Additionally there is some agricultural irrigation from groundwater. However, irrigation using groundwater only makes up about 2% of the irrigated agricultural water use. Groundwater uses do not stress the aquifer system at this time.

A groundwater study is underway by the Wyoming State Geological Survey to further define the groundwater resources of the Basin. Once this study is completed, there will be a better understanding of the groundwater resource, its availability and potential for future use.

Regarding reservoir storage, end of month storage content needs to be collected at all major reservoirs in the basin (i.e. those reservoirs that are used for calculating the consumptive use loss associated with evaporation). Noteworthy differences were found on an annual basis when using actual end of month content (recorded at Woodruff Narrows Reservoir) to determine evaporation amounts rather than using fixed reservoir elevation values.

Where end of month storage content values were available, the mean annual loss to evaporation for Woodruff Narrows over the period 1971-1996 was found to be 850 acre-feet or 20% lower than that calculated using the fixed elevation method in this update.

Additionally, for this update, evaporation data from the weather station at Green River was used, which is in another river basin entirely. To avoid having to extrapolate rates over such distance, monthly, at a minimum, evaporation data need to be collected at the reservoirs and made available in order to more accurately determine water loss.

9.2.2 WATER QUALITY

Water quality in the Basin is generally good. There are two stream segments on the DEQ, WQD 303(d) List of impaired waters: the Bear River between Sulphur Creek and Woodruff Narrows Reservoir and Bridger Creek. Both of these impairments are being addressed through implementation of best management practices. When these impairments are fully addressed, these stream segments should be removed from the 303(d) List. If problems still remain that prevent the development and implementation of a DEQ watershed plan, a WDC watershed study would be advisable.

Furthermore, to be aware of any other potential water quality issues in the Basin, local agencies and the SEO and DEQ, WQD should participate in the Bear River Regional Water Quality Task Force.

9.2.3 FUTURE WATER DEMANDS AND GROWTH

Analysis in this update does not show future water demands and growth exceeding the available water supply under the Compact. Master plans should be used to evaluate potential growth of cities and towns, and watershed studies should be used to assess water resources available for irrigation. These studies should provide options for water development, conservation and management to help meet population growth and increased water demands.

9.2.4 HABITAT, WILDLIFE, AND FISHERIES

This update has added a great deal of information on environmental and recreational water use and demands. Environmental and recreation water demands directly coincide with habitat, wildlife, and fisheries water demands. Most of these demands are non-consumptive but may affect other water uses. Quantifying environmental and recreation water demand is not feasible through this plan update, but knowing where the demands exist will help in project planning and development in the future. From the information available, there are more environmental and recreation demands in the Central Division than in the Upper Division, and many of these demands are on the Smiths Fork.

Depending on the project location, these demands may impact water development projects. Development projects must seek to address environmental and recreation issues and try to complement them through a collaborative planning process. An example would be working with the GFD in their crucial habitat areas to limit impacts to the species of concern.

Controlling and preventing Aquatic Invasive Species remains a major concern in the Basin. Federal, state and local agencies must be aware of the effects of invasive species and work to prevent their migration into the Basin. The GFD has developed a Wyoming Aquatic Invasive Species Management Plan (GFD, 2010). They have conducted boat inspections for Quagga and Zebra mussels at major reservoirs over the state and have a self-check program at smaller less used reservoirs.

9.2.5 ECONOMICS

The economics of the Bear River Basin have not changed greatly since the 2001 Plan. Although a full economic analysis was not undertaken for this update, there were no indications of expansive future growth. As indicated in the previous sections, continuing the planning efforts and tracking growth are the best ways to determine changes in the economic climate. Water is currently available to meet development needs, although some water management or storage may be necessary to meet any significant growth. Future master planning efforts and watershed studies could provide detailed descriptions of available resources and ways to meet increasing water demands for municipalities and industries interested in expansion.

REFERENCES

Bear River Compact, as amended, 1978. http://legisweb.state.wy.us/statutes/titles/title41/c12a01.htm

Wyoming Game and Fish Department. 2010. Wyoming Aquatic Invasive Species Management Plan.

