VOLUME 1

2012 SNAKE/SALT RIVER BASIN PLAN UPDATE

NOVEMBER, 2014

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

TABLE OF CONTENTS

1.0 Introduction 1
1.1 Overview 1
1.2 Basin Advisory Groups 2
1.3 Report Organization 2
References 4

2.0 Presentation Tool 5
2.1 Searching 5
2.2 Database Tables 5
2.3 Maps 5
2.4 Technical Memoranda Changes 5
References 7

3.0 Snake/Salt River Basin Setting and Description 8
3.1 Physical Description 8
3.1.1 Land Area and Ownership 8
3.1.2 Physiography and Topography 9
3.1.3 Drainage Systems 9
3.2 Climate 13
3.2.1 Precipitation 13
3.2.2 Temperature 13
3.2.3 Growing Season 16
3.3 Population and Economics 16
3.3.1 Population 16
3.3.2 Economics 17
3.4 Discussion of Compacts and Legal Constraints 17
3.4.1 Wyoming Water Law 18
3.4.2 Interstate Compacts 18
3.4.3 Wyoming Water Development Program 20
3.4.4 Institutional Constraints 20
3.4.5 Palisades Reservoir Contract 22
3.4.6 Salmon Recovery Efforts 23
3.5 Basin Water Development Studies and Projects 25
References 30

4.0 Water Resources 31
4.1 Surface Water Resources 31
4.1.1 Surface Water Modeling Methodology 31
4.1.2 Surface Water Quantity 33
4.1.3 Major Reservoirs 36
4.1.4 Surface Water Quality 37
4.2 Groundwater Resources 42
4.2.1 Groundwater Quantity 46
4.2.2 Groundwater Quality 47
References 47

5.0 Current Water Use 49
5.1 Agricultural Water Use 49
5.1.1 Agricultural Water Use Methodology 49
5.1.2 Irrigation Zones 50
5.1.3 Irrigation Acreage 52
5.1.4 Irrigated Crops 52
5.1.5 Climate Data 54
5.1.6 Crop Irrigation Requirements (CIR) 56
5.1.7 Irrigation Diversions and Depletions 61
5.1.8 Livestock 65
5.2 Municipal and Domestic Water Use 71
5.3 Industrial Water Use 73
5.4 Environmental and Recreational Water Use 74
5.4.1 Environmental and Recreational Water Use Analysis 74
5.4.2 Environmental and Recreational Water Use Analysis Results 84
5.5 Reservoir Evaporation 92
5.6 Summary of Current Water Use 94
5.6.1 Comparison to Previous Basin Plan 95
References 96

6.0 Water Use Projections 98
6.1 Population and Economic Projections 98
6.1.1 Population Projections 98
6.1.2 Economic Projections 100
6.2 AGRICULTURAL WATER USE 101
6.2.1 Approach for Developing Agricultural Projections 101
6.2.2 Irrigation 102
6.2.3 Livestock 105
6.2.4 Future Water Demand Projections 115
6.3 Municipal and Domestic Water Use 117
6.4 Industrial Water Use 118
6.5 Environmental and Recreational Water Use 119
6.5.1 Grand Teton and Yellowstone National Parks Entrance Data 119
6.5.2 Leisure Tax Trends 121
6.5.3 Lodging Tax Changes 121
6.5.4 Population Relationship to Environmental and Recreational Trends 121
6.5.5 Environmental and Recreational Water Use on Federal Land 122
6.6 Reservoir Evaporation 122
6.7 Summary of Projected Water Use 122
References 125

7.0 Water Availability 126
7.1 Surface Water Model 126
7.1.1 Streamflow Gage Data 130
7.1.2 Dry, Average, and Wet Years Classification 131
7.1.3 Ungaged Tributary Inflow Estimation 131
7.1.4 Diversion Data 133

7.2 Surface Water Availability....133
7.2.1 Physically Available Flow from Spreadsheet Models....134
7.2.2 Adjusted Physically Available Flow....135
7.2.3 Available Flow per Compact Limitations....138
7.2.4 Available Flow Summary....140
7.3 Groundwater Availability....145
7.4 Water Conservation....146
7.5 Summary of Water Availability....148
References....153

8.0 Basin Issues, Strategies, and Water Use Opportunities....155
8.1 Introduction....155
8.2 Future Water Use Opportunities....157
8.2.1 Reservoir Storage Opportunities....158
8.2.2 Groundwater Use Opportunities....160
8.3 Water Conservation and Efficiencies....160
References....161

9.0 Program Strategies and Recommendations....162
9.1 Program Strategies....162
9.1.1 Program Strategies....162
9.1.2 Data Acquisition....162
9.1.3 Water Resources Modeling....163
9.2 Recommendations....163
9.2.1 Agriculture....163
9.2.2 Industry....164
9.2.3 Municipal and Domestic....164
9.2.4 Environmental....164
9.2.5 Recreation....164

Appendix A: Framework Tables....I

Appendix B: Wyoming Surface Water Classification....VII

Appendix C: Snake/Salt River Basin Advisory Group Issues and Strategies....X

LIST OF FIGURES

Figure 1-1: Wyoming River Basin Planning Program Basins 1
Figure 3-1: Snake River Basin 8
Figure 3-2: Snake/Salt River Basin Land Ownership 10
Figure 3-3: Snake/Salt River Basin Physiography and Topography 11
Figure 3-4: Snake/Salt River Basin Sub-basins 12
Figure 3-5: Annual Precipitation in the Snake/Salt River Basin 14
Figure 4-1: Snake/Salt River Sub-basins and 303(d) Listed Streams 39
Figure 4-2: Major Aquifer Groups of the Snake/Salt River Basin 45
Figure 5-1: Snake/Salt River Basin Irrigation Zones 51
Figure 5-2: Crop Distribution by Irrigation Zone 53
Figure 5-3: Average Monthly Temperatures by Irrigation Zone 55
Figure 5-4: Average Monthly Precipitation by Irrigation Zone 55
Figure 5-5: Average Historic 28 and 32 Degree F. Frost Dates by Irrigation Zone 56
Figure 5-6: Monthly Crop Irrigation Requirements by Irrigation Zone 59
Figure 5-7: Cattle Inventory and Historic Trends by County within the Snake/Salt River Basin .67
Figure 5-8: Dairy Cattle Inventory and Historic Trends in Lincoln County within the Snake/Salt River Basin 68
Figure 5-9: Sheep Inventory and Historic Trends by County within the Snake/Salt River Basin 69
Figure 5-10: Horse Inventory and Historic Trends by County within the Snake/Salt River Basin 70
Figure 5-11: Sub-basins Defined for the Environmental and Recreational Analysis 78
Figure 5-12: Salt River Basin Use Layer Map 82
Figure 5-13: Salt River Basin Protection Layer Map 83
Figure 5-14: Snake Headwaters Sub-basin Recreational Sites Map, Grand Teton National Park Enlargement 87
Figure 5-15: Snake Headwaters Sub-basin Environmental Sites Map 88
Figure 5-16: Snake Headwaters Sub-basin Miscellaneous Sites Map 89
Figure 6-1: Population Projections for the Snake/Salt River Basin 99
Figure 6-2: Irrigated Acreage Projections for the Snake/Salt River Basin 105
Figure 6-3: Cattle Population Projections for the Snake/Salt River Basin 107
Figure 6-4: Dairy Cattle Population Projections for the Snake/Salt River Basin 109
Figure 6-5: Sheep Population Projections for the Snake/Salt River Basin 111
Figure 6-6: Horse Population Projections for the Snake/Salt River Basin 114
Figure 6-7: Grand Teton National Park Visitation by Year 120

Figure 6-8: Yellowstone National Park Visitation by Year 120
Figure 6-9: Teton County Leisure and Hospitality Sales Tax Revenue 121
Figure 7-1: Snake River Basin Model Network 128
Figure 7-2: Salt River Basin Model Network 129
Figure 7-3: Snake River Adjusted Physically Available Flows (AFY) 142
Figure 7-4: Salt River Adjusted Physically Available Flows (AFY) 143
Figure 7-5: Snake/Salt River Basin Remaining Diversion Allowance per Snake River Compact Limitations 144
Figure 7-6: Snake River Compact and Roxana Decree Availability 152
Figure 8-1: Future Reservoir Development Opportunities 159

LIST OF TABLES

Table 2-1: Technical Memoranda for the 2012 Snake/Salt River Basin Plan Update and the 2003 Snake/Salt River Basin Plan 6
Table 3-1: Snake/Salt River Basin Area by County 9
Table 3-2: Land Ownership in the Snake/Salt River Basin 9
Table 3-3: Freeze and Frost Dates for Climate Stations in the Snake/Salt River Basin 16
Table 3-4: Population Estimates for Counties Making up the Snake/Salt River Basin, 2003 – 2012 17
Table 3-5: Water Development Program Studies and Projects Completed within the Snake/Salt River Basin 26
Table 4-1: Adjusted Physically Available Flow 33
Table 4-2: Supply-Limited Irrigation Depletions 33
Table 4-3: Instream Flows 34
Table 4-4: Estimates of Natural Streamflow 34
Table 4-5: Estimates of Annual Natural Streamflow, Comparison to Previous Basin Plan 35
Table 4-6: Estimates of Annual Natural Streamflow, Comparison to Framework Water Plan 35
Table 4-7: Major Reservoirs in the Snake/Salt River Basin 36
Table 4-8: Other Important Water Storage Facilities in the Snake/Salt River Basin 37
Table 5-1: Irrigated Acres for the 2012 Snake/Salt River 52
Basin Update 52
Table 5-2: Crop Distribution by Irrigation Zone 53
Table 5-3: Average Latitude and Elevation of Irrigation Zones 54
Table 5-4: Consumptive Use (CU), Effective Precipitation (Re), and Crop Irrigation Requirements (CIR) by Irrigation Zone 60
Table 5-5: Irrigation Depletions by Irrigation Zone (Acre-Feet) 63
Table 5-6: Supply-Limited Diversions Predicted by the Spreadsheet Models 65
Table 5-7: Current Livestock Inventory in the Snake/Salt River Basin by County 66
Table 5-8: Livestock Annual Consumptive Water Use in the Snake/Salt River Basin 71
Table 5-9: Current Population and Estimated Water Use 73
Table 5-10: Total Municipal and Domestic Water Use Comparisons 73
Table 5-11: GIS Layers and Sources Used in the Environmental and Recreational Water Use Analysis 77
Table 5-12: Recreation Sites Inventory by Sub-basin 84
Table 5-13: Environmental Sites Inventory by Sub-basin 85
Table 5-14: Calculation of Reservoir Evaporation 93

Table 5-15: Summary of Current Consumptive Water Use in the Snake/Salt River Basin 94
Table 5-16: Consumptive Water Use in the Snake/Salt River Basin, Comparison to the 2003 Basin Plan.....95
Table 6-1: Population Projections by Growth Scenario.....100
Table 6-2: Estimated Population Projections by County and Growth Scenario.....100
Table 6-3: Irrigated Acreage Projections Summary.....104
Table 6-4: Cattle Population Projections Summary by County.....107
Table 6-5: Dairy Cattle Population Projections Summary.....109
Table 6-6: Sheep Population Projections Summary By County.....111
Table 6-7: Horse Population Projections Summary By Category.....114
Table 6-8: Water Use Factors for Irrigation.....115
Table 6-9: Annual Water Demand Projections for Irrigation.....116
Table 6-10: Annual Water Demand Projections for Livestock.....117
Table 6-11: Annual Agricultural Water Demand Projections for the Snake/Salt River Basin.....117
6-12. Snake/Salt River Basin Projected Municipal and Domestic Annual Consumptive Groundwater Use in 2032.....118
Table 6-13: Annual Industrial Water Demand Projections for the Snake/Salt River Basin.....119
Table 6-14: Projected Water Use for the High-Growth Scenario, 2032 (AFY).....124
Table 6-15: Projected Water Use for the Mid-Growth Scenario, 2032 (AFY).....124
Table 6-16: Projected Water Use for the Low-Growth Scenario, 2032 (AFY).....124
Table 7-1: Streamflow Records Summary.....130
Table 7-2: Indicator Gages Selected for the Snake and Salt River Basins.....131
Table 7-3: Classification of Dry, Average, and Wet Years.....131
Table 7-4: Physically Available Flows Predicted by Spreadsheet Models at the Most Downstream Reach (Reach Outflows).....135
Table 7-5: Adjusted Physically Available Flows at Most Downstream Reach.....138
Table 7-6: Snake/Salt River Basin Remaining Allowable Surface Water Diversions under Compact.....140
Table 7-7: Water Conserved by Converting from Flood to Sprinkler Irrigation Annually.....147
Table 7-8: Surface Water Availability with Current Consumptive Uses (AFY).....149
Table 7-9: Surface Water Availability, High-Growth Scenario, 2032 (AFY).....149
Table 7-10: Surface Water Availability, Mid-Growth Scenario, 2032 (AFY).....150
Table 7-11: Surface Water Availability, Low-Growth Scenario, 2032 (AFY).....150
Table 7-12: Current and Projected Diversions.....151
Table 8-1: Short List of Water Use Opportunities for the Snake River Sub-basin by Water Use Sector.....155

Table 8-2: Short List of Water Use Opportunities for the Salt River Sub-basin by Water Use Sector 156

Table 8-3: Snake/Salt River Basin Issues and Water Use Strategies and Opportunities by Water Use Sector 157

LIST OF ACRONYMS

AF ..... Acre-Feet
AFY..... Acre-Feet per Year
AU..... Animal Unit
BAG ..... Basin Advisory Group
BLM ..... Bureau of Land Management
cfs..... Cubic feet per second
CIR ..... Consumptive irrigation requirement
COE..... U.S. Army Corps of Engineers
CU ..... Crop consumptive use
DAIEAD ..... Wyoming Department of Administration and Information, Economics Analysis Division
ESA ..... Endangered Species Act
ET ..... Evapotranspiration
F ..... Fahrenheit
FWS..... Fish and Wildlife Service
GIS ..... Geographical Information System
gpcpd..... gallons per capita per day
gpm..... gallons per minute
GTNP..... Grand Teton National Park
IWR..... Irrigation water requirement
NMFS ..... National Marine Fishery Service
NPS ..... National Park Service
NASS..... National Agricultural Statistics Service
Re ..... Effective precipitation
SCS ..... Soil Conservation Service – Now the Natural Resources Conservation Service: Part of the U.S. Department of Agriculture
SCCD ..... Sublette County Conservation District
TMDL..... Total daily maximum load
USBR..... United States Bureau of Reclamation
USDA..... United States Department of Agriculture
USDI ..... United States Department of the Interior
USFS ..... United States Forest Service
USGS ..... United States Geological Survey

WDEQ, WQD..... Wyoming Department of Environmental Quality, Water Quality Division
WRDS..... University of Wyoming, Water Resources Data System
WSEO or SEO .... Wyoming State Engineer's Office
WSGS..... Wyoming State Geological Survey
WWDC or WDC .. Wyoming Water Development Commission
WWDO or WDO.. Wyoming Water Development Office
WyGISC..... Wyoming Geographic Information Science Center
YNP ..... Yellowstone National Park

1.0 INTRODUCTION

1.0 INTRODUCTION

TABLE OF CONTENTS

1.1 Overview 1
1.2 Basin Advisory Groups 2
1.3 Report Organization 2
References 4

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 begun 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 as shown in 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 panning, was completed in 2007.

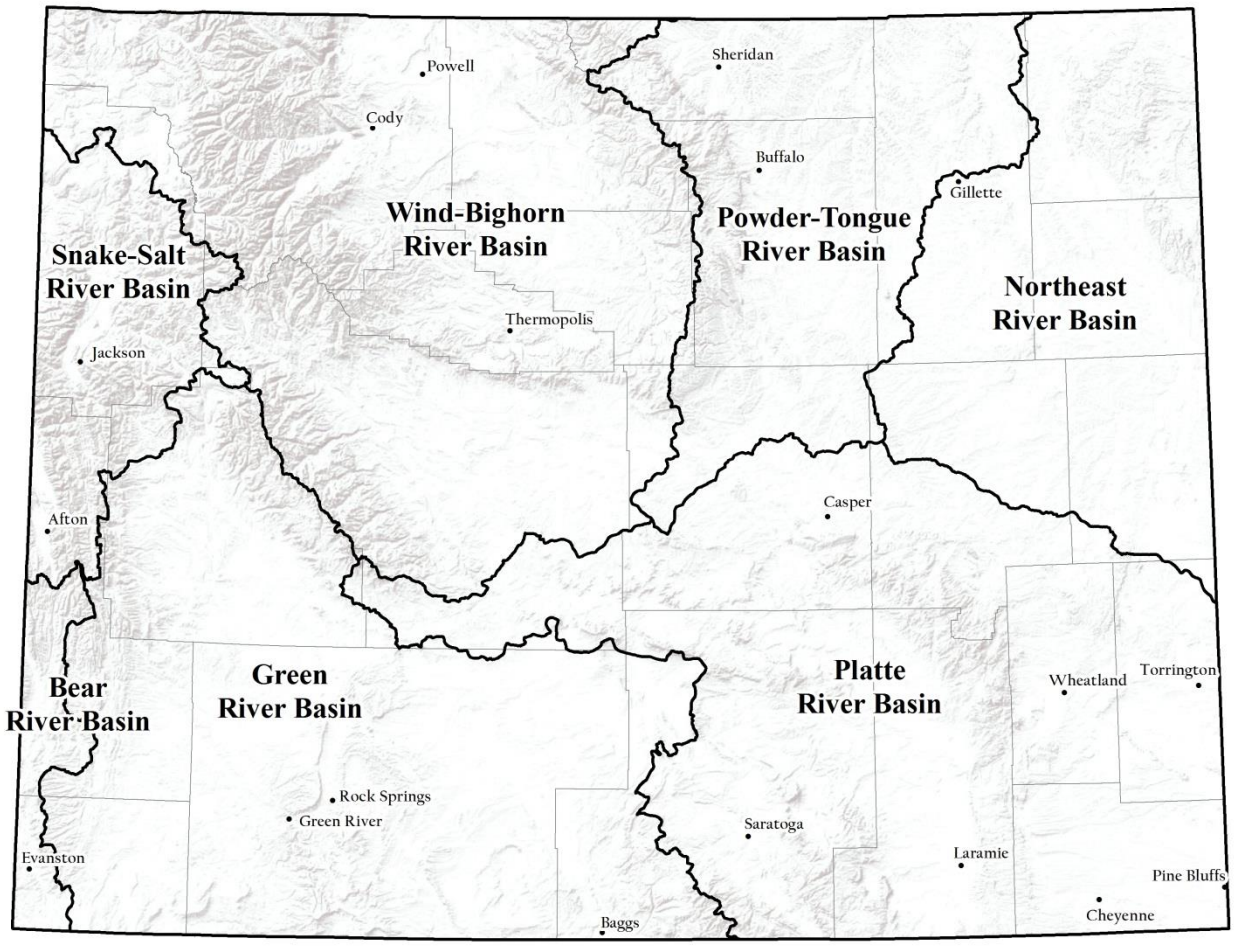

FIGURE 1-1: WYOMING RIVER BASIN PLANNING PROGRAM BASINS

The first Snake/Salt River Basin Plan was completed in 2003 and has been a medium priority for updating. However, because the plan is ten years old, it was determined a plan update would be prudent. The update is being 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 2003 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.

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 groups advise the WDO and the planning team on local issue priorities, data needs, and regional concerns. Basin Advisory Groups also assist decision makers through the review of basin planning products.

The Snake/Salt River Basin Advisory Group (BAG) was first assembled in 2001. The group members represented agricultural, industrial, governmental, recreational and environmental water uses within the basin. The meetings were open to the public, and participation was good. Currently, the Snake/Salt River BAG is an *ad hoc* group with participation from most water use sectors and the public.

Several meetings were held to discuss the plan update and the group and public have been given the opportunity to review and comment on the report. A final meeting will be held to discuss the report and recommendations.

1.3 REPORT ORGANIZATION

This report is titled 2012 Snake/Salt River Basin Plan Update. Primary data collection and analysis were completed in 2011 and 2012, hence the title. During 2013 data and information were compiled and report preparation was completed with final publication in early 2014. The Plan Update is presented in two volumes. Volume I is comprised of the report and Volume II 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 Engineering, Inc, 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 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 agricultural, industrial, municipal, rural domestic, environmental and recreational.

Chapter 6 Water Use Projections provides estimates of future water uses for the basin for all use sectors. The estimates are prepared for three 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 BAG and strategies developed with the BAG. In addition, water use opportunities, that 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 Snake/Salt River Basin. Recommendations for further work and data collection within the basin are also presented.

There are also three 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 Engineering, Inc, 2007). These tables were designed to be updated as new information became available and are available on the water planning web site. Appendix B presents the Wyoming Department of Environmental Quality, Water Quality Division, Wyoming Surface Water Classification List, referenced in Chapter 4. Additionally, Appendix C is a tabular combination of the initial BAG issues, the Framework Water Plan issues and strategies.

Two references used often and throughout the report, and which may not be fully referenced each time are the Snake/Salt River Basin Plan Final Report (Sunrise Engineering, Inc., 2003) 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 2003 Snake/Salt River Basin Plan, the 2003 Basin Plan, previous Basin Plan, and the 2003 Plan; and the 2007 Framework Water Plan, and the 2007 Framework Plan. Appropriate citations are presented in the references section.

REFERENCES

Sunrise Engineering, Inc. (2003, June). *Snake/Salt River Basin Plan Final Report*. Retrieved from http://waterplan.state.wy.us/plan/snake/finalrept/finalrept.html

WWC Engineering, Inc. (2007, October). *Wyoming Framework Water Plan Volume I and Volume II Planning Recommendations*. Retrieved from http://waterplan.state.wy.us/frameworkplan.html

2.0 PRESENTATION TOOL

2.0 PRESENTATION TOOL

TABLE OF CONTENTS

2.1 Searching 5
2.2 Database Tables 5
2.3 Maps 5
2.4 Technical Memoranda Changes 5
References 7

2.0 PRESENTATION TOOL

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

2.1 SEARCHING

The *Water Search Engine* may be accessed from the Wyoming State Water Plan website: http://waterplan.state.wy.us/sites.html. This customized Google search engine allows users to search the State Water Plan and the Wyoming Water Development Commission (WDC) websites as well as the websites of the Water Resources Data System and the Wyoming State Engineer's Office 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 that occurred from1999 through 2006 (WWC Engineering, Inc, 2007). Twenty-one data tables from that plan were revised with new values derived from the Snake/Salt 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. Values 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 2003 data and 2012 data are presented in Appendix A.

2.3 MAPS

High resolution PDFs are available for all of the maps generated during the Snake/Salt River Basin Plan Update at http://waterplan.state.wy.us/plan/snake/snake-plan.html. 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 2003 Snake/Salt River Basin Plan, it was decided that original technical memoranda that were not in need of change would not be altered in the update. 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 and a summary of these changes is listed in Table 2-1.

TABLE 2-1: TECHNICAL MEMORANDA FOR THE 2012 SNAKE/SALT RIVER BASIN PLAN UPDATE AND THE 2003 SNAKE/SALT RIVER BASIN PLAN

2012 Technical Memoranda	Tab	Corresponding 2003 Technical Memoranda	Tab	Comments
Agricultural Water Use	I	▪ Basin Water Use Profile – Agriculture	D	Also see Tabs T, U & V
Municipal and Rural Domestic Water Use	II	▪ Basin Water Use Profile – Municipal ▪ Basin Water Use Profile – Domestic	H I	Also see Tabs T, U & V
Industrial Water Use	III	▪ Basin Water Use Profile – Industrial	J	Also see Tabs T, U & V
Environmental and Recreational Water Use	IV	▪ Basin Water Use Profile – Recreation ▪ Basin Water Use Profile – Environmental	K L	Also see Tabs T, U & V
Irrigation Diversion Operation and Description	V	▪ Irrigation Diversion Operation and Description	F	
Irrigated Acreage	VI	▪ Irrigated Lands and Permit GIS	G	
Crop Water Requirements	VII	▪ Cropping patterns in the Basin	E	Also see Tab D
Surface Water Data Collection and Estimation	VIII	▪ Surface Water Data Collection and Study Period Selection	P	
Spreadsheet Model and Hydrologic Database	IX	▪ Spreadsheet Model Development and Surface Water Model Calibration	Q	
Available Surface Water Determination	X	▪ Available Surface Water Determination	R	
Available Groundwater Determination	XI	▪ Available Groundwater Determination	S	
Major Reservoirs and Reservoir Evaporation	XII	▪ Basin Water Use Profile – Major Reservoirs	M	
Instream Flows	XIII	▪ Basin Water Use Profile – Instream Flows	N	
Surface Water Quality	XIV	▪ Water Quality	O	
Water Conservation	XV	▪ Water Conservation	X	
Climate	XVI			New
Population Projections and Economic Conditions	XVII	▪ Historic and Current Economic & Demographic Conditions ▪ Future Economic & Demographic Scenarios	T U	Also see Tab V
Institutional Constraints	XVIII	▪ Institutional Constraints	Y	
Palisades Reservoir Contract	XIX	▪ Palisades Reservoir Contract	C	
Salmon Recovery efforts in the Snake River Basin	XX	▪ Salmon Recovery efforts in the Snake River Basin	Z	
		▪ Summary of Wyoming Water Law	A	Unchanged and discussed in report text
		▪ Summary of Interstate Compacts and Decrees	B	Unchanged and discussed in report text
		▪ Future Water Demand Projections	V	Unchanged and discussed in report text
		▪ Future Water Use Opportunities	W	Unchanged and discussed in report text

REFERENCES

WWC Engineering, Inc. (2007, October). *Wyoming Framework Water Plan Volume I and Volume II Planning Recommendations*. Retrieved from http://waterplan.state.wy.us/frameworkplan.html

3.0 SNAKE/SALT RIVER BASIN SETTING AND DESCRIPTION

3.0 SNAKE/SALT RIVER BASIN SETTING AND DESCRIPTION

TABLE OF CONTENTS

3.1 Physical Description 8
3.1.1 Land Area and Ownership 8
3.1.2 Physiography and Topography 9
3.1.3 Drainage Systems 9
3.2 Climate 13
3.2.1 Precipitation 13
3.2.2 Temperature 13
3.2.3 Growing Season 16
3.3 Population and Economics 16
3.3.1 Population 16
3.3.2 Economics 17
3.4 Discussion of Compacts and Legal Constraints 17
3.4.1 Wyoming Water Law 18
3.4.2 Interstate Compacts 18
3.4.2.1 Snake River Compact 19
3.4.2.2 Roxana Decree 19
3.4.3 Wyoming Water Development Program 20
3.4.4 Institutional Constraints 20
3.4.5 Palisades Reservoir Contract 22
3.4.6 Salmon Recovery Efforts 23
3.5 Basin Water Development Studies and Projects 25
References 30

3.0 SNAKE/SALT RIVER BASIN SETTING AND DESCRIPTION

3.1 PHYSICAL DESCRIPTION

The Snake/Salt River Planning Basin in Wyoming is a part of the Snake River basin and the Columbia River drainage which flows to the Pacific Ocean. Figure 3-1 shows all of the Snake River Basin including the portion within Wyoming. Wyoming's portion covers approximately 5,100 square miles and includes all of Teton County and portions of Lincoln, Sublette, and Fremont Counties. Grand Teton National Park and portions of Yellowstone National Park are also part of the Snake/Salt River Basin.

FIGURE 3-1: SNAKE RIVER BASIN

3.1.1 LAND AREA AND OWNERSHIP

Teton County and northern Lincoln County make up almost 89 percent of the lands in the basin (Table 3-1). The basin area within Fremont County is small (3.1 percent) and consists primarily of national forest lands. Additionally, 8.2 percent of the basin area is within northwestern Sublette County.

Land ownership in the Snake/Salt River Basin is predominantly federal with 90 percent of the lands owned by several federal agencies while private lands make up only eight percent of the land ownership within the basin (Table 3-2 and Figure 3-2).

TABLE 3-1: SNAKE/SALT RIVER BASIN AREA BY COUNTY

County	Acres	Percent of Area
Fremont	100,527	3.1
Lincoln	731,167	22.3
Sublette	267,714	8.2
Teton	2,174,524	66.4
Total	***3,273,932***	***100***

TABLE 3-2: LAND OWNERSHIP IN THE SNAKE/SALT RIVER BASIN

Land Ownership	Acres
Federal Lands	
Bureau of Land Management	8,056
National Park Service	655,521
National Wildlife Refuge	24,783
U.S. Forest Service Wilderness/Wild & Scenic Rivers	741,236
U.S. Forest Service National Forest	1,520978
Total Federal Lands	***2,950,574***
State Lands	
State Wildlife Habitat Management Areas	4,531
Wyoming State Lands	9,709
Total State Lands	***14,240***
Private Lands	**256,340**
Water (Rivers, Lakes and Reservoirs)	**52,778**
Grand Total	***3,273,932***

3.1.2 PHYSIOGRAPHY AND TOPOGRAPHY

The Snake/Salt River Basin is part of the Middle Rocky Mountain Province. It is mountainous with intermountain valleys and has very complex geology. Several of the mountain ranges and valleys have been created by thrust faults with the mountains rising sharply from the valley floor. Elevations vary from 13,770 feet at Grand Teton Peak to 5,500 feet at Palisades Reservoir. The mountain ranges and topographic structures that define the Snake/Salt River Basin boundaries are shown in Figure 3-3. The largest intermountain valleys are Jackson Hole and Star Valley. A majority of the basin population resides in these valleys.

3.1.3 DRAINAGE SYSTEMS

There are many rivers and streams that make up the seven Snake River sub-basins in Wyoming. These sub-basins are shown in Figure 3-4 and include the Greys-Hoback Basin, Gros Ventre Basin, Henrys Fork Basin, Palisades Basin, Salt Basin, Snake Headwaters Basin, and Teton Basin. Three of the sub-basins, Henrys Fork, Palisades and Teton, drain directly into Idaho and are not tributary to the Snake River in Wyoming.

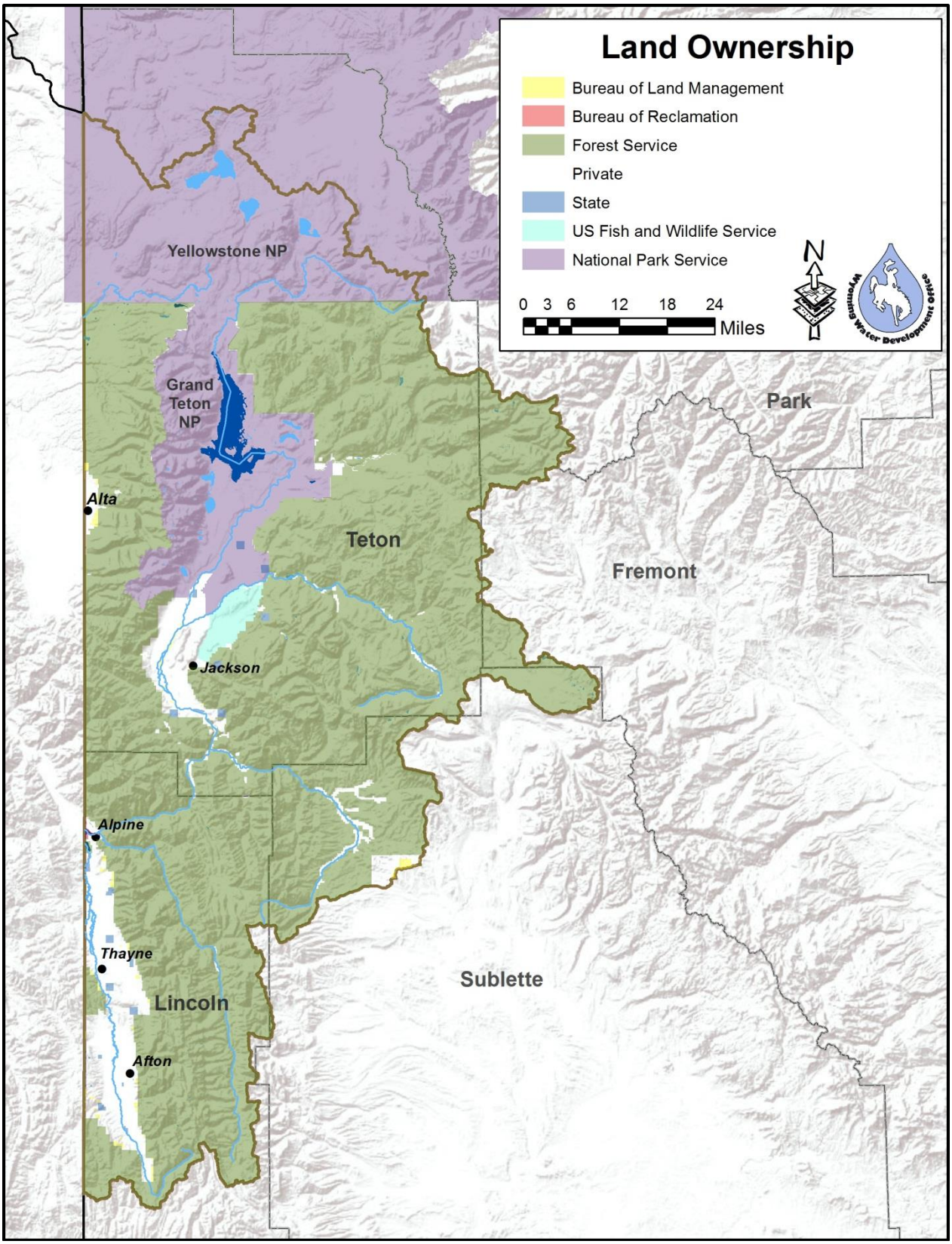

FIGURE 3-2: SNAKE/SALT RIVER BASIN LAND OWNERSHIP

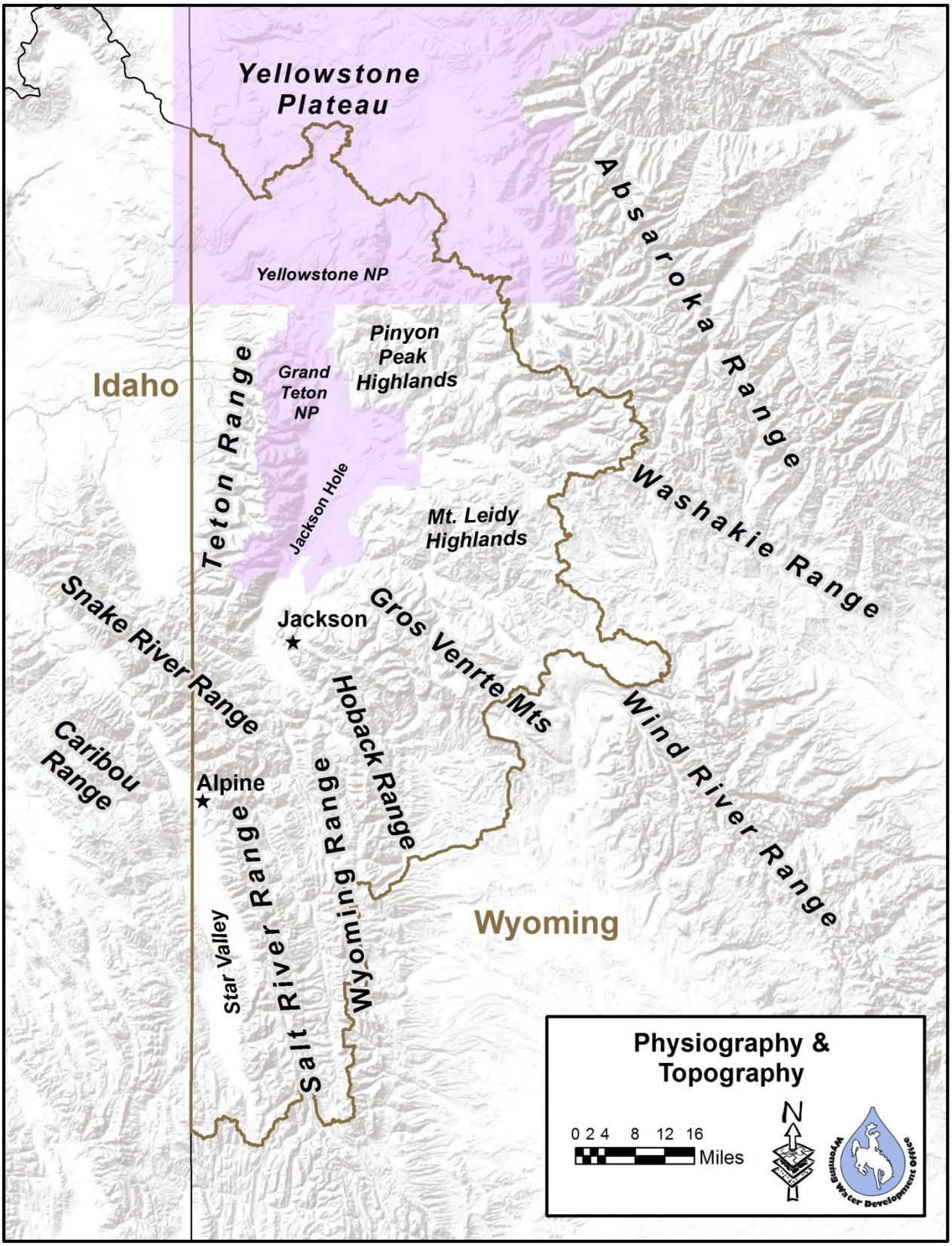

FIGURE 3-3: SNAKE/SALT RIVER BASIN PHYSIOGRAPHY AND TOPOGRAPHY

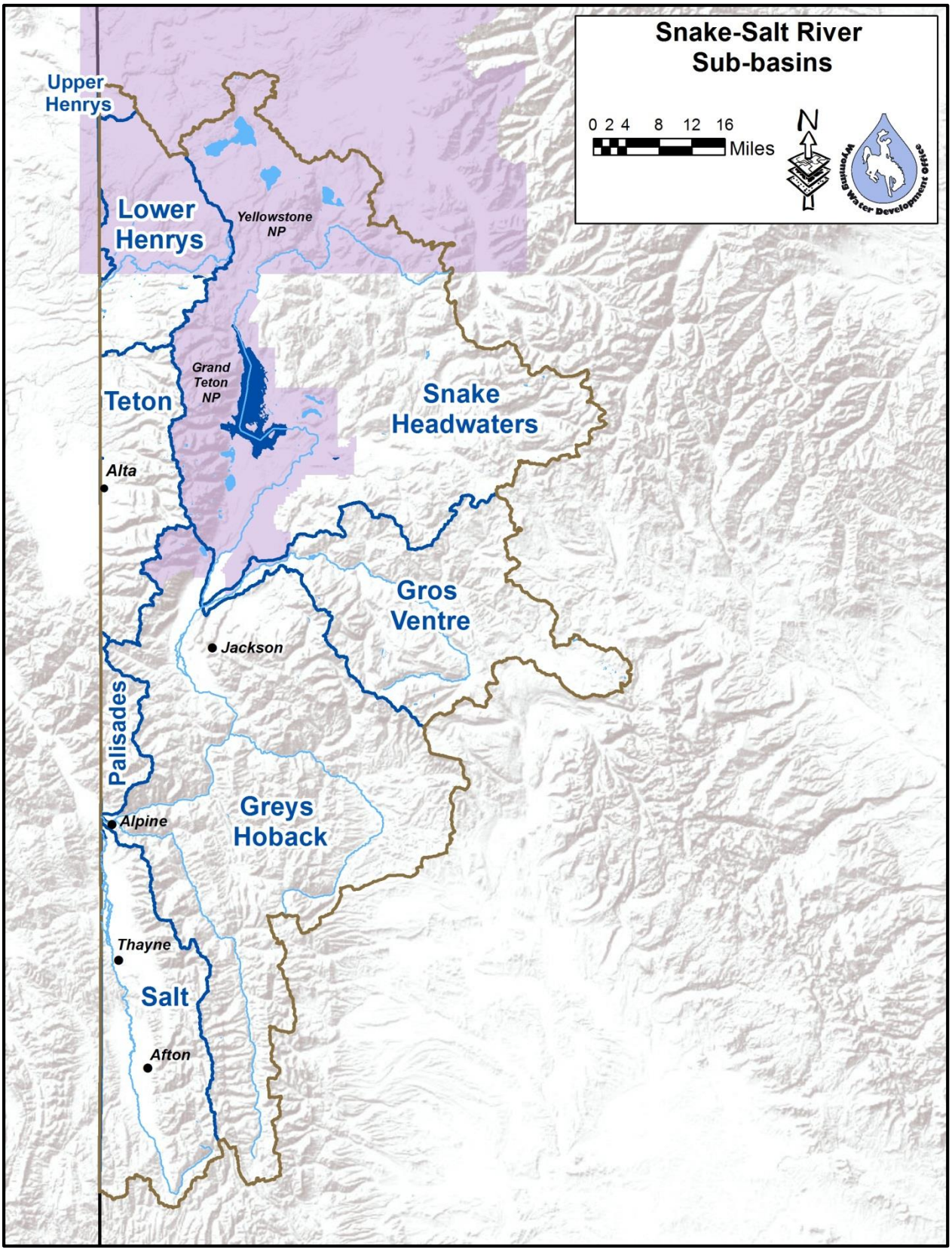

FIGURE 3-4: SNAKE/SALT RIVER BASIN SUB-BASINS

3.2 CLIMATE

This section summarizes the climate within the Snake/Salt River Basin in terms of precipitation, temperature and growing season. Additional information is presented in *Technical Memorandum, Tab XVI: Climate*

3.2.1 PRECIPITATION

Wyoming's Snake/Salt River Basin receives a mean annual precipitation of just less than 36 inches. However, with elevations ranging from about 5,500 feet at Palisades Reservoir, where the Snake River leaves the state, to 13,770 feet at the summit of Grand Teton Peak, the basin has quite a variation in total precipitation. As illustrated in Figure 3-5, the average annual precipitation in the Wyoming portion of the basin ranges from a low of 16 inches just south of Jackson to a high of 95 inches at the southern end of the Teton Range.

Two major types of precipitation patterns exist in the basin. The first is a snow-dominated winter precipitation pattern, where the greatest precipitation contributions come during the months of November/December through January. Typically this pattern is seen in the higher elevation areas where annual precipitation totals are 40 inches or greater.

Within the snow-dominated pattern, there are two *transitional* patterns. The first transitional pattern has winter precipitation dominance, but the May peak starts to become apparent and begins to overtake the snow-derived precipitation. The second transitional pattern relates to the snow-dominated pattern, but the months of November through May provide more equal contributions to the annual total. In this latter precipitation pattern, the June through October period is usually noticeably drier than the rest of the year. This transitional pattern is most noticeable in areas receiving between 25 and 40 inches for the year. Generally, when going from areas with low annual precipitation to areas with high annual precipitation, the contribution of May precipitation to the whole becomes less, and the graph of monthly precipitation across the year takes on the appearance of an inverse bell.

The second pattern in the basin has a more uniform distribution of precipitation throughout the year. May typically has the greatest precipitation and occasionally there is a second peak in July. This pattern is usually seen in the areas of the basin receiving less than 25 inches of annual precipitation.

3.2.2 TEMPERATURE

The average, maximum and minimum temperatures in the Snake/Salt River Basin are illustrated on Figure 3-6. Average monthly maximum temperatures in the valleys are generally highest in July and lowest in December. Average monthly minimum temperatures are lowest in January, except at Alta where the minimum temperatures are lowest in December.