APPENDIX A
FRAMEWORK TABLES

APPENDIX A: FRAMEWORK TABLES

Appendix A presents the updated Framework Tables. Data developed as part of this Plan Update is presented in red text. There are some tables that have changes to the data that may need to be explained further. Those tables are footnoted with the appropriate references. Every table was developed with information presented in this report and associated technical memoranda.

LIST OF TABLES

Table 4-1: Total Annual Flow

Basin Plan	River Basin	Area (Acres)	Ratio Based on Normal Conditions (AF per Acre)	Yield (AFY)		
				Wet	Normal	Dry
2001	Bear	960,000	0.55	888,000	526,000	234,000
2011	Bear	960,000	0.43	783,400	408,538	135,348

Note: Refer to Technical Memorandum "Surface Water Data Collection and Study Period Selection – Tab I (2011)."

Table 5-1: Irrigated Acreage

Basin Plan	River Basin	1973 Total (Acres)	Total (Acres)	Current Irrigated Lands (Acres)	
				Surface Water	Groundwater
2001	Bear	59,000	64,000		
2011	Bear	59,000	64,000		

Note: No new mapping available for this update.

Table 5-2: 1973 versus Current Active Crop Distribution

Basin Plan	River Basin	Active Irrigated Lands (Acres)	Grass/ Pasture (Acres)	Alfalfa (Acres)	Corn (Acres)	Sugar Beets (Acres)	Beans (Acres)	Small Grain (Acres)
2001	Bear	64,000	59,000	5,000				
2011	Bear	64,000	59,000	5,000				

Note: No new mapping available for this update.

Table 5-3: Estimated Average Annual Irrigation Surface Water Diversion

Basin Plan	River Basin	Historical Diversions						Theoretical Diversions	
		Wet (AFY)	Normal (AFY)	Dry (AFY)	Overall Average (AFY)	Surface Irrigated (Acres)	Overall Unit Average (AF per Acre)	Maximum Diversions (AFY)	Maximum Diversions (AF per Acre)
2001	Bear				295,000	64,000	4.61	303,000	4.74
2011	Bear				286,366	64,000	4.48	310,861	4.86

Table 5-4: Estimated Average Annual Irrigation Water Requirement (IWR)

Basin Plan	River Basin	Total IWR (AFY)	Active Irrigated Lands (Acres)	Unit IWR (AF per Acre)	Total IWR (AFY)			Unit IWR (AF per Acre)		
					Wet	Normal	Dry	Wet	Normal	Dry
2001	Bear	97,000	64,000	1.52						
2011	Bear	99,401	64,000	1.54						

Table 5-5: Estimated Average Annual Irrigation Water Supply – Limited Consumptive Use (Depletions)

Basin Plan	River Basin	1973 Total CU (AFY)	Current Total CU (AFY)	Active Irrigated Lands (Acres)	Unit CU (AF per Acre)	Total CU (AFY)		
						Wet	Normal	Dry
2001	Bear		94,000	64,000	1.47			
2011	Bear		91,209	64,000	1.42			

Table 5-6: Municipal and Domestic Use

Basin Plan	River Basin	Demand Factor[1] (gpcpd)	Surface Water (gpd)		Groundwater (gpd)	
			Municipal	Domestic	Municipal	Domestic
2001	Bear[2]	198	2,056,700		897,000	
2011	Bear[2]	215	2,149,600		1,092,650	

1. Demand factors are based on average use in the basin, which are reported as gallons per capita per day (gpcdp). Use is calculated in gallons per day (gpd).
2. Combined the data for municipal and domestic uses. Number is from percentage of total water use.