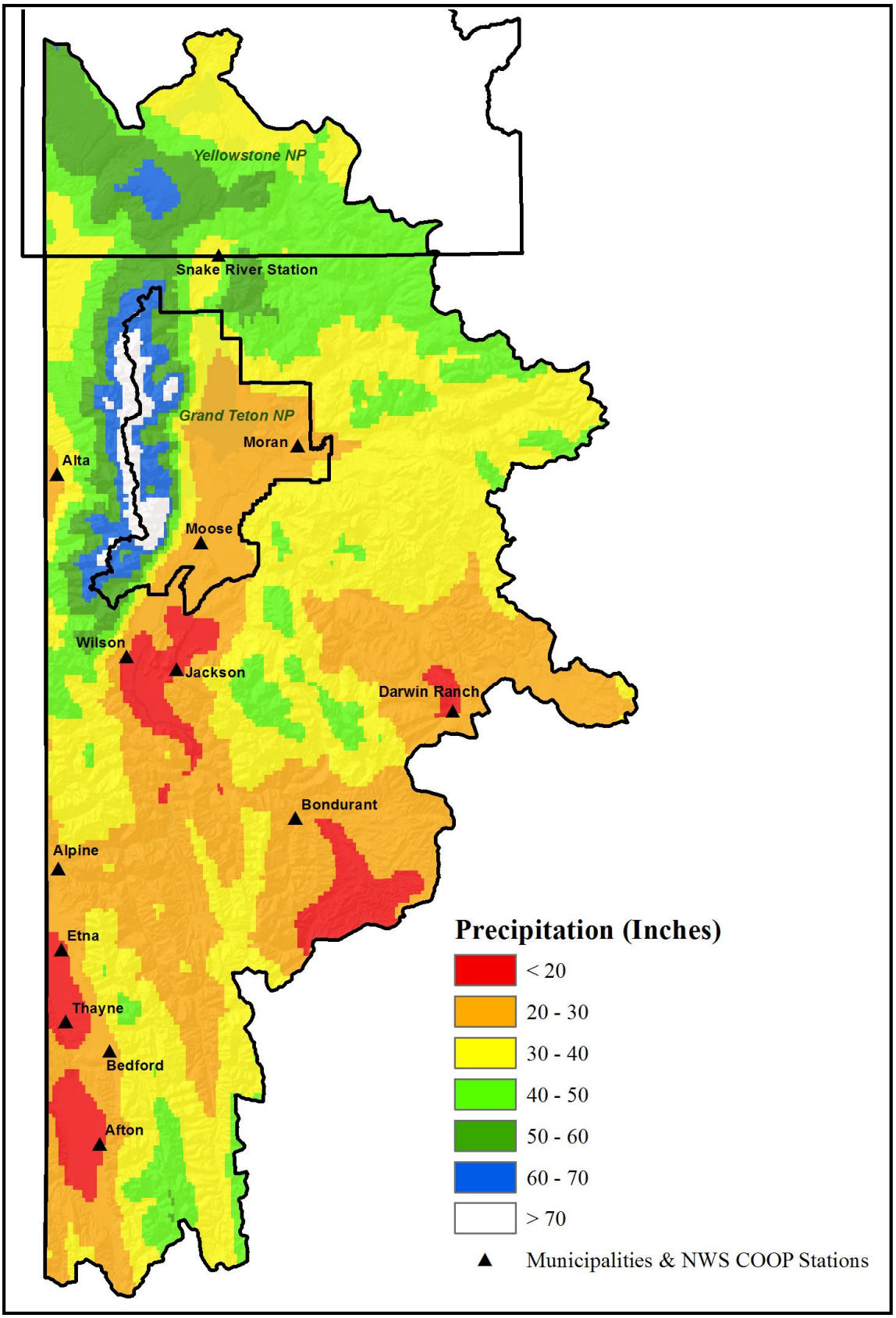

FIGURE 3-5: ANNUAL PRECIPITATION IN THE SNAKE/SALT RIVER BASIN

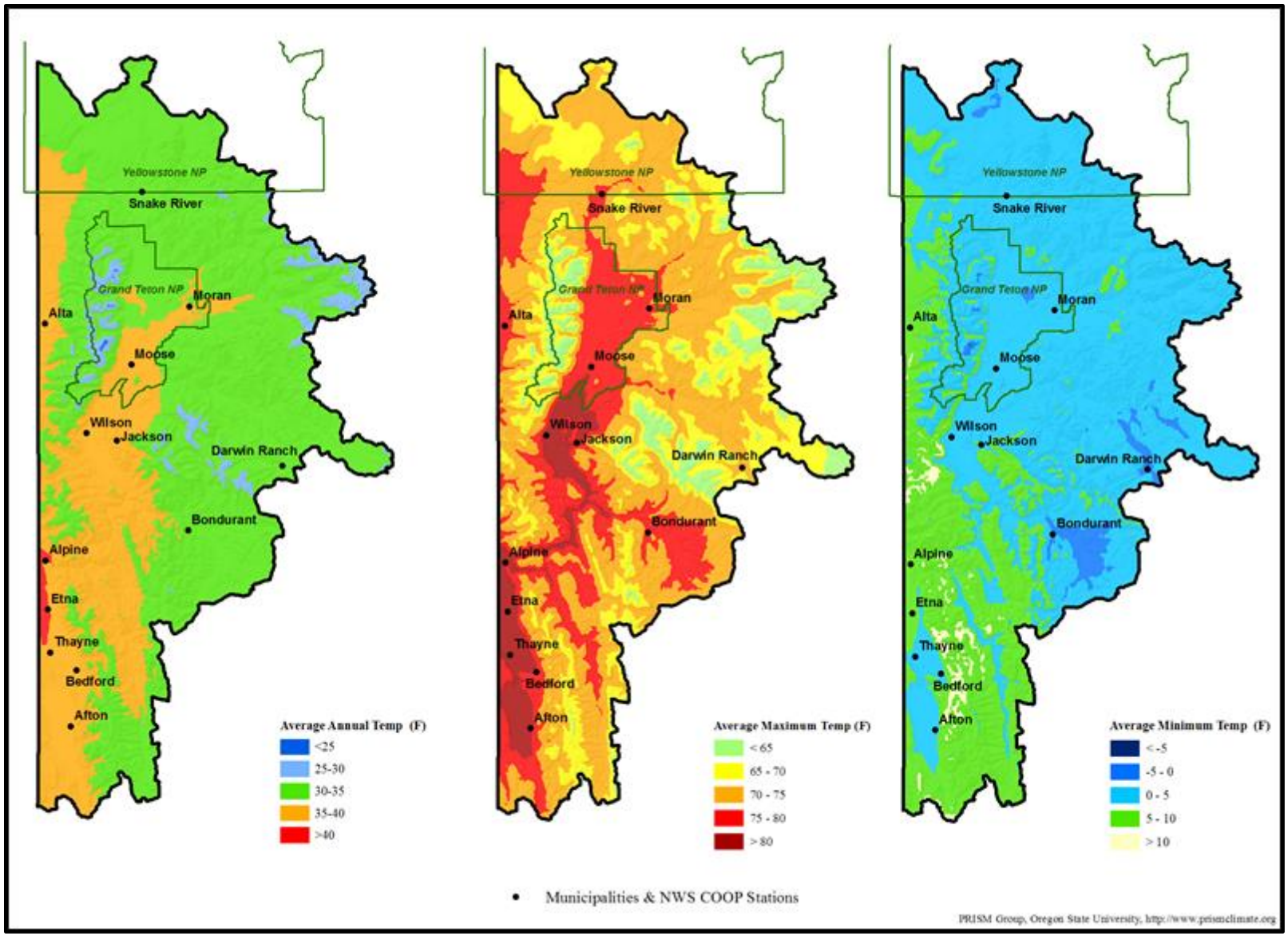

FIGURE 3-6: AVERAGE, MAXIMUM, AND MINIMUM TEMPERATURES IN THE SNAKE/SALT RIVER BASIN

3.2.3 GROWING SEASON

The growing season in the Snake/Salt River Basin is quite short due to the high elevation. Minimum elevation of the basin is 5,500 feet near Palisades Reservoir. The average last frost (≤ 32°F) in Afton occurs on July 1 while the average first frost is on August 26, resulting in a frost-free season of just 55 days. With regards to freezes (≤ 28°F), the average last freeze in spring for Afton is June 7, and the average first freeze in fall is September 7. Bedford's season is very similar with dates of last and first frost being June 25 and August 28, respectively, while the last and first freeze dates are June 4 and September 12, respectively. The higher elevation climate station site of Darwin Ranch has an even shorter frost-free season with the average last frost in spring occurring July 23 and the average first frost of the fall occurring August 6, resulting in an average frost-free season of only 13 days. When considering freeze dates for Darwin Ranch, the average last freeze is around July 11, while the average first freeze in the fall is around August 16. Table 3-3 presents a list of frost/freeze dates for select climate stations within the Snake/Salt River Basin.

TABLE 3-3: FREEZE AND FROST DATES FOR CLIMATE STATIONS IN THE SNAKE/SALT RIVER BASIN

Station	Average Date of:			
	Last Freeze ≤ 28°F	Last Frost ≤ 32°F	First Frost ≤ 32°F	First Freeze ≤ 28°F
Afton	07 Jun	01 Jul	26 Aug	07 Sep
Alta 1NNW	02 Jun	29 Jun	30 Aug	11 Sep
Bedford 3SE	04 Jun	25 Jun	28 Aug	12 Sep
Bondurant	15 Jul	27 Jul	04 Aug	10 Aug
Darwin Ranch	11 Jul	23 Jul	06 Aug	16 Aug
Jackson	20 Jun	10 Jul	16 Aug	30 Aug
Moose	12 Jun	02 Jul	22 Aug	03 Sep
Moran 5WNW	16 Jun	10 Jul	17 Aug	01 Sep
Snake River	05 Jul	21 Jul	08 Aug	15 Aug

Source: High Plains Regional Climate Center CLIMOD System

3.3 POPULATION AND ECONOMICS

This section presents a brief summary of population and economics within the Snake/Salt River Basin. More detailed information can be found in *Technical Memorandum, Tab XVII: Population Projections and Economic Conditions.*

3.3.1 POPULATION

Population of the three counties that make up a majority of the Snake/Salt River Basin (Lincoln, Sublette and Teton) remained constant during the 1950s and 1960s. The population grew rapidly in the 1970s, showed slow but steady growth during the 1980s, and grew rapidly again in the 1990s (Sunrise Engineering, Inc., 2003) (BBC Research and Consulting, Inc., 2002). The portion of Sublette County within the basin is small and has little impact on the total population of the basin. Historically, population changes in Teton and Lincoln Counties have been driven by immigration to meet increasing job opportunities.

The 2002 basin population was estimated to be 26,370 in the 2003 Plan, and the Wyoming Department of Administration and Information, Economic Analysis Division (DAIEAD) estimated the population to be 34,473 in 2012. This shows a moderate growth rate of about three percent annually over approximately ten years. Table 3-4 shows population estimates provided by DAIEAD for the portions of the three counties within the Snake/Salt River Basin and the basin total (DAIEAD, 2012). Teton County showed the greatest population growth over the period from 2003 to 2012 and has the greatest projected growth to 2030. Sublette County has only a small area within the Snake/Salt River Basin, and this area showed limited growth from 2003 to 2012.

TABLE 3-4: POPULATION ESTIMATES FOR COUNTIES MAKING UP THE SNAKE/SALT RIVER BASIN, 2003 – 2012

County	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Lincoln	10,903	11,172	11,339	11,625	11,957	12,315	12,536	12,574	12,645	12,730
Teton	18,417	18,870	19,154	19,636	20,196	20,802	21,174	21,239	21,360	21,503
Sublette	206	211	214	219	225	232	236	237	238	240
Total	***29,526***	***30,252***	***30,707***	***31,480***	***32,378***	***33,350***	***33,946***	***34,050***	***34,244***	***34,473***

Note: Estimates presented in this table were prepared by DAIEAD.

3.3.2 ECONOMICS

Historically, agriculture and tourism have been the major economic sectors of the Snake/Salt River Basin. In the 2003 Plan, these were the two important economic sectors considered. Industry was a minor economic sector with only three businesses including Star Valley Cheese Corporation, Northern Foods and Water Star Bottling Company.

Currently, agriculture and tourism remain important economic sectors, and agriculture is the largest water use sector. However, agriculture is decreasing in importance and tourism is the main economic driver. Industry has been a minor part of the economy in the basin and has actually decreased with the closing of the three businesses described in the 2003 Plan.

The economy and population grew steadily from 2002 to 2008 and slowed during the recession from 2008 to 2012. Planners within the basin indicate that the economy is beginning to pick-up again in 2012 (Teton County, 2012) (Town of Jackson, 2012) (Lincoln County Planning and Engineering, 2012).

3.4 DISCUSSION OF COMPACTS AND LEGAL CONSTRAINTS

In recent years, federal and state laws, rules, regulations, and policies have affected water development and management. This section identifies and discusses some of these institutional constraints on the development and use of water as related to issues in the Snake/Salt River Basin. Additional information can be found in *Technical Memorandums, Tab XVIII: Institutional Constraints; Tab XIX: Palisades Reservoir Contract; and, Tab XX: Salmon Recovery Efforts in the Snake River Basin.*

3.4.1 WYOMING WATER LAW

Wyoming water law is based on the prior appropriation doctrine as characterized in the shorthand phrase, "first in time, first in right." The state's water laws are administered by the State Engineer's Office and State Board of Control. Under the prior appropriation doctrine, during periods when there is insufficient water to fulfill all water rights, those water users having an earlier (senior) priority date on their water right are entitled to receive their full amount of water for beneficial use before those water rights that have a later priority date, referred to as the "junior" water rights.

The State Engineer's Office also administers the Wyoming laws associated with safety of dams. The general requirements of the law outlines the need to submit and receive approval from the State Engineer of a set of engineered plans and construction specifications for any dam equal to or greater than 20 feet in height or 50 acre-feet in capacity. These public health safety laws must be considered in the planning and design of any dam that may affect the public safety. The law also outlines a safety of dam inspection program, where every dam meeting the above size criteria must be physically inspected by the agency every five years.

3.4.2 INTERSTATE COMPACTS

Wyoming is a headwater state; its mountain ranges are often the highest elevation source of water for many of the most significant rivers in the western United States. Wyoming straddles a portion of the continental divide and is a primary contributing source of water to the Colorado River, the Missouri River and the Columbia River. As such, the waters originating in Wyoming are shared by water users in many surrounding downstream states.

As a result of more rapid development and population growth in downstream states, an upstream state is critically interested in protecting its long-term right and ability to develop the waters of a shared interstate river. Soon after the turn of the 20th century, upstream states were concerned that the "first in time, first in right" doctrine, uniformly adopted for intrastate distribution of water, would be applied across state lines to the detriment of "junior" or later developing upstream water uses. To address these concerns and circumstances, legal processes were established over the past ninety years to provide for the orderly allocation and protection of the use, rights, and privileges of the waters of streams and rivers that flow across state lines.

There are two basic ways the rights and allocations of water sources shared between states are established. The first is a result of litigation between states that is resolved by a decree of the Courts of the United States that equitably apportions the shared water resources between the states. The second way is established cooperatively through an interstate compact, which is an agreement between the participating states, with the consent of Congress, dividing the waters of an interstate stream. Wyoming has many such arrangements for the interstate rivers and streams leaving our borders, including the Snake/Salt River Basin. The rights of Wyoming and Idaho to the waters of Teton Creek and South Leigh Creek, on the west side of the Teton Mountain Range, have been settled by a decree of the District Court of the United States for the District of Wyoming, and the rights to the waters of the Snake and Salt River watersheds are included in the Snake River Compact.

3.4.2.1 SNAKE RIVER COMPACT

Congress, by the Act of June 3, 1948, provided their consent to Wyoming and Idaho negotiating a compact over the waters of the Snake River. The Snake River Compact, negotiated by the representatives of both states with participation of a representative of the United States, was signed on October 10, 1949. The compact divided the waters of the Snake and Salt River watersheds between the states of Idaho and Wyoming. This agreement was subsequently ratified by the State of Idaho on February 11, 1950, by the State of Wyoming on February 20, 1950 and by an act of Congress on March 21, 1950.

The compact recognizes, without restriction, all existing water rights in Wyoming and Idaho established prior to July 1, 1949. It permits Wyoming unlimited use of water for domestic and stock watering purposes, providing stock water reservoirs shall not exceed 20 acre-feet in capacity. The compact allocates to Wyoming, for all future uses, the right to divert or store four percent of the Wyoming-Idaho state line flow of the Snake River. Idaho is entitled to the remaining 96 percent of the flow. The use of water is limited to diversions or storage within the Snake River drainage basin unless both states agree otherwise. The compact also provides preference for domestic, stock and irrigation water use over storage for the generation of power.

The historical perspective of this seemingly "un-equitable" division of water was the fact that the majority of the existing and potential future use of water was in Idaho. In 1949, the lack of arable land for irrigation and the high percentage of federal land (national parks, national forests and wildlife reserves) in the Wyoming portion of the Snake River Basin were factors in the negotiations.

One unique aspect of the Snake River Compact, compared to other compacts to which Wyoming is a party, is a requirement that calls for Wyoming to provide Idaho replacement storage for one-third of any usage after the first two percent is put to beneficial use. Early estimates of these replacement storage quantities, based upon the average state line flow, are 33,000 acre-feet.

3.4.2.2 ROXANA DECREE

The Roxana Decree is a shorthand name for a United States District Court decision resolving an interstate dispute between water users in Wyoming and Idaho diverting from Teton Creek and South Leigh Creek. The District Court for the District of Wyoming Docket Equity No. 2447, Roxana Canal Co., a Corporation, et al. v. Daniels, et al. entered its decision and decree on February 4, 1941. This decree adopted a stipulation of agreement entered into by the water user parties to the case located within Wyoming and Idaho, dated March 20, 1940.

The stipulation generally sets forth that Wyoming water users shall be unlimited in their diversions from Teton Creek and its tributaries until the measured flow of the creek diminishes to 170 cubic feet per second (cfs). After that, the Wyoming water users are limited to a diversion of one cfs for each 50 acres of irrigated land. When the flow further reduces to 90 cfs, the flow of Teton Creek and its tributaries is divided equally between the Wyoming and Idaho water users.

For South Leigh Creek, the stipulation generally provides the appropriators in Wyoming unlimited diversion of water from South Leigh Creek until the natural flow of the creek diminishes to a total of 16 cfs, after which time the Wyoming water users are permitted to divert one-half of the streamflow and Idaho water users can divert the balance.

3.4.3 WYOMING WATER DEVELOPMENT PROGRAM

Planning, constructing and implementing a water project is costly. Adding the costs to acquire state and federal permits can be overwhelming for many small public and private entities in Wyoming. In 1975, recognizing water development was becoming more difficult and additional water development was necessary to meet the economic and environmental goals and objectives of the state, the Wyoming Legislature authorized the Wyoming Water Development Program and defined the program in W.S. 41-2-112(a), which states the following:

The Wyoming water development program is established to foster, promote, and encourage the optimal development of the state's human, industrial, mineral, agricultural, water and recreation resources. The program shall provide through the commission, procedures and policies for the planning, selection, financing, construction, acquisition and operation of projects and facilities for the conservation, storage, distribution and use of water, necessary in the public interest to develop and preserve Wyoming's water and related land resources. The program shall encourage development of water facilities for irrigation, for reduction of flood damage, for abatement of pollution, for preservation and development of fish and wildlife resources [and] for protection and improvement of public lands and shall help make available the water of this state for all beneficial uses, including but not limited to municipal, domestic, agricultural, industrial, instream flows, hydroelectric power and recreational purposes, conservation of land resources and protection of the health, safety and general welfare of the people of the state of Wyoming.

The task of setting priorities under the above all-encompassing definition falls to the WDC, which was also authorized by the Wyoming Legislature. The WDC is made up of ten Wyoming citizens appointed by the Governor. The director and staff of the WDO administer the Wyoming Water Development Program.

3.4.4 INSTITUTIONAL CONSTRAINTS

In the late 1960's and early 1970's, Congress passed legislation to protect the environment. Prior to the passage of these laws, most water projects were designed and operated for specific consumptive uses for municipal, agricultural, or industrial purposes or to provide flood control or recreational benefits. Any environmental benefits derived from the projects were indirect and incidental to the purposes for which they were designed. While such benefits could be considerable, they were not protected or required by law. With passage of environmental laws, a variety of environmental protection and mitigation actions became a “standard” consideration in the development of water projects as well as for many other types of projects. These considerations often included minimum streamflow releases and mitigation for impacted wetlands as requirements of federal approvals or permits for a particular project. At the same time, the economic and environmental benefits of recreation, fisheries, wetlands and other habitats were documented and became more apparent to the public and developers alike, which

resulted in minimum reservoir pools or streamflows often becoming a planned component of reservoir operations.

Water supply development often requires "federal action" that initiates or triggers federal environmental law reviews and permitting. These actions or where there is a "federal nexus" include, but are not necessarily limited to, the following:

1. Issuance of special use, right-of-way or other permits for new water projects on federal lands, including those lands administered by the U.S. Forest Service (USFS), National Park Service (NPS), Bureau of Land Management (BLM), and other federal agencies.
2. Renewal of special use, right-of-way or other permits for existing water projects located on federal lands, including those lands administered by the USFS, NPS, BLM and other federal agencies.
3. Contracting for storage space or water from federal reservoirs, such as those owned and operated by the U.S. Bureau of Reclamation (USBR) or U.S. Army Corps of Engineers (COE).
4. Renewal of existing contracts for storage space or water from federal reservoirs. For example, in the Snake/Salt River Basin water users have contracts for storage space and water in Jackson Lake, Grassy Lake and Palisades Reservoir.
5. Actions that involve the discharge of dredged and/or fill material into waters of the United States, including rivers, streams, and wetlands, require the issuance of a Section 404 permit under the Clean Water Act (e.g. the construction or repair of dams, diversion dams, pipeline crossings, levees, etc.). These types of permits are issued by the COE.
6. Procurement and renewal of licenses from the Federal Energy Regulatory Commission (FERC) to produce hydropower at private or federal dams and reservoirs.
7. Use of federal funds, loans or grants to construct a new water project or rehabilitate an existing water project.

The only water development activity not subject to federal environmental laws is drilling a well with non-federal funds on non-federal lands outside the banks of rivers, streams, and wetlands. However, piping the water from such wells across federal lands or rivers, streams, and wetlands could initiate a federal environmental review and a federal permitting or approval action. A full discussion of the laws that must be considered when undertaking an action requiring federal permitting or approval is presented in *Technical Memorandum, Tab XVIII, Institutional Constraints.*

Water development in the 21st century is often difficult and costly. However, if a project proponent has a need for water, with patience and adequate financial resources, the federal environmental review and permitting processes can be successfully completed and permits obtained for construction of water projects. In the Snake/Salt River Basin, the extensive amount of federal lands and particularly the national parks and forests act as a practical limitation on extensive water development in the basin. However, carefully sized and smartly located water development projects to meet the needs of basin citizens are institutionally possible.

The State of Wyoming has historically been proactive in dealing with institutional constraints that may impact its ability to develop water resources as allocated by court decrees and interstate compacts. State officials routinely monitor water related activities in downstream states, review proposed federal legislation and federal mandates that are derived from a variety of sources such as new federal environmental legislation, regulations or forest and park management plans, to interject the state's position on these matters and provide for a state perspective in their development and implementation. These efforts are important to Wyoming water users and citizens and should continue.

3.4.5 PALISADES RESERVOIR CONTRACT

As a result of evaluation and involvement by the State of Wyoming with the reservoir and river operations, use of storage space set aside by the U.S. Bureau of reclamation (USBR) became the state's primary opportunity for addressing several important issues in the Snake/Salt River Basin. First, the quantity of storage space "reserved" by the USBR was the amount estimated to be required to meet Wyoming's compact replacement storage space obligations. By securing the replacement storage space, Wyoming would assure its long-term ability to continue to develop and beneficially use the waters allocated from the Snake/Salt River Basin. Secondly, by holding a contract for storage space in the USBR's reservoir system, through an exchange of storage water between Palisades and Jackson Lake reservoirs, the state could also provide water or protection for the minimum river flow regime below Jackson Lake Dam and for the maintenance of higher levels in Jackson Lake during periods of drought.

To accomplish these dual benefits, the State initiated a negotiation and contracting process with the USBR to obtain control over the "set aside" storage space in 1988 and eliminate any other potential water user from obtaining this water resource. On July 13, 1989, the USBR commissioner approved the "basis of negotiation," an internal USBR document authorizing the regional representatives to move forward with the detailed negotiations. The USBR entered the final contract effective October 31, 1990.

The contract provides Wyoming with 33,000 acre-feet or 2.75 percent of the 1,200,000 acre-feet of active storage space in Palisades Reservoir. Wyoming is entitled to the water accruing to this space in priority for a variety of purposes, including the compact replacement storage space obligations, subcontracting the use of storage water to others, and to maintain instream flows and lake levels within Wyoming, through an exchange. Wyoming is contractually treated, for the most part, like any other storage spaceholder in Palisades Reservoir under contract with the USBR, with the same general rights and obligations for the use, accounting, and administration of the storage space.

Under the spaceholder's contract, Wyoming agreed to pay a proportion of the USBR's construction costs allocated to irrigation and a corresponding share of the interest during construction for the 33,000 acre-feet (2.75 percent) of Palisades Reservoir storage space. This amount totaled $567,270, which was appropriated from the Water Development Program Account I by the Wyoming legislature during the 1991 session. In addition, Wyoming annually pays a proportion (2.75 percent) of the Palisades Reservoir operation and maintenance costs.

The amount of replacement storage space is based upon the provisions of Article III A of the Snake River Compact (1949). Under the Compact, four percent of the waters of the Snake River Basin (including the Greys and Salt Rivers) are allocated to Wyoming for direct diversion or storage. The first half or two percent of the compact allocation can be diverted or stored without any storage space replacement requirement. Wyoming shall provide replacement storage space equal to one-third of any additional use under the second half of the four percent allotment. It is estimated that Wyoming's four percent share at the Wyoming-Idaho border is approximately 200,000 acre-feet (5,000,000 acre-feet times 4 percent). One-half is approximately 100,000 acre-feet and one-third of this amount is 33,000 acre-feet of storage space. This was the amount "set aside" by the USBR and, in 1990, placed under contract with Wyoming.

3.4.6 SALMON RECOVERY EFFORTS

In the Snake River Basin, the primary downstream issue relates to the on-going efforts of recovering a variety of salmon and steelhead fish species that are listed as either threatened or endangered by the National Marine Fishery Service (NMFS) pursuant to the Endangered Species Act (ESA). These anadromous fish species are located along the Columbia River and Lower Snake River in western Idaho. There are additional listed species of trout, snails, and plants located along the Snake River upstream of the river reaches directly affected by the salmon and steelhead yet downstream of the Wyoming/Idaho border. These ESA listings are under the management of the Fish and Wildlife Service (FWS), and the flow and habitat needs of these species often conflict with the desired flow regimes for the listed anadromous fish.

For a number of years, federal agencies, primarily through the COE and NMFS, have committed extensive financial resources to a variety of scientific studies and structural changes to existing COE dams and hydropower plants. River and reservoir operational changes within the Columbia River system were also addressed. These studies and suggested changes address moving salmon and steelhead juveniles more rapidly to the ocean. This study evaluated methods of moving the juveniles more rapidly to the ocean.

One alternative proposed was to increase the downstream river flow velocity to convey the juvenile fish to and through the Columbia River and the existing set of mainstem reservoirs to the ocean. Another controversial alternative to achieve this same migration result was an evaluation of removing some of the mainstem COE dams and reservoirs thereby eliminating flow impediments and slack water regimes. With regard to river flow augmentation alternative, the COE and NMFS requested that the USBR evaluate their Upper Snake River reservoir operations and identify additional water resources that could be committed to the recovery of the listed fish species. Separate from facilities owned by Idaho Power Company, all of the larger reservoirs in the Snake River system upstream of Lower Granite Dam are owned and operated by the USBR. This system of reservoirs has a combined capacity of about seven million acre-feet of active storage space. While most of this space is contracted for irrigation purposes, some quantities are also assigned to environmental quality, other water supplies, and flood control.

In 1995, the USBR agreed to annually provide 427,000 acre-feet of water to these recovery efforts. Depending on water availability, half of this amount is derived from the Upper Snake River Rental Pool, the purchase of a small amount of natural flow water rights, and un-contracted storage space in the USBR's extensive Snake River reservoir system. The other half

is derived from the Boise and Payette River Basins. This initial commitment of water did not significantly impact the operations of Palisades or Jackson Lake Reservoirs or the Snake River flow regime through Wyoming. However, the USBR has reported that there have been some problems and concerns expressed by residents, irrigators, the states, tribes, and elements of the federal government.

In 1997, the COE requested that the USBR analyze the effects of providing flow augmentation for the listed species at an additional one million acre-feet of water from the entire Snake River basin upstream of Lower Granite Dam. This is a commitment of water beyond the 427,000 acre-feet already being provided for the recovery efforts. This study evaluated the possible effects of acquiring both natural flow water rights and reservoir storage space in USBR facilities located in the Boise, Payette, and Owyhee River basins as well as the upper Snake River. The USBR study developed new water demand schedules up to a total of 1,427,000 acre-feet under several reservoir operation scenarios and then evaluated the environmental, economic, social, cultural, and recreational effects of meeting these new demands.

The USBR study identified a block of water coming from natural flow water rights in Wyoming (approx. 30,000 acre-feet) as well as from other areas of the basin. The USBR simply assumed for their study that they would be able to acquire certain quantities of water rights from existing appropriators in Wyoming and from Nevada, Idaho, and Oregon that would be a portion of the additional one million acre-feet. These blocks of water would then be managed together with significant amounts of water from reservoir storage space in USBR reservoirs that would also be acquired or reassigned from irrigation to the new purposes under evaluation pursuant to federal and state laws. The amount of actual water yield was then estimated and routed through the reservoir and river system using a computer simulation model over a 62-year period of historic streamflow conditions from 1928 to 1989. This period of record provided results that could be reviewed under wet (1983), dry (1977), and average hydrologic circumstances.

The results from the model were used to evaluate the potential effects or impacts upon other resources in the river basin. Because of the abbreviated and broad basin-wide nature of the USBR study, specific and definitive impacts on the resources within Wyoming are not provided. A summary of the general findings related to Jackson Lake and Palisades Reservoir follows:

1. In the areas where natural flow water rights are acquired, the report indicated there would be job losses related to irrigated agriculture and the quality and character of rural communities would be irreversibly changed.
2. The recreation impacts, measured in terms of visitations, had predictable losses ranging between 6 and 14 percent for river recreation and between one and 11 percent for the reservoirs.
3. Negligible changes were identified between the current or base conditions and the additional one million acre-feet conditions for the cultural, wild and scenic rivers, and Indian trust asset resources.
4. Slightly adverse effects were identified for the quality and amount of habitat for aquatic snails, bald eagles, plants, and other general fish species. Slight decreases in water quality were also noted in the Wyoming river reaches.

5. Some improvements in streamside wildlife and riparian areas were anticipated.

The USBR's "million acre-feet study" was submitted to the COE. Since that time, no further actions evaluating or implementing the options and alternatives presented have been pursued.

3.5 BASIN WATER DEVELOPMENT STUDIES AND PROJECTS

This section discusses Wyoming Water Development Program studies and construction projects funded by the Wyoming WDC in the Snake/Salt River Basin. A full list of studies and projects funded by the WDC is presented in Table 3-5 at the end of this section.

All of the studies and projects conducted in the basin have been for community water systems except one irrigation diversion dam project and one reservoir enlargement project. An irrigation study was conducted on the Etna diversion dam, and the dam was replaced for the Etna Irrigation District in a WWDC Level III construction project. An enlargement of Cottonwood Lake has also been undertaken, and that project is scheduled to go to Level III construction. The enlargement project has an irrigation component and a recreational component.

Many of the community water system studies and construction projects conducted in the 1980s and 1990s were in response to system deterioration. Many of the systems were spring developments and had been developed in the late 1940s and early 1950s. Because the systems were old and had deteriorated to the point where they were vulnerable to contamination, the water supply would not meet increasingly stringent federal drinking water standards. The spring developments were not always fully enclosed and were subject to surface contamination.

More recent studies and projects have been designed to improve and protect the community water system supplies to meet the needs of population growth. A 2009 study prepared for the WDC and sponsored by Lincoln County looked at developing regional water systems within the Star Valley area. Star Valley is an area with many small community water systems. The study led by Sunrise Engineering was titled Star Valley Regional Master Plan (Sunrise Engineering, Inc., 2009). The WDC encourages regionalization of community water systems for operation and maintenance efficiency and cost effectiveness. The study concluded that, "the most feasible alternative is to develop two regional systems, one for the upper valley and one for the lower valley." To advance regionalization in Star Valley, Level II feasibility projects should be conducted as sponsors become interested in regionalization. The areas that may have potential for the first developments of a regional system are listed below. They would be small regional systems that could lead to further regional developments.

- Alpine, North Alpine and North Star Utilities
- Bedford and Thayne
- Afton and Auburn
- Smoot, Happy Valley, Osmond and West View

TABLE 3-5: WATER DEVELOPMENT PROGRAM STUDIES AND PROJECTS COMPLETED WITHIN THE SNAKE/SALT RIVER BASIN

Study and/or Project Title	Level	Date	Notes
Afton Municipal Water Study Level II Study	II	1990	Recommended to upgrade system & construct hydropower facility
Afton Water Supply Level III Construction	III	1994	Construct spring renovation, pipeline, & storage tank & drill well Hydropower facility constructed under other funding
Afton Water Supply Project, Level II	II	1999	Recommended to upgrade transmission pipeline & add telemetry
Afton Springs Water Supply Level III	III	2000-2001	Renovated spring intake & pipeline to protect from rock fall
Afton Groundwater Exploration Grant	GW Grant	2004	Drill well to add supply to the system
Afton Well, Level III	III	2006-2008	Hook well to system & add well house, meter, controls, and pipeline
Alpine Water Supply	III	1995-1997	Drill well & construct pipeline & storage tank
Alpine Spring Irrigation Supply Project	II	2001	Recommended to use spring water for green area irrigation
Alpine Raw Water	III	2002-2005	Pipeline & tank constructed for green area irrigation
Alpine Master Plan Update Level II	II	2009	Recommended to upgrade well and water transmission system
Alpine Water Supply	III	Underway 2012	Construct transmission pipelines
Alpine Wells Rehabilitation	III	Underway 2012	Upgrade well, & add generator & construct control building
Alpine Junction Water Study Level I	I	1995	Recommended to construct a test well & form a district
North Alpine Rehabilitation Level II	II	2002	Determined feasibility of drilling a well & developing a water system (Name changed from Alpine Junction to North Alpine after district formed)
North Alpine Rehabilitation Level III	III	2003-2005	Drill well, construct transmission lines, & storage tank
Alta Master Plan Level I	I	2002	Water system needed due to growth. Recommended to form a district & apply for Level ll test well
Alta Groundwater Supply Study Level II	II	2007	Test wells were drilled
Alta/Targhee Towne Water Supply	III		Two wells drilled, well houses & pipeline constructed
Bedford Water Supply Study, Level I	I	1986	Recommended to form a district, upgrade spring water source, upgrade transmission lines, & develop storage
Bedford Water Supply Study Level II	II	1987	Recommended to follow Level I recommendations & also drill a water supply well
Bedford Water Supply	III	1988-1989	Spring source upgraded, drilled well, & upgraded transmission lines
Bedford Water Tank	III	2004-2007	Constructed storage tank

Study and/or Project Title	Level	Date	Notes
Buffalo Valley Level I Water Supply Project	I	1996	Recommended Level II test wells & look at feasibility of storage tank & pipeline
Buffalo Valley Water Supply Project Level II	II	1997	Drilled 2 test wells & recommended storage tank & pipeline
Buffalo Valley Water Supply	III	2001/2005-2005	Drilled wells, constructed storage tank & transmission line
Cottonwood Lake Enlargement Level II Study	II	2006	Recommended constructing new dike & enlarge reservoir
Cottonwood Lake Enlargement Level II Study	II	2009	Continuing study of reservoir enlargement
Cottonwood Lake Enlargement	III	2013	Funded for construction 2013
Etna Diversion Dam Project Level II Study	II	1990	Irrigation project. Recommended replacement of diversion dam
Etna Diversion Dam	III	1991	Irrigation project. Replaced diversion dam
Etna Water and Sewer District Water Supply System – Star Valley Level II Study	II	1993	(Part of Star Valley Municipal Water Supply, Level II Study, 1991) Study needed because of water quality problems. Recommended to repair 1 spring & redevelop a second spring
Well Construction and Testing Program Level II Etna, WY	II	1993	Drilled & tested a new well
Etna Water Supply	III	1994/1998-2002	Redevelop a spring & connect the new well & transmission line
Freedom Water and Sewer District Water Supply System – Star Valley Level II Study	II	1992	(Part of Star Valley Municipal Water Supply, Level II Study 1991) Recommended replace existing well with new well
Construction and Testing Report, Freedom No. 2 Test Well, Freedom, WY	II	1993	Drill well & test (part of 1992 Level II)
Freedom Water Supply	III	1993-1997	Develop new well, construct storage tank & pipeline
Fairview Water Supply	III	1992-1995	(Part of Star Valley Municipal Water Supply, Level II Study 1991) Drill new well, construct storage tank & pipeline
Grover Water Supply	III	1992-1995	(Part of Star Valley Municipal Water Supply, Level II Study 1991) Rehabilitate one spring, drill a well & construct storage tank & pipeline
Hoback Junction Water Supply Study Level I	I	2006	Adequate groundwater would be available to serve a water district. No district was formed & there was no further action.
Indian Paintbrush Water Supply	II	On-going 2014	Well may need replaced and system upgraded
Jackson Water Feasibility Study		1984	Groundwater Exploration Program
Town of Jackson Groundwater Exploration Program	GW Grant	1985	Drilled two exploratory wells & one test well
Town of Jackson Groundwater Exploration	GW	1993	Drilled two exploratory wells

Study and/or Project Title	Level	Date	Notes
Program	Grant		
Jackson Water Supply	III	1994-1998	Drill 3 new wells & constructed a control building (also see Teton County)
Kennington Springs Pipeline Company Level I Water System Reconnaissance Study	I	2003	Recommended upgrade to spring protection & improve transmission pipeline This project has not advanced at this time
North Canal Master Plan Level I	I	2003	Recommended improvements to the canal system. This project has not advanced at this time
Porto Canal Rehabilitation Project Level II Study	II	1994	Recommended placing open ditches in pipelines
Porto Canal	III	1996-1997	Open ditches were converted to pipeline
Rafter J Water Supply Level II Study	II	1998	Recommended drilling a third well & adding transmission pipelines. This project has not advanced at this time
Rafter J Rehabilitation	III	2003 – 2012	Drill new well & replacement well and construct storage tank
Smoot Water Supply	III	1991-1994	(Part of Star Valley Municipal Water Supply, Level II Study 1991) Drilled well, made spring improvements & constructed storage tank & pipeline
Squaw Creek Water Supply Project Level I	I	1991	Recommended drilling deep well, test existing spring & investigate other spring sources
Squaw Creek Water District Test Well #1		1993	Test Well SQ #1 could not be completed correctly
Squaw Creek Water Supply Project Level II, Well Siting, and Construction – Alternative sites	II	1993	Proposed looking at drilling deep well & also look at alluvial wells
Squaw Creek Water Supply Project Level II	II	1994	Recommended drilling Game Creek alluvial wells
Squaw Creek Water Supply	III	1995 – 1998	Drilled Game Creek alluvial wells, constructed pipeline & storage tank.
Squaw Creek Water Supply	GW Grant	2004 – 2005	Drilled test well but the well did not produce adequate water
Squaw Creek Water Supply	III	2006	Funding turned back The well drilled under the GW grant was not adequate
Squaw Creek Water Supply	GW Grant	2007	Second attempt to drill a deep well was unsuccessful
Squaw Creek Water Supply Level II Study	II	2012	Examined past work & requested expansion of Level II Study & increase in budget to drill test well near Teton County Well, request was approved
Star Valley Municipal Water Supply Level I Study	I	1989	Evaluated six community water systems – Etna/Fairview/Freedom/Grover, Osmond/Smoot, all had water quality violations & need water system improvements.

Study and/or Project Title	Level	Date	Notes
Star Valley Municipal Water Supply Level II Study	II	1991	Provided recommended improvements for the six community water systems See individual water system recommendations
Star Valley Regional Master Plan	I	2009	Provided reasonable alternatives for establishing regional water systems
Water System Master Plan – Star Valley Ranch Association	I	1996	Recommended drilling a new well, upgrading undersized pipelines, & adding third storage tank
Star Valley Ranch Master Plan	I	2008	The Town of Star Valley Ranch was formed from the Star Valley Ranch Association in 2006, recommended new wells, additional storage, & improvement of pipelines
Star Valley Ranch Groundwater Level II Study	II	2009	Drilled & tested a new well & designed other improvements
Star Valley Ranch Water Supply	III	Ongoing	Connected the new well to the system, constructed additional storage, & improved the transmission pipeline system
Teton County Water Supply Master Plan Level I	I	1999	Groundwater quantities/quality are good, some areas may be suitable for regional systems, while other areas are too isolated, individual wells & septic systems may be a problem
Jackson Raw Water Supply	III	1999-2001	Drilled wells for irrigation & thawing Flat Creek, constructed pipeline
Jackson Storage Tanks	III	2010-ongoing	Designed and constructed 2 storage tanks
Teton Village Water Supply Study Level I	I	1991	Recommended drilling 2 new high yield wells
Teton Village Water Supply	III	1992-1996	Drilled 2 wells & constructed a pipeline
Teton Village Water Supply	III	2009-ongoing	Drilled a new high yield well & constructed a storage tank & pipeline
Thayne Area Water Supply	I	1995	Recommended redevelop spring, drill well, emergency tie to Bedford & install meters Recommended for Bedford - construct storage tank, larger pump in well, booster pump to increase pressures in area, loop system.
Thayne Water Supply Level II Study	II	1997	Recommended redevelop spring, drill well, construct pipeline, & install meters
Turnerville Water Supply	II	1998	(Part of Thayne Area Water Supply Level II Study 1997) Recommended redevelop spring & build storage tank, pipeline, disinfection facility & install meters
Turnerville Water Supply Project	III	2004/2006-2009	Redeveloped spring, constructed pipeline & storage tank
Thayne Water Supply	III	1998-2002	Drilled well, developed spring & constructed pipeline
Thayne Storage, Level II Study	II	2012	There is not a need for storage if booster pump station is completed. Water use is well above average, there is need for metering use.

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4.0 WATER RESOURCES

4.0 WATER RESOURCES

TABLE OF CONTENTS

4.1 Surface Water Resources 31
4.1.1 Surface Water Modeling Methodology 31
4.1.1.1 Streamflow Gage Data 31
4.1.1.2 Diversion Data 32
4.1.1.3 Ungaged Tributary Inflow Estimation 32
4.1.1.4 Dry, Average, and Wet Years Classification 32
4.1.1.5 Physically Available Flow 32
4.1.1.6 Adjusted Physically Available Flow 32
4.1.2 Surface Water Quantity 33
4.1.2.1 Comparison to Previous Basin Plan and Framework Water Plan 35
4.1.3 Major Reservoirs 36
4.1.4 Surface Water Quality 37
4.1.4.1 Snake River Headwaters Sub-basin 40
4.1.4.2 Gros Ventre River Sub-basin 40
4.1.4.3 Greys River and Hoback River Sub-basin 40
4.1.4.4 Salt River Sub-basin 42
4.1.4.5 Surface Water Quality Summary 42
4.2 Groundwater Resources 42
4.2.1 Groundwater Quantity 46
4.2.2 Groundwater Quality 47
References 47

4.0 WATER RESOURCES

This chapter presents a discussion of the quantity and quality of surface water and groundwater in the Snake/Salt River Basin. Section 4.1 presents information on basin surface water resources, including the modeling methodology, surface water quantity, reservoir storage and surface water quality. Section 4.2 presents information regarding basin groundwater resources, including quantities and quality.