Table 5-7: Municipal and Domestic Water Depletions

Basin Plan	River Basin	Depletions (AFY)		
		Surface Water	Groundwater	Total
2001	Bear	2,300	1,000	3,300
2011	Bear	2,408	1,224	3,632

Table 5-8: Annual Industrial Water Use (AFY)

Basin Plan	River Basin	Coal-Fired Electric Power	Conventional Oil and Gas	Mining and Mine Reclamation	Trona Mining / Soda Ash	Coal Bed Methane	Manufacturing	Misc.	Aggregate Cement Concrete	Road and Bridge Construction	Total
2001	Bear	0	300	0	0	0	0	0	0	0	300
2011	Bear	0	42	0	0	0	0	0	0	0	42

Table 6-1: Presently Irrigated Acreage and Projected Irrigation Development

Basin Plan	River Basin	Current (Acres)	30-Year Projections (Acres)		
			High Scenario	Mid Scenario	Low Scenario
2001	Bear	64,000	69,000		61,000
2011	Bear	64,000	69,000		61,000

Table 6-2: Current and Projected Irrigation Diversion

Basin Plan	River Basin	Current (AFY)	30-Year Projections (AFY)		
			High Scenario	Mid Scenario	Low Scenario
2001	Bear	295,000	312,000		277,000
2011	Bear	286,366		295,000	

Note: Current use was developed for Mid Scenario only.

Table 6-3: Current and Projected Consumptive Irrigation Use

Basin Plan	River Basin	Current (AFY)	30-Year Projections (AFY)		
			High Scenario	Mid Scenario	Low Scenario
2001	Bear	95,000	100,000	95,000	89,000
2011	Bear	91,209		95,000	

Note: Current use was developed for Mid Scenario only.

Table 6-6: Livestock Consumptive Use

Basin Plan	River Basin	Current (AFY)	30-Year Projections (AFY)		
			High Scenario	Mid Scenario	Low Scenario
2001	Bear	530	610	540	490
2011	Bear	345		528	345

Note: Current use was developed for Mid Scenario only.

Table 6-7: Actual and Projected Populations

Basin Plan	River Basin	Current (No. People)	30-Year Projections (No. of People)		
			High Scenario	Mid Scenario	Low Scenario
2001	Bear	14,550	29,400	21,500	15,100
2011	Bear	15,078		16,274	

Note: Current use was developed for Mid Scenario only.

Table 6-9: Projected Annual Electrical Generation Water Needs

Basin Plan	River Basin	Type of Generation	Existing Generation Capacity (MW)	30-Year Projections: Additional Projected Generation Capacity (MW) High Scenario	Mid Scenario	Low Scenario	Cooling Water Total Use Surface Water (AFY) High Scenario	Mid Scenario	Low Scenario	Cooling Water Total Use Groundwater (AFY) High Scenario	Mid Scenario	Low Scenario
2001	Bear	0	0	0	0	0	0	0	0	0	0	0
2011	Bear	Wind	0	0	0	0	0	0	0	0	0	0

Table 6-10: Total Industrial Water Demand Projections

Basin Plan	River Basin	30-Year Projections (AFY) High Scenario	Mid Scenario	Low Scenario
2001	Bear	500	0	0
2011	Bear	126	74	0

Table 6-14: Projected Annual Total Consumptive Water Demands by Use

Basin Plan	River Basin	Agriculture 30-Year Projections (AFY) High Scenario	Mid Scenario	Low Scenario	Municipal & Domestic 30-Year Projections (AFY) High Scenario	Mid Scenario	Low Scenario	Industrial 30-Year Projections (AFY) High Scenario	Mid Scenario	Low Scenario	Recreational 30-Year Projections (AFY) High Scenario	Mid Scenario	Low Scenario
2001	Bear	100,000	94,500	88,900	6,200	4,500	4,700	500	0	0			
2011	Bear		92,300			2,703			126	0			

Table 6-15: Summary of Current and Projected Future Water Uses

Basin Plan	River Basin	Current (AFY)	30-Year Projections (AFY) High Scenario	Mid Scenario	Low Scenario
Surface Water					
2001	Bear	99,300	108,900	103,200	100,100
2011	Bear	97,460		100.966	
Groundwater					
2001	Bear	3,000	3,600		2,600
2011	Bear	3,098		3,259	