4.1 SURFACE WATER RESOURCES

Natural surface water flows are developed and defined by using spreadsheet models. Historic stream flow records form the basis for the spreadsheet models natural flow analyses. Model results provide estimates of surface water quantities within and leaving the basin.

Major and important reservoirs are inventoried as important water resources in the basin. However, they are not counted in the spreadsheet modeling analysis. Releases from Jackson Lake are considered as part of the basin water use determination and are combined with the model results (Chapter 7).

Water quality is important in the Snake/Salt River Basin and is important to a variety of water uses. Water quality information for this report comes from numerous sources, including data collected at select streamflow gaging stations and various site specific studies and monitoring programs.

4.1.1 SURFACE WATER MODELING METHODOLOGY

For the 2012 Update, the spreadsheet models prepared for the previous Basin Plan were revised to a new study period of record 1971 through 2010. Three 12-month spreadsheet models were analyzed for both the Snake and Salt River Basins, each representing newly classified dry, average and wet years. Inputs to the models were updated in terms of streamflow gage data, ungaged tributary inflow estimates and diversion data.

Revisions to the spreadsheet models for the 2012 Update involve integrating the models with a direct link to dataset queries contained within a new hydrologic database. Other changes include an update to the model map schematic and corresponding calculations that reflect the addition of Greys River into the Salt River Basin spreadsheet models.

A summary of key components to the spreadsheet models is presented below. Detailed information on the models is presented in Chapter 7.

4.1.1.1 STREAMFLOW GAGE DATA

The source of raw streamflow data used to build the historic streamflow records for the spreadsheet models was the U. S. Geological Survey (USGS) daily streamflow data. Daily streamflow data were loaded into a hydrologic database and queries were run to convert the daily data to monthly data. After performing the necessary data filling, further queries

determined dry, average and wet years; and the data were formatted for integration into the spreadsheet models.

4.1.1.2 DIVERSION DATA

Diversion data in the spreadsheet models represents depletions to surface water supplies by irrigation activity. Updates to the diversion data employed a method for estimating crop irrigation requirements (CIR) that differed from the previous Basin Plan. For this study, StateCU was used, which is a public domain software model developed as part of Colorado's Decision Support System tools (State of Colorado, 2011). Crop water requirements calculated in this study reflect the climatic conditions within the basin during the new study period. More information on diversion data is presented in Chapter 5. For a detailed description on how diversion data for the spreadsheet models were determined, refer to *Technical Memorandum, Tab VII: Crop Water Requirements.*

4.1.1.3 UNGAGED TRIBUTARY INFLOW ESTIMATION

Several tributaries to the Snake and Salt Rivers, while included in the spreadsheet models, do not have gaging station records. For these tributaries, natural inflows were estimated using physical characteristics including basin area and mean basin elevation. As in the previous Basin Plan, mean annual flow for these watersheds was estimated using a regression equation derived for mountainous regions of Wyoming published in *USGS WRIR 88-4045* (Lowham, 1988). Once mean annual inflows were determined, monthly values were derived. A shift from mean annual inflows to monthly values was completed by correlation to a nearby gaged watershed with similar characteristics.

4.1.1.4 DRY, AVERAGE, AND WET YEARS CLASSIFICATION

Classification of dry, average and wet years was performed within a hydrologic database developed as part of the 2012 Update. After acquiring the updated gage records and performing the necessary data filling, the wettest and driest 20 percent of the study period years, based on an annual flow basis, were identified based on select indicator gages. The resulting dry, average, and wet year classifications are presented in Chapter 7.

4.1.1.5 PHYSICALLY AVAILABLE FLOW

Output from the spreadsheet models estimates the quantity, timing and location of surface water flows, which constitute the physically available supply as constrained by hydrologic supply and current water use within the basin. The spreadsheet models represent conditions in each basin under current levels of development for three hydrologic conditions; dry, average, and wet year water supply. Availability is a function of location analyzed within the models at "stream reach" levels and at a monthly timing level. These physically available flows, or "Reach Outflows" as predicted by the spreadsheet models, are presented and further discussed in Chapter 7.

4.1.1.6 ADJUSTED PHYSICALLY AVAILABLE FLOW

Flows predicted by the spreadsheet models do not account for Jackson Lake operations and existing instream flow rights. Deliveries of storage water from Jackson Lake to Palisades Reservoir occur throughout the Snake River mainstem. Also, flows are released from Jackson

Lake to satisfy fishery requirements. These reservoir releases, as well as existing instream flow rights, are not accounted for in the spreadsheet model. Therefore, adjustments were made to the "Reach Outflows" provided by the spreadsheet models. These adjusted physically available flows are presented and further discussed in Chapter 7.

4.1.2 SURFACE WATER QUANTITY

The objective of this section is to present basin estimates of total surface water supply resources or annual natural streamflow. A coarse estimate of these volumes can be made by simply adding the quantity of surface water leaving the state to estimates of surface water depletions and the existing instream flow rights that were accounted for in the adjusted available flow calculations. Equation 4-1 describes this relation. Instream flow quantities and estimates of water leaving the state can be derived from the adjusted physically available flow determinations that are described above and presented in Chapter 7. Estimates for surface water depletions come from the data as described and presented in Chapter 5.

EQUATION 4-1

$$Natural\,Flow = Adjusted\,Physically\,Available\,Flows + Depletions + Instream\,Flows$$

The adjusted physically available flows at the most downstream reach in the spreadsheet models are shown on Table 4-1. These quantities represent a point in the model where surface water leaves the state. Table 4-2 shows the total annual irrigation supply-limited consumptive use or depletions, as determined by the spreadsheet models, upstream of the most downstream reach in the models. Table 4-3 displays the instream flow rights that were subtracted in the determination of adjusted physically available flows.

TABLE 4-1: ADJUSTED PHYSICALLY AVAILABLE FLOW

Sub-Basin	Dry Year (AFY)	Average Year (AFY)	Wet Year (AFY)
Snake River	1,775,752	2,717,548	4,049,867
Salt River	199,120	410,726	701,601
Greys River	117,292	278,374	488,441
Total	***2,092,165***	***3,406,648***	***5,239,909***

TABLE 4-2: SUPPLY-LIMITED IRRIGATION DEPLETIONS

Sub-Basin	Dry Year (AFY)	Average Year (AFY)	Wet Year (AFY)
Snake River	26,284	26,284	26,284
Salt River	53,935	54,278	54,294
Greys River	185	185	185
Total	***80,405***	***80,747***	***80,763***

TABLE 4-3: INSTREAM FLOWS

Sub-Basin	Dry Year (AFY)	Average Year (AFY)	Wet Year (AFY)
Snake River	0	0	0
Salt River	159,999	159,999	159,999
Greys River	174,044	174,044	174,044
Total	***334,043***	***334,043***	***334,043***

With respect to the instream flow quantities present in Table 4-3, it is important to note that permits for instream flows in Wyoming are awarded on the basis of cubic feet per second and can be specified as a different flow rate for each month. However, in order to keep the units consistent with the two previous tables, Table 4-3 presents the permitted instream flows as converted to an annual volume in acre-feet (AF). For example, the permitted instream flow right on the Greys River is 221 cfs, January through December. Converting 221 cfs to an annual quantity in acre-feet yields 159,999 acre feet per year (AFY) as exemplified in Equation 4-2.

EQUATION 4-2

$$\frac{221ft^3}{sec} * \frac{86{,}400sec}{day} * \frac{365days}{year} * \frac{1AF}{43{,}560ft^3} \cong 159{,}999AFY$$

Note that instream flow adjustments were only applicable to those segments located on the Salt and Greys Rivers. Instream flows for Snake River Basin are zero despite the existence of two instream flow segments on Fish Creek. Unlike the segments on the Salt and Greys Rivers, the Fish Creek instream flow segments are located on a tributary rather than the mainstem. In the adjusted available flow calculations, instream flows were only subtracted in reaches upstream from the instream flow segment. River reaches located downstream of the segment are not affected. The segments on Salt and Greys Rivers are located at or near the farthest downstream reach; therefore, all reaches upstream were affected by the adjustment and the instream flows must be counted as part of the natural flow. For more information on how adjustments were made for instream flows, refer to Chapter 7. Additional information on state instream flow water rights and those that exist in the Snake/Salt River basin, refer to *Technical Memorandum, Tab XIII: Instream Flows.*

Table 4-4 presents the resulting estimates of annual natural flows generated within each river sub-basin at a point where the flows leave the state (or enter Palisades Reservoir). The quantities shown in this table are for dry, average, and wet years and were determined by summing the values presented in the three preceding tables (Tables 4-1, 4-2 and 4-3).

TABLE 4-4: ESTIMATES OF NATURAL STREAMFLOW

Sub-Basin	Dry Year (AFY)	Average Year (AFY)	Wet Year (AFY)
Snake River	1,802,037	2,743,832	4,076,151
Salt River	413,055	625,003	915,894
Greys River	291,521	452,603	662,670
Total	***2,506,613***	***3,821,438***	***5,654,715***

4.1.2.1 COMPARISON TO PREVIOUS BASIN PLAN AND FRAMEWORK WATER PLAN

A direct comparison of estimated natural flow between the 2003 Plan and this Update is problematic. The 2003 Plan did not report estimates of annual natural streamflow as presented in the previous section, and Greys River was not included in that analysis. However, a rough comparison can be made by extracting the physically available flows, or "Reach Outflows," from the previous spreadsheet models and applying the same calculations to determine adjusted physically available flow and annual natural streamflow. A comparison between the previous Basin Plan and this Update of the annual natural streamflow estimates is presented on Table 4-5.

A direct comparison to the quantities presented in the Wyoming Framework Water Plan from 2007 is also difficult because a different methodology was used and it is unclear whether Greys River was included in the accounting. Nevertheless, a comparison between the Framework Plan and this Update is summarized in Table 4-6.

TABLE 4-5: ESTIMATES OF ANNUAL NATURAL STREAMFLOW, COMPARISON TO PREVIOUS BASIN PLAN

Description		Dry Year (AFY)	Avg. Year (AFY)	Wet Year (AFY)
Snake River Basin	**2012 Update**	**1,802,037**	**2,743,832**	**4,076,151**
	2003 Basin Plan	1,810,567	2,923,420	4,196,462
Salt River Basin	**2012 Update**	**413,055**	**625,003**	**915,894**
	2003 Basin Plan	430,797	676,656	915,507
Total: 2012 Update (Greys River Excluded[1])		**2,215,091**	**3,368,835**	**4,992,045**
Total: 2003 Basin Plan (Greys River Excluded[1])		2,241,363	3,600,076	5,111,969
Change		*-26,272*	*-231,242*	*-119,924*
Percent Change		*-1.2%*	*-6.4%*	*-2.3%*

1. Greys River was not considered in the previous Basin Plan

TABLE 4-6: ESTIMATES OF ANNUAL NATURAL STREAMFLOW, COMPARISON TO FRAMEWORK WATER PLAN

Description	Dry Year (AFY)	Avg. Year (AFY)	Wet Year (AFY)
Total: 2012 Update (Greys River Excluded[1])	**2,215,091**	**3,368,835**	**4,992,045**
Total: 2007 Framework Water Plan (Greys River Excluded[1])	2,179,000	3,540,000	5,047,000
Change	*+36,091*	*-171,165*	*-54,955*
Percent Change	*+1.7%*	*-4.8%*	*-1.1%*

1. It was assumed that Greys River was not considered in the Framework Water Plan

The 2012 Update shows a decrease in total annual natural streamflow from that presented in the previous Basin Plan. Decreases range from 1.2 percent in a dry year to 6.4 percent in an average year. In comparing the results of this study to quantities presented in the Framework Water Plan, a slight increase of 1.7 percent is noted in a dry year, and a slight decrease of 1.1 percent is noted in a wet year. A decrease of 4.8 percent is seen in an average year.

These noted differences can likely be attributed to the extended study period, which includes some very dry years as reflected in the streamflow records. Also, different methodologies were used to estimate CIR, obtain climatic data, and delineate irrigation zones as further described in Chapters 5 and 7.

4.1.3 MAJOR RESERVOIRS

All major reservoir facilities in the Snake/Salt River Basin are owned and managed by the USBR for irrigation and hydropower production in Idaho. Jackson Lake Dam and Grassy Lake Dam are managed as part of the Minidoka Project, which provides irrigation water for over one million acres of farmland in Idaho. Palisades Dam, part of the Palisades Project, is also managed in conjunction with the Minidoka Project. Table 4-7 summarizes information on the three major reservoirs in the basin. Additionally, an inventory of other important storage facilities is presented in Table 4-8. Further information is presented in *Technical Memorandum, Tab XII: Major Reservoirs and Reservoir Evaporation.*

TABLE 4-7: MAJOR RESERVOIRS IN THE SNAKE/SALT RIVER BASIN

Reservoir	Permit No.	Year Complete	Normal Capacity (Acre-Feet)	Dam Height (Feet)	Surface Area (Acres)
Grassy Lake	4631R	1939	15,182	70	310
Jackson Lake	Various	1911	847,000	65	25,530
Palisades	Idaho	1957	1,200,000	270	16,150

JACKSON LAKE NEAR JACKSON LAKE DAM

TABLE 4-8: OTHER IMPORTANT WATER STORAGE FACILITIES IN THE SNAKE/SALT RIVER BASIN

Water Storage Facility	Normal Capacity (Acre-Feet)
Afton Electric Reservoir (aka Swift Creek Reservoir)	48
Baldwin Reservoir	30
Bergman Lake Reservoir	201
Cottonwood Lake	70
Cottonwood Reservoir	487.55
Flat Creek Ranch Reservoir	151
Four Shadows Reservoir	78.69
Indian Lake Reservoir	904
Jackson Wastewater Treatment Plant	260
Leidy Lake	65
Leland's Reservoir	65.83
McLean Reservoir	16.4
Melody Ranch Pond	70
Porter Reservoir	52
Strawberry Creek Reservoir	11
Teal Reservoir	79
Teton Meadows Ranch Reservoir Enlargement	200.40
Timber Creek Reservoir	12
Tracy Lake	380
Tucker Ranch No. 23 Reservoir	146
Tucker Ranch No. 24 Reservoir	270
Two Ocean Reservoir	512
Uhl Reservoir	543
West Borrow Area Lake	96

4.1.4 SURFACE WATER QUALITY

Water quality is an important issue in the Snake/Salt River Basin. It was listed as one of the major issues for the basin in the 2007 framework water planning process (WWC Engineering, Inc, 2007). The issue expanded from the initial water quality concern by the Snake/Salt River BAG as listed in the issues for the 2003 Snake/Salt River Basin Plan Final Report (Sunrise Engineering, Inc., 2003), to the need for water quality monitoring during the framework water planning process.

Prior to preparation of the previous Basin Plan, there was no extensive water quality monitoring activities underway in the basin. Therefore, water quality discussions were based on the Wyoming 2002, 305(b) State Water Quality Assessment Report, which included 303(d) impaired stream listings, and the three USGS gaging stations where water quality samples were taken (Sunrise Engineering, Inc., 2003).

There were three stream segments listed on the 2002, 303(d) list as having water quality threats including: North Fork Spread Creek due to habitat degradation; Flat Creek between Snake River and Cache Creek due to habitat degradation; and Salt River near the Etna USGS gaging station

due to fecal coliform bacteria. A channel rehabilitation project had been completed on the North Fork Spread Creek, but the stream remained on the 303(d) list because the riparian vegetation was not yet well established. It was stated in the 305(b) report that overall there were few threats to water quality in the basin, and there were no waters in the basin requiring establishment of a total daily maximum load (TMDL) (Sunrise Engineering, Inc., 2003).

Sunrise Engineering, Inc. (2002) reviewed data from the three water quality stations. These data indicated there were no water quality problems present, except the fecal coliform bacteria contamination at the gage station near Etna.

In the time period since the 2003 Snake/Salt River Basin Plan, a number of water quality monitoring programs have been implemented. Discussions, in *Technical Memorandum, Tab XIV: Surface Water Quality*, present the information and results from these monitoring programs to provide an overall description of water quality in the basin. The following sections summarize water quality within the major sub-basins of the Snake/Salt River Basin. These sub-basins are shown on Figure 4-1. Streams listed on the Wyoming Department of Environmental Quality, Water Quality Division 2012 303(d) list of impaired streams (WDEQ, WQD, 2012) are also shown on the figure.

GREYS RIVER AT ALPINE

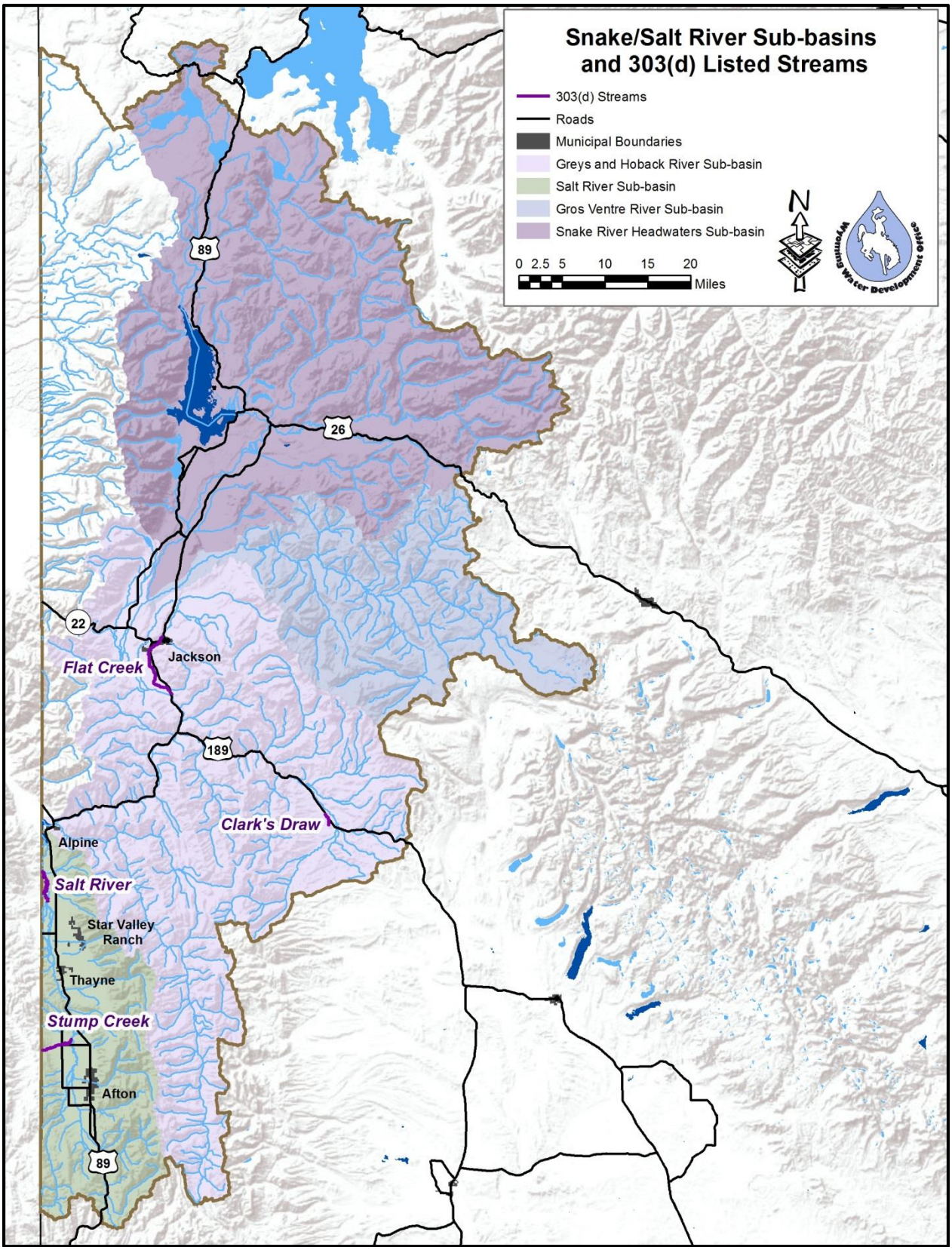

FIGURE 4-1: SNAKE/SALT RIVER SUB-BASINS AND 303(D) LISTED STREAMS

4.1.4.1 SNAKE RIVER HEADWATERS SUB-BASIN

Waters of the Snake River Headwaters Sub-basin originate in southern Yellowstone National Park, Grand Teton National Park, and the Grand Teton and Jedediah Smith Wilderness Areas (WDEQ, WQD, 2010). Many of the waters in this sub-basin are WDEQ, WQD Class 1 waters, including all waters within Yellowstone National Park, Teton National Park, Jedediah Smith Wilderness Area, and Teton Wilderness Area. Additionally, the Snake River main stem above Wyoming State Highway 22 bridge is a Class 1 water. Other waters in this sub-basin are class 2AB. Appendix A to *Technical Memorandum, Tab XIV: Surface Water Quality* and Appendix B of this report contain Wyoming's Surface Water Classification System (WDEQ, WQD 2007).

Monitoring data show that water quality is very good in the Snake River Headwaters Sub-basin, and there are few impacts from human activities (USDI. National Park Service, 2009).

4.1.4.2 GROS VENTRE RIVER SUB-BASIN

The Gros Ventre River Sub-basin originates in the Bridger-Teton National Forest with a large portion of the watershed arising in the Gros Ventre Wilderness Area. The main stem of the Gros Ventre River is Class 2AB (WDEQ, WQD, 2007). Streams within the Gros Ventre Wilderness Area, in addition to The Six Lakes and Clear Creek, are Class 1 waters. Other streams within the sub-basin are class 2AB.

Water quality with in the Gros Ventre River Sub-basin is considered good, and minimal development has occurred in the sub-basin. However, it is suspected the sub-basin may be impacted by wildlife grazing and browsing. Monitoring to determine use support has not been conducted in the sub-basin (WDEQ, WQD, 2010).

4.1.4.3 GREYS RIVER AND HOBACK RIVER SUB-BASIN

This sub-basin has been divided into three watersheds for this discussion; Lower Snake River Watershed, Greys River Watershed and Hoback River Watershed.

The Lower Snake River Watershed begins at the confluence of the Gros Ventre and Snake Rivers and continues to the confluence of the Snake and Hoback Rivers. The watershed then continues from this confluence to Palisades Reservoir. It is the most populated area within the sub-basin. The Town of Jackson, communities of Wilson and Teton Village, and the rural developed area between the Town of Jackson and Hoback Junction are all within this watershed.

Most streams in this watershed, including the main stem of the Snake River and Flat Creek, are classified as 2AB (WDEQ, WQD, 2007). All waters in the Fish Creek drainage are Class 1 to its confluence with the Snake River.

Water quality within this watershed is considered good because the quality of waters entering the watershed is good. There are impacts to this watershed from development that affect the water quality on a local basis. Flat Creek was listed on the 1996 303(d) list of impaired streams as being possibly impaired. Water quality assessments of Flat Creek indicated that urban runoff, primarily sediment from the Town of Jackson, limits aquatic habitat. Flat Creek

was listed on the 2000 303(d) list because support for cold water game fishery and aquatic life other than fish was threatened from storm water runoff, and it remains on the 2012 303(d) list as threatened (WDEQ, WQD, 2012). The stream segment that is listed extends from the confluence with the Snake River to the confluence with Cache Creek. A project to rehabilitate Flat Creek is underway and portions of the stream have been rehabilitated. The project provides planning, design, and implementation of instream fish habitat structures to allow the stream segment to reach its ecological potential (Trout Unlmited, 2012).

Fish Creek is a Class 1 stream, and its headwaters are in Teton National Park. The creek flows south, parallel to the Snake River, through the valley, and passes through the community of Wilson. In the 1990s, residents began noticing excessive algal growth in the creek. Studies are underway to determine the source of nutrients promoting excessive algal growth.

The Greys River Watershed originates in the Bridger-Teton National Forest with very little private land and limited development within the watershed. The Greys River drains directly into Palisades Reservoir near the Town of Alpine. It is located between the Salt River Range and the Wyoming Range. The river and its tributaries are Class 2AB (WDEQ, WQD, 2007). There are fairly high rates of erosion from the sedimentary rocks forming these geologically young mountains (WDEQ, WQD, 2010). Although there has not been any reported monitoring in the watershed, the water quality is expected to be good due to lack of development.

The Hoback River Watershed begins in the Gros Ventre Mountains to the east and the Wyoming Range to the west. A ridge that extends between the two mountain ranges divides the Green River Basin from the Hoback River Watershed. Streams in the watershed are classified as 2AB, except those in the Gros Ventre Wilderness area and the full length of Granite Creek, which are Class 1 (WDEQ, WQD, 2007). Development is limited in the watershed to the upper basin near the community of Bondurant. The lower segment of river flows through Hoback Canyon which restricts the river and potential for development. U.S. Highway 191/189 follows the river through the canyon and is very close to the river in some locations.

Water quality within the Hoback River Watershed is considered good. The Sublette County Conservation District (SCCD) has been monitoring surface water quality in the Hoback River Watershed since 2000. No exceedances of the WDEQ, WQD surface water quality standards for chemical parameters have been found to date (Sublette County Conservation District, 2009).

Western Watersheds Project collected fecal coliform samples in 2010 on Clark's Draw, a small tributary to the Hoback River near Bondurant, and a five-sample geomantic mean exceeded the primary and secondary standards protective of recreational use. The source of the bacteria appeared to be from livestock grazing. A 1.9 mile segment of Clark's Draw adjacent to U.S. Highway 191/189 was placed on the 303(d) list of impaired streams in 2012 (WDEQ, WQD, 2012).

4.1.4.4 SALT RIVER SUB-BASIN

The Salt River Sub-basin drains Star Valley and the surrounding mountains and is tributary to Palisades Reservoir. Salt River and the majority of its tributaries are classified as 2AB. There are no Class 1waters in this sub-basin.

Water quality monitoring in the Salt River Sub-basin has primarily focused on bacterial contamination. Sunrise Engineering, Inc., reported that Salt River near the Etna USGS gaging station was on the 2000 303(d) list of impaired streams due to fecal coliform bacteria contamination (Sunrise Engineering, Inc., 2002). In 2002, the lower reach of Salt River was placed on the 303(d) list as threatened because of fecal coliform contamination (Ashworth, 2012). This segment was listed in 2008 as impaired and not fully supporting contact recreation uses. This stream segment remained on the 303(d) list in 2010 and 2012 due to fecal coliform contamination.

Stump Creek, a tributary to Salt River, was also placed on the 303(d) list in 2008 for fecal coliform contamination and non-support of recreational uses (Ashworth, 2012). Stump Creek has the highest concentration of fecal coliform bacteria of any of the sampling sites in the sub-basin. Many sampling sites show some level of fecal coliform bacteria contamination and additional segments may be placed on future 303(d) lists.

There are also concerns about potential high selenium (Se) concentrations in Crow Creek, a tributary to Salt River. Phosphate mining at the Smoky Canyon Mine in Idaho has impacted surface and groundwater resources through selenium contamination (WDEQ, WQD, 2012). Crow Creek originates in Idaho within the phosphate mining district and flows into the Salt River in Wyoming. A grab sample taken in 2006 from Crow Creek at the Idaho/Wyoming boarder during spring runoff had a total recoverable selenium concentration greater than Wyoming's chronic criterion (WDEQ, WQD, 2012). However, samples taken by WDEQ, WQD in 2008 at the state-line and near Fairview, Wyoming had concentrations below the state's chronic selenium criterion of five micrograms per liter.

4.1.4.5 SURFACE WATER QUALITY SUMMARY

Much of the Snake/Salt River Basin is comprised of wildland consisting of forests, sagebrush steppes and grasslands. There are several federally designated wilderness areas within the basin. These wildland watersheds provide high quality surface water to the basin. Environmental and recreational land uses are important in the basin; therefore, considerable monitoring has been conducted to evaluate and help protect these high quality water resources. Most water quality problems identified in the basin result from human activities and management. Because the area for development is relatively small, human activities have been concentrated. This leads to potential impacts on streams and water quality such as loss of stream habitat due to sedimentation and channel alteration along with bacterial contamination.

4.2 GROUNDWATER RESOURCES

The Snake/Salt River Basin is situated in the northwestern portion of the State of Wyoming with adjacent portions of the drainage basin located in Idaho. Calculations show there are more than

32.5 million acre-feet of groundwater resources potentially available in the Snake/Salt River Basin. The abundance of groundwater resources in the basin is primarily a function of the high annual precipitation rate and the local hydrogeology.

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 in mountainous bedrock formations and Volcanic and Intrusive Formations. The steeper mountain uplifts and ridges are commonly cored by older Paleozoic and Mesozoic bedrock formations in the Overthrust Belt or cored by Precambrian basement bedrock formation uplifts, which are partially overlain and flanked by younger Paleozoic and Mesozoic 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 five major aquifer groups based on geologic time, associated lithologies, and the stratigraphic columns for the basin areas. Major aquifers, minor aquifers, marginal 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. A fifth unit: "Volcanic and Intrusive Formations" is also considered. Therefore, five major regional aquifer groups have been identified in the Snake/Salt River Basin. These five major aquifer groups are shown on Figure 4-2 by hydrogeologic unit, in descending geologic order:

- Volcanic and Intrusive Formations,
- Cenozoic aquifer group,
- Mesozoic aquifer group,
- Paleozoic aquifer group, and
- Precambrian aquifer group.

Volcanic and Intrusive Formations are a subset of the Cenozoic aquifer group. These igneous formations are of Middle Eocene age and younger.

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 (Cenozoic, Mesozoic, Paleozoic, and Precambrian). 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 Quaternary unconsolidated deposits, most of the Tertiary bedrock formations (Cenozoic aquifer group), and Volcanic and Intrusive Formations are relatively flat-lying and unconformably overlie the older, intensely deformed, Mesozoic and Paleozoic bedrock formations in the Snake/Salt River Basin. The contact between the relatively flat-lying geologic

units with the underlying formations is commonly an erosional and angular unconformity. 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 within these formations.

The most heavily used aquifer within the Snake/Salt River Basin consists of the Quaternary alluvial deposits located along the river and stream drainages and the associated Quaternary unconsolidated deposits. A second heavily used aquifer includes the Tertiary formations, especially the extensive valley-fill deposits including the Teewinot Formation and Salt Lake Formation. The Volcanic and Intrusive Formations are heavily used in the vicinity of Alta, Wyoming, on the western flank of the Teton Range.

Complex recharge-discharge interactions occur between the surface water and groundwater within some areas of the Snake/Salt 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 topographic elevations located along the Snake/Salt River Valley and associated tributary streams.

GRAND TETON NATIONAL PARK, HWY 191

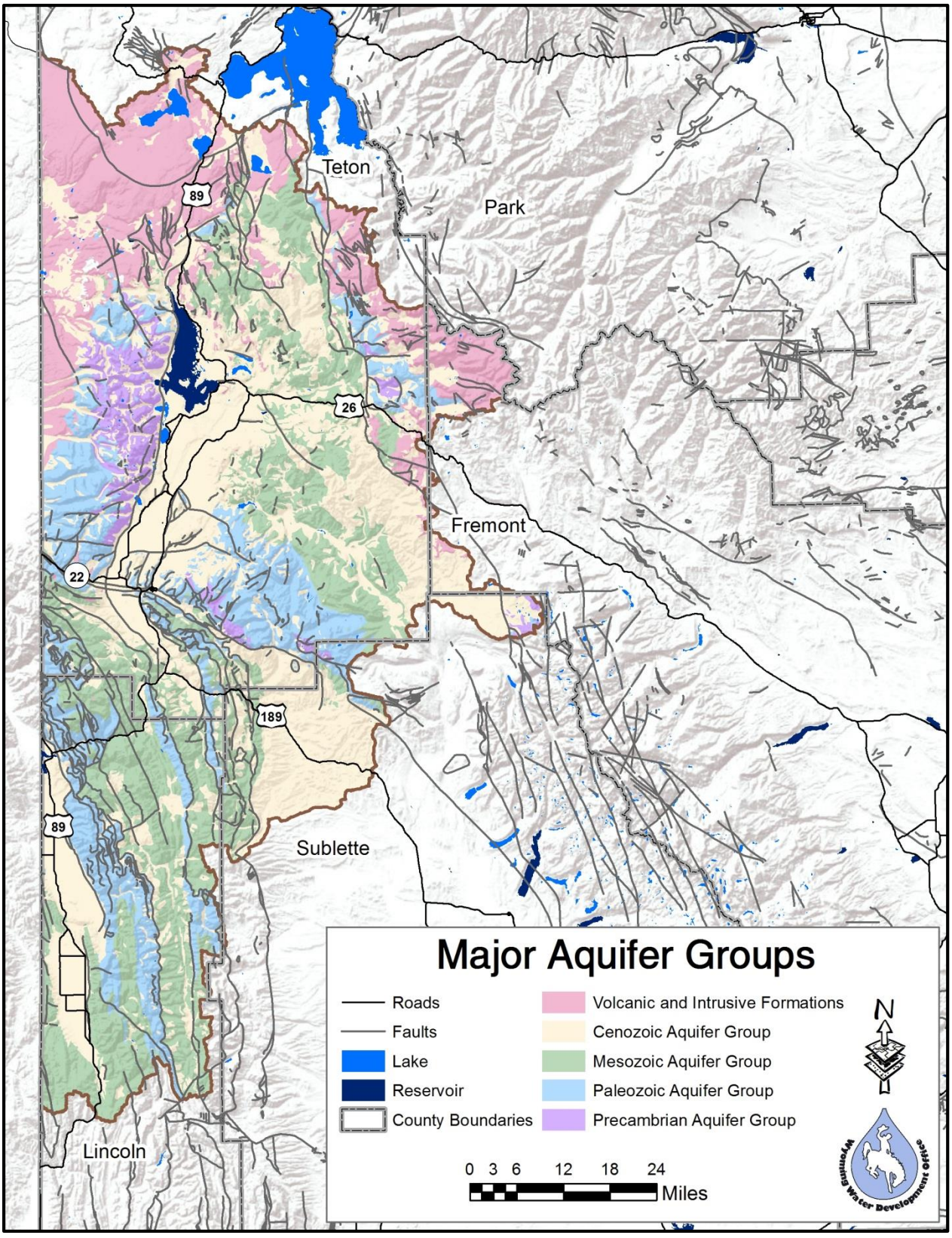

FIGURE 4-2: MAJOR AQUIFER GROUPS OF THE SNAKE/SALT RIVER BASIN

4.2.1 GROUNDWATER QUANTITY

Groundwater resources are generally available in abundance on most private land areas of the Snake/Salt River Basin. In order to calculate the amount of groundwater available in the bedrock aquifers (Mesozoic and Paleozoic aquifer groups) of the Snake/Salt River Basin, start with one-square mile section in the basin, and assume the ground surface is level and a useable aquifer extends down 1,000 feet. The surface area of the section is 27,878,400 square feet, and the volume is 27,878,400 square feet times 1,000 feet which equals 27,878,400,000 cubic feet (27.9 billion cubic feet). If the static water level ("water table" or groundwater surface) is assumed to be at 50 feet below the ground surface, the water saturation is 95 percent (950 feet) of the 1,000 feet deep section.

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

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-foot)

= 60,796 acre-feet per square mile in storage

If 60,796 acre-feet per square mile is used for groundwater contained in a 95 percent saturated aquifer (10 percent porosity) down to a depth of 1,000 feet (approximate depth limit for acceptable groundwater quality), and take the Mesozoic and Paleozoic mapped areas of the basin (combined total of approximately 2,000 square miles), the maximum volume of groundwater contained within these two major aquifer groups of the basin can be estimated as follows:

Groundwater of 60,796 acre-feet/square mile x 2,000 square miles

= 121, 592,000 acre-feet of groundwater in maximum aquifer storage

This maximum quantity of 121.6 million acre-feet includes both recoverable and non-recoverable groundwater in the Mesozoic and Paleozoic bedrock aquifers of the basin. 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 - the volume of groundwater that can be recovered by pumping a well per unit volume of that aquifer. If we assume an average specific yield for bedrock formations of approximately 18.5 percent [ranges from 12 to 27 percent (Johnson, 1967)], then the amount of water available to pumping wells can be calculated as follows:

121,592,000 acre-feet maximum groundwater volume x 18.5% specific yield

= 22,494,520 acre-feet of groundwater is available to pumping wells

Approximately 22.5 million acre-feet of groundwater is the total amount of groundwater available to wells constructed into Mesozoic and Paleozoic bedrock aquifers within the Snake/Salt River Basin. In addition, Hinckley Consulting (2003) estimated the available groundwater in useful storage in the 400-square mile area of the alluvial aquifer to be approximately 10 million acre-feet (Hinckley Consulting, 2003).

Based on these assumptions and calculations, more than 32.5 million acre-feet of groundwater may be available (recoverable) for development from wells constructed in the saturated alluvial aquifer and the saturated bedrock formations of the Snake/Salt River Basin of Wyoming. This very large estimated quantity of groundwater available in the bedrock formations greatly exceeds the current total use of groundwater within the basin.

An estimate of the total annual water recharge to the unconsolidated and bedrock aquifers of the entire Snake/Salt River Basin may range between one million and 1.5 million acre/feet (Hinckley Consulting, 2003). This is approximately the upper limit of sustainable groundwater development within the Snake/Salt River Basin per year.

4.2.2 GROUNDWATER QUALITY

The available groundwater resources are commonly of acceptable quality on most private land areas of the Snake/Salt River Basin. However, the quality of the groundwater available in the basin is widely variable and may range from very good to very poor. Groundwater quality generally depends on the geochemistry of the soils, sediments, and bedrock that water encounters while traveling to the aquifer and of the geochemistry of the aquifer host rock.

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 in earth materials (soils and rocks). Time is another factor affecting groundwater quality, because the longer water remains in contact with soluble chemicals, the higher the total dissolved solids within the water.

Generally, in the basin, shallow groundwater tends to be of the calcium-sulfate-type water chemistry and deeper groundwater tends to be sodium-bicarbonate-type or sodium-chloride-type. Groundwater in the Preuss Sandstone (as called the 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 rock salt (evaporite minerals) deposits contained within parts of the formation. The Wyoming State Engineer's Office Snake River Basin report noted the occurrence of salty springs located in the Gannett Hills associated with groundwater flowing through the Preuss Sandstone (WSEO, 1972).

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5.0 CURRENT USE

5.0 CURRENT USE

TABLE OF CONTENTS

5.1 Agricultural Water Use 49
5.1.1 Agricultural Water Use Methodology....49
5.1.2 Irrigation Zones....50
5.1.3 Irrigation Acreage 52
5.1.4 Irrigated Crops....52
5.1.5 Climate Data....54
5.1.6 Crop Irrigation Requirements (CIR) 56
5.1.6.1 Consumptive Use (CU) 57
5.1.6.2 Effective Precipitation (Re) 58
5.1.6.3 Crop Irrigation Requirements Results 59
5.1.6.4 Irrigation Days 61
5.1.7 Irrigation Diversions and Depletions 61
5.1.7.1 Full-Supply Diversions for the Spreadsheet Models....64
5.1.7.2 Supply-Limited Diversions Predicted by the Spreadsheet Models....64
5.1.8 Livestock 65
5.1.8.1 Current and Historic Livestock Inventory....65
5.1.8.2 Livestock Consumptive Water Use 71
5.2 Municipal and Domestic Water Use....71
5.3 Industrial Water Use....73
5.4 Environmental and Recreational Water Use....74
5.4.1 Environmental and Recreational Water Use Analysis 74
5.4.1.1 Geographical Information System (GIS) Sources....76
5.4.1.2 Procedures Unique to the Snake/Salt River Basin 76
5.4.2 Environmental and Recreational Water Use Analysis Results 84
5.4.2.1 Summary Tables and Sample Maps 84
5.4.2.2 Use Classification Analysis Results 90
5.5 Reservoir Evaporation....92
5.6 Summary of Current Water Use 94
5.6.1 Comparison to Previous Basin Plan....95
References 96

5.0 CURRENT WATER USE

This chapter presents an inventory of water use in the Snake/Salt River Basin. The purpose of this chapter is to provide the necessary understanding of the location, source and quantity of current water use. This existing water use profile is the basis for subsequent water use evaluations in the report.

Water use includes both consumptive and nonconsumptive uses. Consumptive uses are generally agricultural, municipal and domestic, industrial and reservoir evaporation. Environmental and recreational uses are generally considered nonconsumptive uses. All uses are described in the following sections and consumptive uses are quantified.

5.1 AGRICULTURAL WATER USE

The agricultural sector consumes more water than any other use sector in the Snake/Salt River Basin. Agricultural uses mainly consist of crop irrigation by either flood or sprinkler application methods and livestock water use. The vast majority of agricultural water use is diverted from surface water sources.

5.1.1 AGRICULTURAL WATER USE METHODOLOGY

The following sections describe the methodology used to determine crop water requirements as part of the 2012 Update. Irrigation zones (or climate zones) created for this analysis are discussed, along with associated cropping patterns and climatic data. Additionally, an overview of irrigated acres is presented, followed by a description of irrigation days. An estimation of diversion data used as input to the spreadsheet models and a summary of the agricultural depletions are also provided.

The methodology and data used for the previous Snake/Salt River Basin Plan in 2003 were reviewed to determine whether they could be implemented for this analysis (Sunrise Engineering, Inc., 2003). With the exception of additional acreage added to account for actively irrigated lands within the Greys River Sub-basin, the tallies of irrigated acreages developed for the previous Basin Plan were found to be satisfactory for this update. Irrigation days established for the 2003 Basin Plan were also determined to be satisfactory. However, a departure involved use of a different methodology to estimate crop irrigation requirements. StateCU was used for this study. StateCU is a public domain model developed by the State of Colorado as part of Colorado's Decision Support System tools (State of Colorado, 2011).

Objectives of this Update, with regards to crop water requirements and the new study period of 1971 through 2010, involved the following:

- Gather, review and update information from the previous Basin Plan related to mapping and quantification of irrigated acreage and association to demand nodes in the spreadsheet models.
- Establish new irrigation zones that serve as a basis for obtaining representative climatic data.

- Confirm cropping patterns within each irrigation zone.
- Gather climatic data required for use in the StateCU model based on the irrigation zones.
- Prepare required input files for use in the StateCU model and execute the model to determine crop irrigation requirements.
- Compile results into full-supply diversion data that can be used as input to the spreadsheet models.

5.1.2 IRRIGATION ZONES

For calculating crop water requirements, the 2003 Basin Plan utilized the following five irrigation zones that corresponded to sub-basins and climate stations located within or near each sub-basin:

- Upper Snake
- Lower Snake
- Upper Salt
- Lower Salt
- Teton

This previous delineation of irrigation zones was examined with respect to the planned methodology for acquiring updated climatic data. The climate stations used in the previous Basin Plan were found to be somewhat limited in terms of available data and proximity to irrigated lands. Rather than acquiring data from these climate stations again, a new approach was taken that involved accessing data-sets from the PRISM (Parameter-elevation Regressions on Independent Slopes Model) climate mapping system (Oregon State University, 2010). For information on PRISM and the techniques used to gather climate data for this study, refer to *Technical Memorandum, Tab VII: Crop Water Requirements.*

Since PRISM is a gridded data-set, data could be gathered for any point on the ground without regard to the nearest climate station location. Therefore, two additional irrigation zones were able to be established for the 2012 Update, which represent the irrigated lands within the Hoback River Sub-basin and the Greys River Sub-basin. These new zones were established so the unique locations and elevations of these lands could be better represented in terms of climatic data.