Table 7-1: Average Annual Streamflow and Uses – Normal Conditions

Basin Plan	River Basin	State Line Outflow-Natural Conditions (AFY)	Depletions of Streamflows to Wyoming (AFY)					Depleted Streamflow Leaving Wyoming (AFY)	Wyoming's Remaining Share Under Compact (AFY)
			Irrigation	Municipal, Domestic, and Stock	Industrial	Reservoir Evaporation	Total		
2001	Bear	526,000	92,300	1,400	300	5,300	99,300	426,700	187,800
2011	Bear	388,588	89,309	2,753	37	5,361	97,460	291,128	9,790

Table 7-2: Available Flows

Basin Plan	River Basin	Division	Hydrologic Condition					
			Wet		Normal		Dry	
			Physically Available Flow (AFY)	Legally Available Flow (AFY)	Physically Available Flow (AFY)	Legally Available Flow (AFY)	Physically Available Flow (AFY)	Legally Available Flow (AFY)
2001	Bear	Upper Division	360,000	325,000	176,000	142,000	37,000	27,000
		Lower Division	786,000	508,000	427,000	188,000	132,000	0
2011	Bear	Upper Division	263,711	232,339	108,317	78,032	17,168	11,596
		Lower Division	624,728	506,926	291,128	194,009	101,937	59,874

Table 7-3: Average Annual Streamflow and Uses – Mid-Level Development – Dry Condition

Basin Plan	River Basin	State Line Outflow-Natural Conditions (AFY)	Depletions of Streamflows to Wyoming (AFY)					Depleted Streamflow Leaving Wyoming (AFY)	Wyoming's Remaining Share Under Compact (AFY)
			Irrigation	Municipal, Domestic, and Stock	Industrial	Reservoir Evaporation	Total		
2001	Bear	235,200	94,500	3,400	0	5,300	103,200	132,000	0
2011	Bear	202,903	92,300	3,231	74	5,361	100,966	101,937	9,790

APPENDIX B
WYOMING SURFACE WATER CLASSIFICATION

APPENDIX B: WYOMING SURFACE WATER CLASSIFICATION

The Wyoming Surface Water Classifications presented in this Appendix were taken directly from The Wyoming Department of Environmental Quality, Water Quality Rules and Regulations, Chapter 1, Wyoming Surface Water Quality Standards, 2007, Appendix A, Wyoming Surface Water Classifications. For additional information, refer to Chapter 1 of the Rules and Regulations

Wyoming Surface Water Classifications

Class 1 waters (Outstanding Waters) are those surface waters in which no further water quality degradation by point source discharges other than from dams will be allowed. Nonpoint sources of pollution shall be controlled through implementation of appropriate best management practices. Pursuant to Section 7 of these regulations, the water quality and physical and biological integrity which existed on the water at the time of designation will be maintained and protected. In designating Class 1 waters, the Environmental Quality Council shall consider water quality, aesthetic, scenic, recreational, ecological, agricultural, botanical, zoological, municipal, industrial, historical, geological, cultural, archaeological, fish and wildlife, the presence of significant quantities of developable water and other values of present and future benefit to the people.

Class 2 waters (Fisheries and Drinking Water) are waters, other than those designated as Class 1, that are known to support fish or drinking water supplies or where those uses are attainable. Class 2 waters may be perennial, intermittent or ephemeral and are protected for the uses indicated in each sub category listed below. There are five subcategories of Class 2 waters.

> Class 2AB waters are those known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where a game fishery and drinking water use is otherwise attainable. Class 2AB waters include all permanent and seasonal game fisheries and can be either "cold water" or "warm water" depending upon the predominance of cold water or warm water species present. All Class 2AB waters are designated as cold water game fisheries unless identified as a warm water game fishery by a "ww" notation in the "Wyoming Surface Water Classification List". Unless it is shown otherwise, these waters are presumed to have sufficient water quality and quantity to support drinking water supplies and are protected for that use. Class 2AB waters are also protected for nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value uses.

> Class 2A waters are those that are not known nor have the potential to support game fish but are used for public or domestic drinking water supplies, including their perennial tributaries and adjacent wetlands. Uses designated on Class 2A waters include drinking water, aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value.