Temperature, precipitation and growing season data were collected using the PRISM data-sets for the following seven irrigation zones and corresponding irrigated lands established as part of this study and as shown on Figure 5-1:

- Zone 1: Teton
- Zone 2: Upper Snake
- Zone 3: Lower Snake
- Zone 4: Hoback
- Zone 5: Lower Salt
- Zone 6: Upper Salt
- Zone 7: Greys

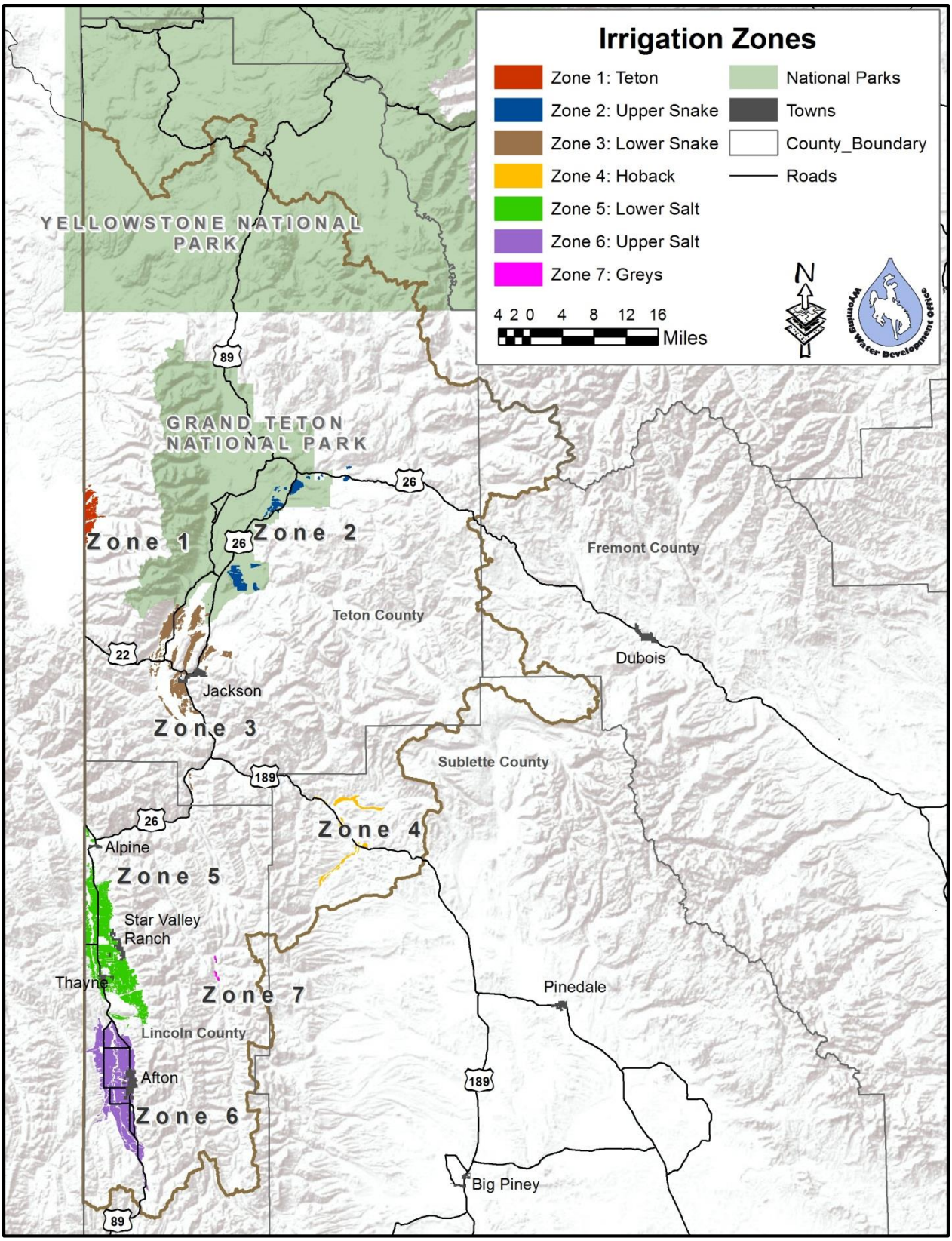


FIGURE 5-1: SNAKE/SALT RIVER BASIN IRRIGATION ZONES

5.1.3 IRRIGATION ACREAGE

The final quantification of irrigated lands is presented in Table 5-1. The table shows the irrigated lands by sub-basin and tallies the lands by the new irrigation zones established for this analysis. With the exception of the Teton Sub-basin, which was not analyzed in the spreadsheet models, these acreages correspond with those used in the analysis of crop water requirements and subsequent input to the spreadsheet models. Refer to *Technical Memorandum, Tab VI: Irrigated Acreage* for further information on the quantification of irrigated lands for this study.

TABLE 5-1: IRRIGATED ACRES FOR THE 2012 SNAKE/SALT RIVER BASIN UPDATE

Description		2012 Acres
Sub-basin	Salt (excluding Greys Sub-basin)	65,190
	Snake (including Hoback Sub-basin)	28,963
	Teton	4,647
	Greys	229
	Total	***99,029***
Irrigation Zone	Zone 1: Teton	4,647
	Zone 2: Upper Snake	6,967
	Zone 3: Lower Snake	18,017
	Zone 4: Hoback	3,979
	Zone 5: Lower Salt	33,810
	Zone 6: Upper Salt	31,380
	Zone 7: Greys	229
	Total	***99,029***

5.1.4 IRRIGATED CROPS

Crops grown in the Snake/Salt River Basin are greatly influenced by climate. Typical farmland in the basin is located in the high mountain valleys with low to moderate precipitation. These valleys have short growing seasons and long winters with significant accumulations of snow. Hard frosts have been observed in every month of the year. Because of these conditions, typical crops consist of alfalfa, small grains (mainly barley with some oats), and native hay and grass.

As part of this Update, cropping patterns were reexamined to ascertain any changes from the previous Basin Plan. Information was solicited from various state hydrographers within the Snake/Salt River Basin to confirm the distribution of crops grown in each of the irrigation zones. The estimates obtained were based on their knowledge of the area and of crops grown by various producers. Given the hydrographers' responses, cropping mixes assumed for this study were similar to those used in the previous Basin Plan and consisted of alfalfa, small grains, grass pasture and mountain meadow hay. The distinction between grass pasture and mountain meadow hay is based on the method of irrigation, with grass pasture being sprinkler irrigated and mountain meadow hay being flood irrigated. It is important to note that in some locations, crops are rotated between alfalfa and small grains, and that the acreage of each crop will vary somewhat each season.

Resulting distribution of crops by irrigation zone is presented in Table 5-2. A visual depiction of the cropping patterns is shown on Figure 5-2. Note that for the purpose of relating these crops to cropping coefficients, mountain meadow hay was simulated as "Grass Pasture TR-21" in the StateCU model, and grain was simulated as "Spring Grain TR-21."

TABLE 5-2: CROP DISTRIBUTION BY IRRIGATION ZONE

Irrigation Zone	Alfalfa	Grain[1]	Grass Pasture[2]	Mtn. Meadow Hay[3]
Zone 1: Teton	40%	30%	30%	--
Zone 2: Upper Snake	--	--	--	100%
Zone 3: Lower Snake	--	--	2%	98%
Zone 4: Hoback	--	--	--	100%
Zone 5: Lower Salt	58%	25%	12%	5%
Zone 6: Upper Salt	50%	18%	24%	8%
Zone 7: Greys	--	--	--	100%

1. Grain simulated as Spring Grain TR-21 in StateCU model.
2. Grass pasture is sprinkler irrigated.
3. Mountain meadow hay is flood irrigated; simulated as Grass Pasture TR-21 in StateCU model.

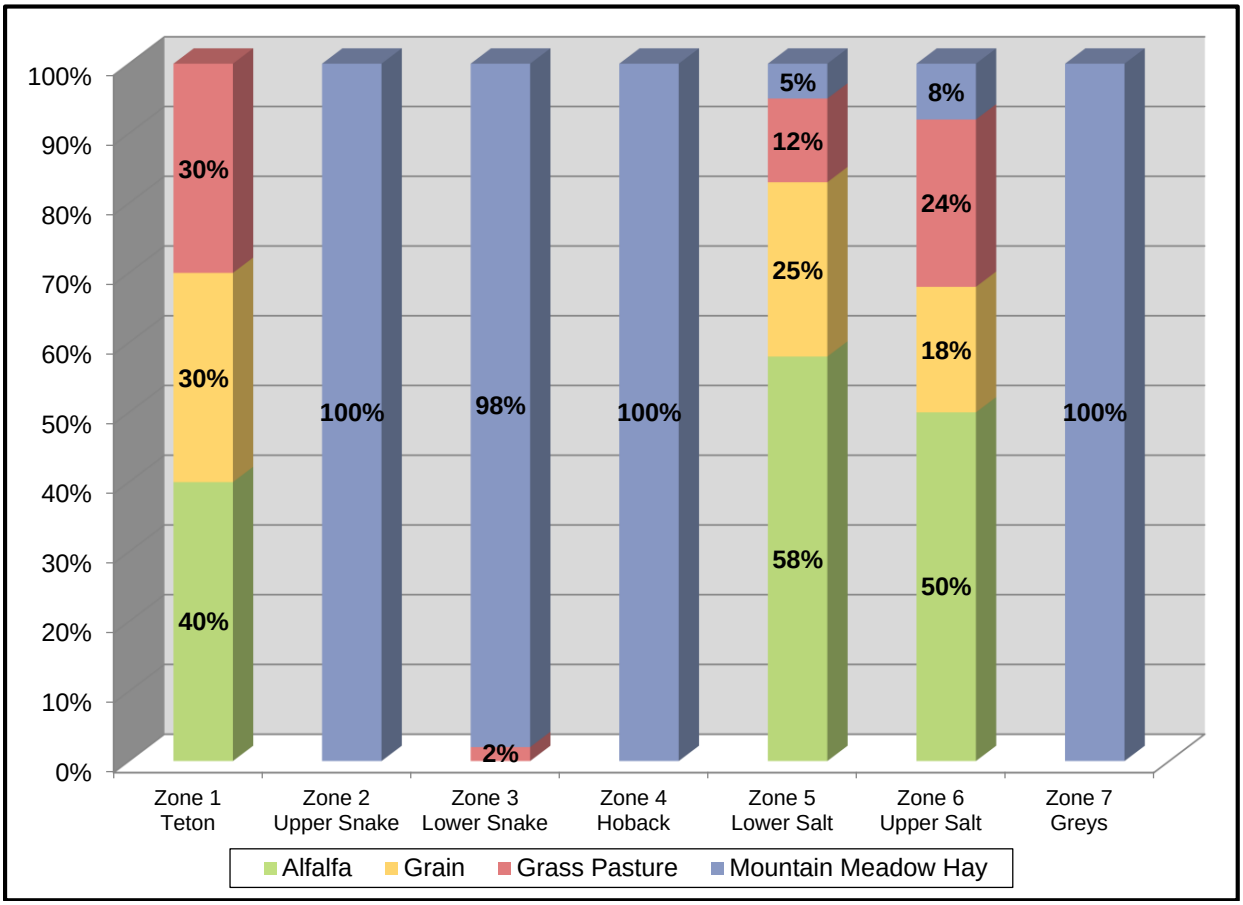


FIGURE 5-2: CROP DISTRIBUTION BY IRRIGATION ZONE

5.1.5 CLIMATE DATA

This section presents a summary of the climate data collected for the 2012 Update in terms of the requirements of StateCU. Climate data were obtained for each irrigation zone from the PRISM data-sets as described in *Technical Memorandum, Tab XVI: Climate*.

Climate requirements, for the StateCU model with the study period of 1971 through 2010, consisted of monthly average temperature and precipitation data for each irrigation zone. Additionally, frost dates were required for each irrigation zone. These frost dates specify the beginning and end of each growing season, and each crop can be assigned one of these conditions within the model. The growing season for alfalfa begins on the last spring 28 degree F. day and ends on the first fall 28 degree F. day, while spring grain ends its growing season on the first fall 32 degree F. day.

The modified Blaney-Criddle formula was chosen for the consumptive use analysis, and percent daylight is required for this formula. Percent daylight data are hard-coded within the StateCU program. The values used in the model's calculations are based on the average latitude of each irrigation zone input by the user. The average latitude is presented in Table 5-3 for each irrigation zone. This table also shows the average elevation of each zone, which is an additional StateCU model required input. These average latitudes and elevations were extracted from GIS irrigated lands mapping.

TABLE 5-3: AVERAGE LATITUDE AND ELEVATION OF IRRIGATION ZONES

Irrigation Zone	Average Latitude (Decimal Degrees)	Average Elevation (feet)
Zone 1: Teton	43.76	6509.19
Zone 2: Upper Snake	43.76	6745.41
Zone 3: Lower Snake	43.48	6194.23
Zone 4: Hoback	43.19	6860.24
Zone 5: Lower Salt	42.97	6069.55
Zone 6: Upper Salt	42.73	6250.00
Zone 7: Greys	42.94	6560.00

Figures 5-3 and 5-4 illustrate the average monthly temperature and precipitation data, respectively. These data were obtained from the PRISM data-sets for each irrigation zone within the study period (1971 – 2010). Figure 5-5 illustrates the growing season for each irrigation zone by showing the average historic frost dates, including the last spring 28 and 32 degree F. dates and the first fall 32 and 28 degree F. dates. The wide bands represent the last and first 28 degree F. dates, while the narrow bands (darker bands) represent the last and first 32 degree F. dates.

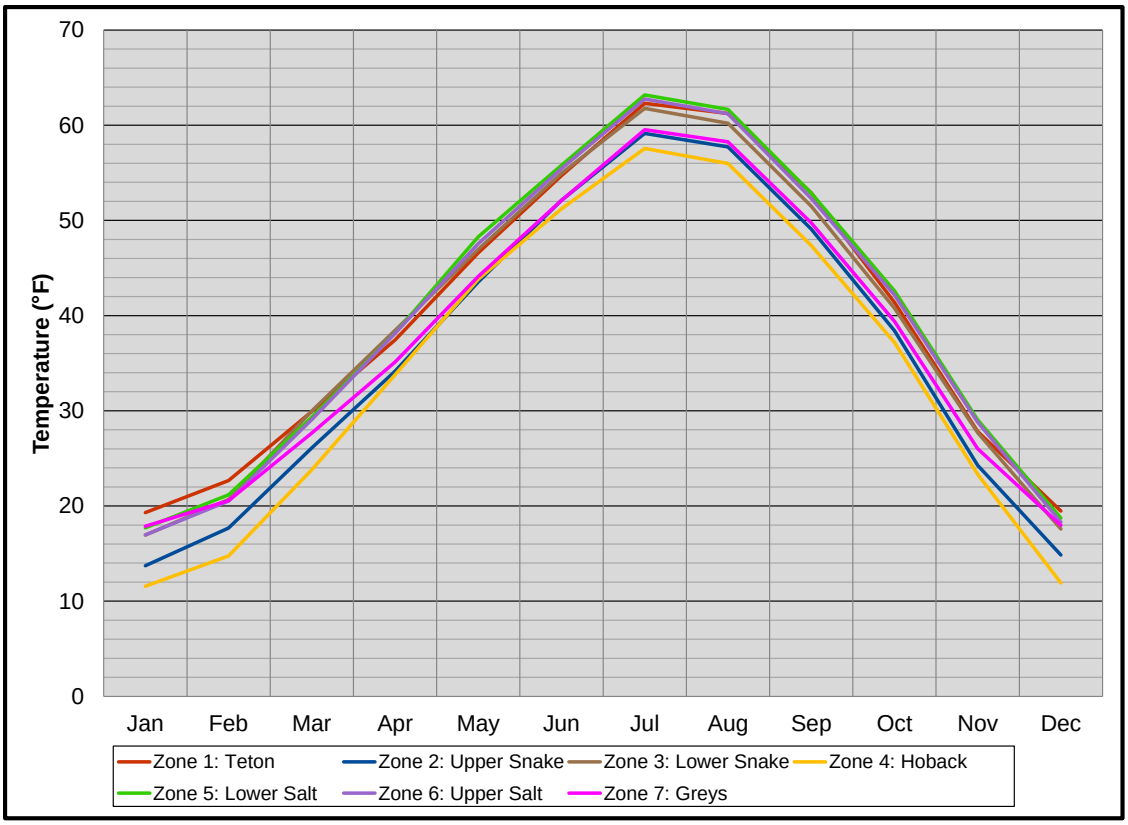


FIGURE 5-3: AVERAGE MONTHLY TEMPERATURES BY IRRIGATION ZONE

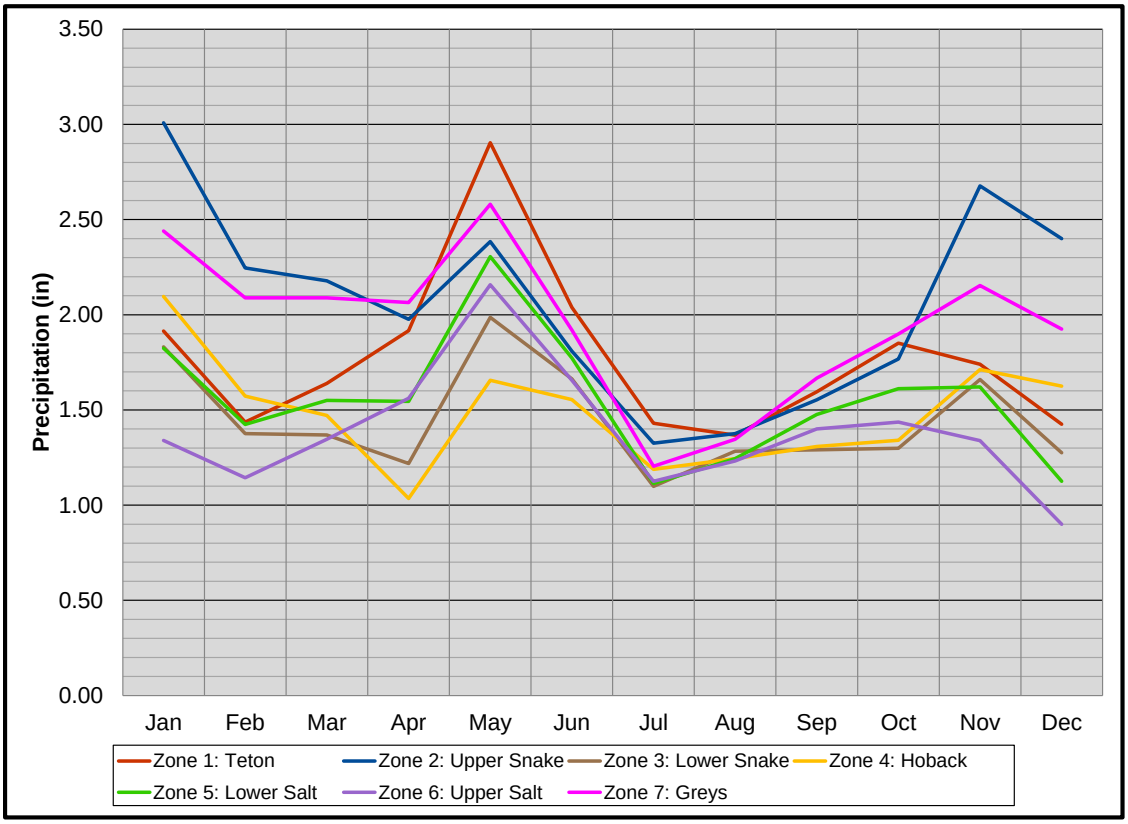


FIGURE 5-4: AVERAGE MONTHLY PRECIPITATION BY IRRIGATION ZONE

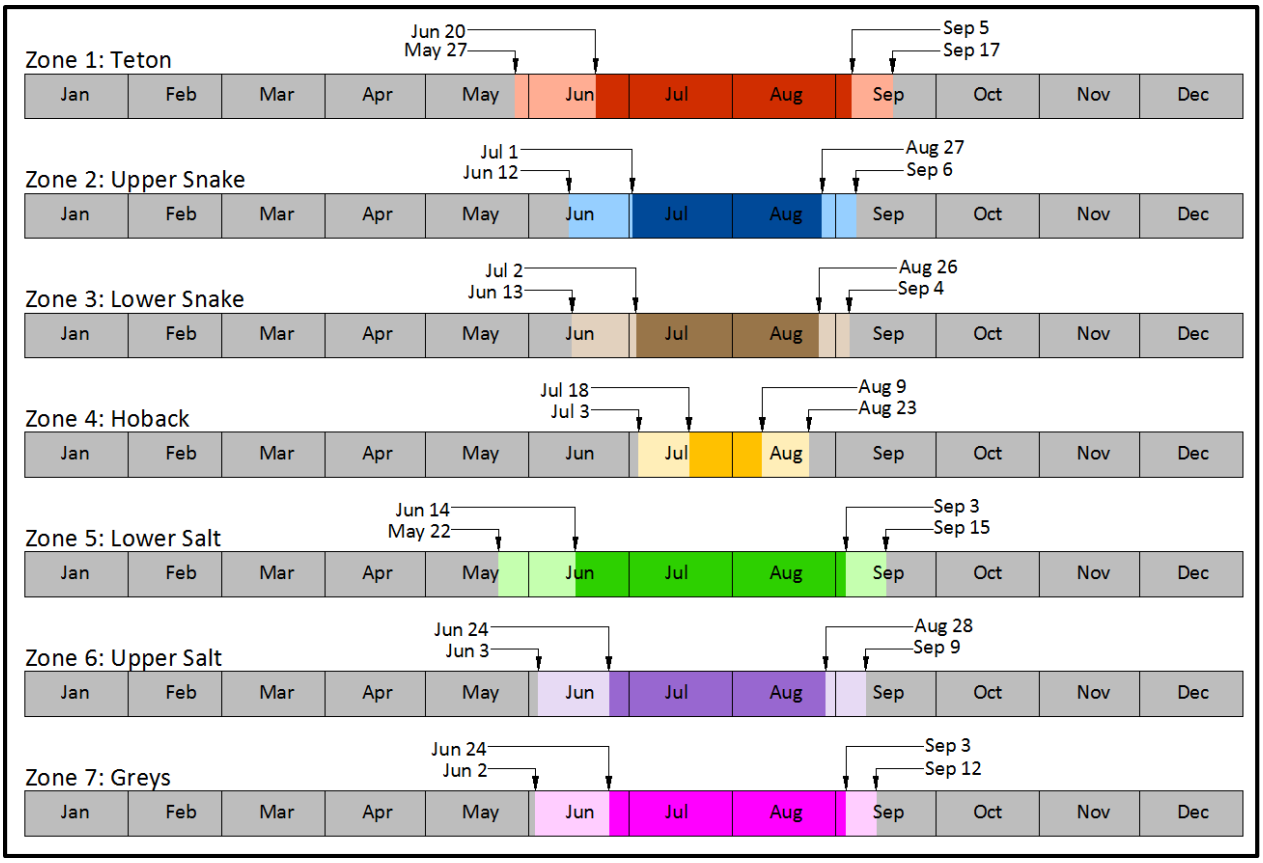


FIGURE 5-5: AVERAGE HISTORIC 28 AND 32 DEGREE F. FROST DATES BY IRRIGATION ZONE

5.1.6 CROP IRRIGATION REQUIREMENTS (CIR)

Crop irrigation requirement (CIR) (also called irrigation water requirement [IWR]) is the amount of water required from surface or groundwater diversions to meet crop consumptive needs. It is calculated as crop consumptive use (CU) minus the amount of water contributed by precipitation during the growing season (effective precipitation) as presented in Equation 5-1:

EQUATION 5-1

$$CIR = CU - Re$$

where,
CIR = crop irrigation requirement
CU = crop consumptive use (or crop evapotranspiration)
Re = effective precipitation

In the previous Basin Plan, CIR data were obtained from the publication, *Consumptive Use and Consumptive Irrigation Requirements in Wyoming* (Pochop, 1992). CIR values in Pochop's 1992 publication were based on climatic data within a study period that ended in 1990. However, the study period for the 2012 Update extends through 2010. Therefore, in order to derive CIR estimates based on climatic data that represented the entire study period, this analysis departed from the use of Pochop's 1992 data and instead, generated new CIR estimates using the StateCU program.