Class 2B waters are those known to support or have the potential to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where it has been shown that drinking water uses are not attainable pursuant to the provisions of Section 33. Class 2B waters include permanent and seasonal game fisheries and can be either "cold water" or "warm water" depending upon the predominance of cold water or warm water species present. All Class 2B waters are designated as cold water game fisheries unless identified as a warm water game fishery by a "ww" notation in the "Wyoming Surface Water Classification List". Uses designated on Class 2B waters include game and nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value.

Class 2C waters are those known to support or have the potential to support only nongame fish populations or spawning and nursery areas at least seasonally including their perennial tributaries and adjacent wetlands. Class 2C waters include all permanent and seasonal nongame fisheries and are considered "warm water". Uses designated on Class 2C waters include nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value.

Class 2D waters are effluent dependent waters which are known to support fish populations and where the resident fish populations would be significantly degraded in terms of numbers or species diversity if the effluent flows were removed or reduced. Class 2D waters are protected to the extent that the existing fish communities and other designated uses are maintained and that the water quality does not pose a health risk or hazard to humans, livestock or wildlife. Uses designated on Class 2D waters include game or nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value.

Class 3 waters (Aquatic Life Other than Fish) are waters, other than those designated as Class 1, that are intermittent, ephemeral or isolated waters and because of natural habitat conditions, do not support nor have the potential to support fish populations or spawning, or certain perennial waters which lack the natural water quality to support fish (e.g., geothermal areas). Class 3 waters provide support for invertebrates, amphibians, or other flora and fauna which inhabit waters of the state at some stage of their life cycles. Uses designated on Class 3 waters include aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value. Generally, waters suitable for this classification have wetland characteristics, and such characteristics will be a primary indicator used in identifying Class 3 waters. There are four subcategories of Class 3 waters.

Class 3A waters are isolated waters including wetlands that are not known to support fish populations or drinking water supplies and where those uses are not attainable.

Class 3B waters are tributary waters including adjacent wetlands that are not known to support fish populations or drinking water supplies and where those uses are not attainable. Class 3B waters are intern1ittent and ephemeral streams with sufficient hydrology to norn1ally support and sustain communities of aquatic life including invertebrates, amphibians, or other flora and fauna which inhabit waters of the state at some stage of their life cycles. In general, 3B waters are characterized by frequent linear wetland occurrences or impoundments within or adjacent to the stream channel over its entire length. Such characteristics will be a primary indicator used in identifying Class 3B waters.

Class 3C waters are perennial streams without the natural water quality potential to support fish or drinking water supplies but do support wetland characteristics. These may include geothermal waters and waters with naturally high concentrations of dissolved salts or metals or pH extremes.

Class 3D waters are effluent dependent waters which are known to support communities of aquatic life other than fish and where the existing aquatic habitat would be significantly reduced in terms of aerial extent, habitat diversity or ecological value if the effluent flows are removed or reduced.. Class 3D waters are protected to the extent that the existing aquatic community, habitat and other designated uses are maintained and the water quality does not pose a health risk or hazard to humans, livestock or wildlife.

Class 4 waters (Agriculture, Industry, Recreation and Wildlife) are waters, other than those designated as Class 1, where it has been determined that aquatic life uses are not attainable pursuant to the provisions of Section 33 of these regulations. Uses designated on Class 4 waters include recreation, wildlife, industry, agriculture and scenic value. There are three subcategories of Class 4 waters.

Class 4A waters are artificial canals and ditches that are not known to support fish populations.

Class 4B waters are intermittent and ephemeral stream channels that have been determined to lack the hydrologic potential to normally support and sustain aquatic life pursuant to the provisions of Section 33(b)(ii) of these regulations. In general, 4B streams are characterized by only infrequent wetland occurrences or impoundments within or adjacent to the stream channel over its entire length. Such characteristics will be a primary indicator used in identifying Class 4B waters.

Class 4C waters are isolated waters that have been determined to lack the potential to normally support and sustain aquatic life pursuant to the provisions of Section 33(b)(i), (iii), (iv), (v), or (vi) of the regulations. Class 4C includes, but is not limited to off-channel effluent dependent ponds where it has been determined under Section 33(b)(iii) that removing a source of pollution to achieve full attainment of aquatic life uses would cause more environmental damage than leaving the source in place