The StateCU program can use diversion data, irrigated acreage and crop types to estimate the amount of water consumptively used by a crop (State of Colorado, 2008).

StateCU allows several levels of analysis, including the following:

- Crop Irrigation Water Requirement by CU Location (a "*Climate Station Scenario"*)
- Water Supply Limited Crop Consumptive Use by Structure (a "*Structure Scenario"*)

Within StateCU, a "*Climate Station Scenario*" calculates crop consumptive use and irrigation water requirements based on user inputs primarily consisting of climatic and crop type data. A "*Structure Scenario*" within StateCU offers a more complex level of analysis, requiring historic diversion data as input. Since comprehensive diversion data are not available within the Snake/Salt River Basin, a Climate Station Scenario was used for this study.

A total of seven "*CU Locations*" were defined for the Climate Station Scenario, each corresponding to one of the seven irrigation zones. For each CU Location, StateCU output consisted of monthly consumptive use values (CU), effective precipitation (Re) and crop irrigation requirement (CIR) through every year in the study period of 1971 through 2010.

The previous Basin Plan determined CIR values for three hydrologic conditions: dry, average and wet years. For this study, only a single set of values was determined, which corresponds to monthly CIR values averaged across the entire study period. This set of CIR values was used to derive the full-supply diversion data for input to all three of the spreadsheet models. The elimination of the dry, average and wet year CIR classifications for this study was based on rationale developed during the 2010 Wind/Bighorn River Basin Plan Update which stated the following (MWH Americas, Inc., 2010).

> *As with the previous Basin Plan, because climatic dry, average and wet periods in summer months during irrigation are often different than the dry, average and wet periods in the winter that produce runoff, the average CIR was used in the hydrologic model for years in all three hydrologic conditions. This assumption should be reasonable as the hydrologic year designations used for the hydrologic components of the model are based on streamflow, which typically depends on winter moisture, whereas crop irrigation requirements are dependent upon summer temperature and moisture, which may not correlate directly with winter precipitation.*

5.1.6.1 CONSUMPTIVE USE (CU)

Consumptive use (also called evapotranspiration [ET]) is defined as the total amount of water that would be used for crop growth if provided with an ample water supply. Monthly evapotranspiration was estimated within the StateCU model using the Soil Conservation Service (SCS) TR-21 modified Blaney-Criddle method described by the Equation 5-2 (Soil Conservation Service, 1970):

EQUATION 5-2

$$ET = Kc * Kt\left(t + \frac{P}{100}\right)$$

where,
ET = evapotranspiration (or monthly consumptive use) (inches)
Kc = monthly crop growth stage coefficient
Kt = climatic coefficient: 0.0173t – 0.314
t = mean monthly temperature (°F)
P = monthly percentage of annual daylight hours

The modified Blaney-Criddle approach to determine crop evapotranspiration is widely used due to its limited climate data requirements. The modified Blaney-Criddle only requires average monthly temperature, whereas other methods may require daily parameters such as temperature, precipitation, wind speed, vapor pressure and solar radiation.

Mean monthly temperature data were obtained from the PRISM data-sets as described in Section 5.1.5. The crop coefficients (Kc) used in this analysis are described and presented *Technical Memorandum, Tab VII: Crop Water Requirements.* Values for the monthly percentage of annual daylight hours are calculated within the StateCU model based on the average latitude of each CU Location, or in this case, irrigation zone. (Refer to Table 5-3.)

5.1.6.2 EFFECTIVE PRECIPITATION (RE)

In order to determine the amount of irrigation water the crop actually needs, it is important to estimate the portion of monthly precipitation the plants can directly use. Effective precipitation is that portion of total precipitation that satisfies or reduces crop CU requirements. The remaining rainfall is lost either to deep percolation below the root zone, surface runoff, or direct evaporation of water intercepted by the plant foliage. This lost rainfall is not considered effective in reducing the CU requirements. Therefore, rainfall that can be effectively used by the crop is dependent upon the amount, timing and rainfall intensity, soil permeability, soil water-holding capacity, runoff characteristics and the rate of crop evapotranspiration.

Effective precipitation (Re) was estimated within the StateCU model by employing the widely used United States Department of Agriculture (USDA)-SCS technique described by Equation 5-3:

EQUATION 5-3

$$Re = \left(0.7091 * Rt^{0.82416} - 0.11556\right) * \left(10^{(0.02426 * CU)}\right) * F$$

where,
Re = monthly effective precipitation (inches)
Rt = monthly total precipitation (inches)
CU = monthly crop consumptive use (inches)
$F = 0.531747 + 0.295164D - 0.057697D^2 + 0.003804D^3$
where,
D = normal depth of application, assumed to be 3.0 inches

5.1.6.3 CROP IRRIGATION REQUIREMENTS RESULTS

Results from the StateCU model are presented in this section as monthly averages over the study period. Figure 5-6 displays the monthly crop irrigation requirements for each irrigation zone. Table 5-4 summarizes the monthly consumptive use (CU), effective precipitation (Re) and crop irrigation requirement (CIR) by irrigation zone. For a comparison of these results to those reported in the previous Basin Plan, refer to *Technical Memorandum, Tab VII: Crop Water Requirements.*

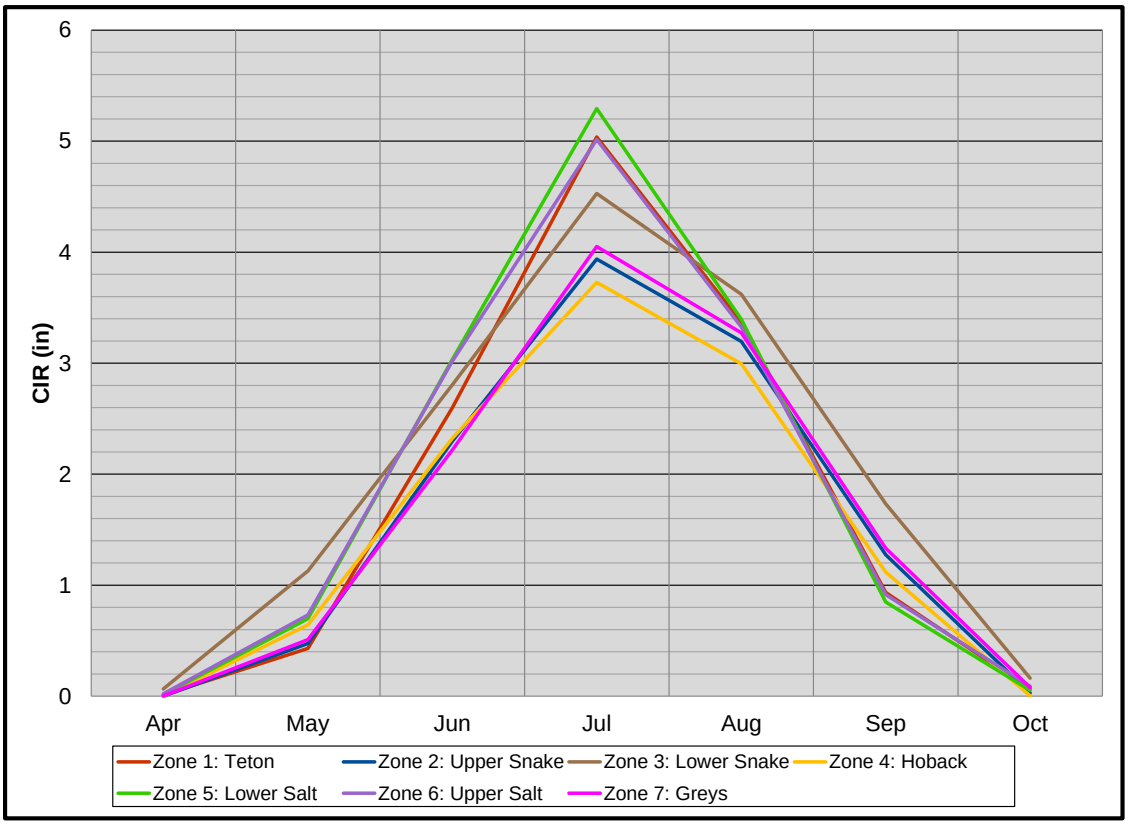


FIGURE 5-6: MONTHLY CROP IRRIGATION REQUIREMENTS BY IRRIGATION ZONE

TABLE 5-4: CONSUMPTIVE USE (CU), EFFECTIVE PRECIPITATION (RE), AND CROP IRRIGATION REQUIREMENTS (CIR) BY IRRIGATION ZONE

Month	Zone 1: Teton			Zone 2: Upper Snake			Zone 3: Lower Snake			Zone 4: Hoback		
	CU (in)	Re (in)	CIR (in)	CU (in)	Re (in)	CIR (in)	CU (in)	Re (in)	CIR (in)	CU (in)	Re (in)	CIR (in)
Apr	0.02	0.01	0.01	0.00	0.00	0.00	0.10	0.03	0.06	0.00	0.00	0.00
May	1.15	0.72	0.43	1.05	0.58	0.47	2.07	0.94	1.13	1.06	0.42	0.64
Jun	3.96	1.36	2.60	3.53	1.23	2.30	3.97	1.17	2.80	3.36	1.04	2.32
Jul	6.17	1.13	5.04	4.91	0.98	3.94	5.37	0.84	4.53	4.60	0.87	3.73
Aug	4.35	0.98	3.37	4.19	1.00	3.20	4.57	0.95	3.62	3.89	0.89	2.99
Sep	1.55	0.62	0.93	2.10	0.82	1.27	2.55	0.81	1.73	1.70	0.58	1.12
Oct	0.13	0.07	0.06	0.06	0.03	0.03	0.27	0.11	0.16	0.01	0.00	0.00
Season	***17.33***	***4.89***	***12.44***	***15.84***	***4.63***	***11.21***	***18.90***	***4.86***	***14.04***	***14.62***	***3.81***	***10.81***

(cont'd)

Month	Zone 5: Lower Salt			Zone 6: Upper Salt			Zone 7: Greys			Monthly Total		
	CU (in)	Re (in)	CIR (in)	CU (in)	Re (in)	CIR (in)	CU (in)	Re (in)	CIR (in)	CU (in)	Re (in)	CIR (in)
Apr	0.03	0.01	0.01	0.03	0.01	0.02	0.00	0.00	0.00	0.18	0.07	0.11
May	1.39	0.69	0.70	1.37	0.64	0.73	1.17	0.66	0.51	9.26	4.65	4.62
Jun	4.28	1.25	3.03	4.17	1.15	3.02	3.49	1.27	2.22	26.76	8.47	18.29
Jul	6.19	0.89	5.29	5.89	0.88	5.02	4.95	0.90	4.05	38.08	6.49	31.59
Aug	4.29	0.90	3.40	4.20	0.87	3.33	4.25	0.98	3.27	29.74	6.57	23.17
Sep	1.37	0.52	0.85	1.43	0.52	0.91	2.24	0.91	1.33	12.95	4.79	8.16
Oct	0.11	0.05	0.05	0.15	0.06	0.09	0.13	0.05	0.08	0.86	0.38	0.48
Season	***17.66***	***4.32***	***13.33***	***17.25***	***4.13***	***13.11***	***16.23***	***4.77***	***11.46***	***117.83***	***31.41***	***86.42***

5.1.6.4 IRRIGATION DAYS

By estimating the number of days in which irrigation takes place in the basin, the effects of being short of water in a particular sub-basin are taken into account. Additionally, the time period when irrigation is stopped to harvest crops is counted. Fields under flood irrigation must have the water shut off for a number of days in order to let the ground dry for harvest. Areas under sprinkler irrigation do not require as many days for the ground to dry. They also experience very little down time because the sprinklers may be back on one side of the field before the harvest is completed on the other.

In the previous Basin Plan, the number of days in which crops were irrigated was determined for each sub-basin. The main source of data for irrigation days was conversations with various state hydrographers. Data for the number of irrigation days from the previous Basin Plan were reviewed and determined to be satisfactory for use in the 2012 Update analysis.

Irrigation days used in calculations to determine the fraction of months irrigated for the seven irrigation zones are fully described and presented in *Technical Memorandum, Tab VII: Crop Water Requirements.*

5.1.7 IRRIGATION DIVERSIONS AND DEPLETIONS

Because actual diversion records were unavailable for the Snake/Salt River Basin, the spreadsheet models simulate depletions. Depletions are the consumptive portion of stream diversions. The models treat depletion quantities as if they were the diverted amount, and for consistency with other basin spreadsheets, this document refers to this information as "diversion data" or "full-supply diversions" although it is a depletion or consumptive use quantity.

"Supply-limited consumptive use" or "supply-limited diversions," which can also be considered a depletion quantity, is ultimately determined in the spreadsheet models. Supply-limited consumptive use implies the crop does not receive a full supply of water. Subject to available water supply, supply-limited consumptive use may be less than the full-supply diversion amounts requested in the spreadsheet models. (Refer to Section 5.1.7.2.)

Agricultural irrigation depletions, which are synonymous with diversion quantities input to the Snake/Salt River Basin spreadsheet models, consist of the water supplied by artificial means that is consumed by irrigated crops. This is water required by the plants beyond natural precipitation. As depicted in Equation 5-4, the determination of irrigation depletions consisted of taking the monthly CIR for each irrigation zone (weighted by crop type) and multiplying that value by the number of irrigated acres. This monthly result was then adjusted based on the number of days irrigated for each month, resulting in the irrigation depletion, or in the case for input to the Snake/Salt River Basin spreadsheet models, full-supply diversions.

EQUATION 5-4

$$Diversion = CIR * Acres * Fraction$$

where,
Diversion = irrigation depletion quantity (acre-feet per month)
CIR = crop irrigation requirement (feet per month)
Areas = number of irrigated acres
Fraction = fraction of month irrigated = irrigation days / days in month

Resulting irrigation depletions (or full-supply diversions within the spreadsheet models) for each irrigation zone are summarized in Table 5-5. As indicated in the table, the total annual irrigation depletion equates to 84,671 acre-feet for the basin. This constitutes a reduction of approximately 18,000 acre-feet from the previous Basin Plan.

This reduction in CIR values from the previous Basin Plan is most evident in the Upper Snake, Lower Snake, Hoback and Greys irrigation zones. This reduction can most likely be attributed to the different methodologies used to estimate CIR, updated climatic data, and the changes made to the delineation of irrigation zones for the this Update. In the previous Basin Plan, irrigated lands within the Hoback River Sub-basin were assumed to have the same climatic data that were gathered for the Lower Snake River Sub-basin, and irrigated lands within the Greys Sub-basin were not analyzed. The Hoback and Greys River Sub-basins were treated as individual irrigation (climate) zones for the 2012 Update. Separate climatic data were gathered for each of these sub-basins, which resulted in a more realistic CIR estimation, better representing the increased precipitation and shorter growing seasons that occur in the higher elevations. Further discussion and comparison of these results to those reported in the previous Basin Plan are presented in *Technical Memorandum, Tab VII: Crop Water Requirements, Appendix B.*

TYPICAL IRRIGATION DIVERSION STRUCTURE

TABLE 5-5: IRRIGATION DEPLETIONS BY IRRIGATION ZONE (ACRE-FEET)

Irrigation Zone	2012 Acres	April	May	June	July	August	September	October	2012 Total
Zone 1: Teton[1]	4,647	0	0	1,006	1,951	841	109	2	3,908
Zone 2: Upper Snake	6,967	0	222	1,333	1,917	1,556	494	8	5,531
Zone 3: Lower Snake	18,017	0	1,367	4,211	5,703	4,560	1,735	118	17,694
Zone 4: Hoback	3,979	0	172	771	1,037	833	247	1	3,060
Zone 5: Lower Salt	33,810	0	761	8,548	12,025	5,863	638	24	27,860
Zone 6: Upper Salt	31,380	9	1,358	7,890	10,576	5,330	1,196	74	26,434
Zone 7: Greys	229	0	8	42	65	52	17	1	185
Total	***99,029***	***9***	***3,888***	***23,801***	***33,274***	***19,035***	***4,435***	***228***	***84,671***

Note: Irrigation depletions represented in this table are synonymous with the full-supply diversion quantities input to the spreadsheet models. The values in the table, however, do not represent supply-limited depletions, which are ultimately determined by the spreadsheet models for dry, average, and wet hydrologic conditions. (Refer to Section 5.1.7.2.)
1. Note that the Teton River Sub-Basin was not represented in the spreadsheet models.

5.1.7.1 FULL-SUPPLY DIVERSIONS FOR THE SPREADSHEET MODELS

Equation 5-4 was applied to each model node to generate the diversion data for entry into the spreadsheet models. As presented in *Technical Memorandum, Tab VI: Irrigated Acreage*, every model node was associated with an acreage it represents. Each node was also associated to an irrigation zone, which relates it to a cropping pattern, crop irrigation requirements and number of irrigation days. Calculations to obtain diversion quantities for each model node were performed in the hydrologic database as described in *Technical Memorandum, Tab IX: Spreadsheet Models and Hydrologic Database*.

As within the previous Basin Plan, the Teton River Sub-basin was not analyzed within a spreadsheet model and no model nodes exist. Flows within the Teton Sub-basin are not hydraulically connected to flows in the mainstem of the Snake or Salt Rivers in Wyoming. Additionally, the Teton River Sub-basin area is relatively small when compared to the Snake and Salt River Basins; water resources planning and management issues are less complex; and therefore, development of a spreadsheet model for this sub-basin was not warranted. However, crop water requirements and depletions for the Teton River Sub-basin have been determined and are presented within this report.

Technical Memorandum, Tab VII: Crop Water Requirements presents diversion data used as input to the Snake and Salt River Basins spreadsheet models. This study did not separate the crop water requirement calculations into dry, average and wet year hydrologic conditions. Consequently, the same diversion data were used in dry, average and wet year spreadsheet models.

5.1.7.2 SUPPLY-LIMITED DIVERSIONS PREDICTED BY THE SPREADSHEET MODELS

The spreadsheet models predicted that full-supply diversions were met for each hydrologic condition within the Snake River Basin. In other words, the supply-limited diversions were equal to the requested full-supply diversions for the dry, average and wet year simulations. In the Salt River Basin models, the dry year spreadsheet model indicated shortages in the Dry Creek and Toms Creek tributary reaches. Dry year irrigation diversions on Dry Creek requested 2,865 AFY but were only supplied 2,627AFY, resulting in an annual shortage of 238 AF. In Toms Creek, irrigation diversions requested 1,005 AFY but were only supplied 884 AFY, resulting in an annual shortage of 120 AF.

Results of the average year spreadsheet model for the Salt River Basin indicated a shortage in Toms Creek where irrigation diversions requested 1,005AFY but were only supplied 989 AFY, yielding an annual shortage of 16 AF. The supply-limited diversions from the spreadsheet models are summarized in Table 5-6.

TABLE 5-6: SUPPLY-LIMITED DIVERSIONS PREDICTED BY THE SPREADSHEET MODELS

Spreadsheet Model[1]	Dry Year (AFY)	Average Year (AFY)	Wet Year (AFY)
Snake River Basin	26,284	26,284	26,284
Salt River Basin	54,120	54,463	54,479
Total	***80,404***	***80,747***	***80,763***

1. Note that the Teton Sub-basin was not represented in the spreadsheet models.

5.1.8 LIVESTOCK

In order to understand historic and current livestock activity in the Snake/Salt River Basin and factors that may affect future numbers, WWDO planning staff interviewed relevant personnel and collected data from a variety of federal and state land management, conservation and agricultural agencies:

- Star Valley Conservation District
- Lincoln Conservation District
- Sublette County Conservation District
- Teton Conservation District
- USFS Buffalo Ranger District
- USFS Jackson Ranger District
- USFS Greys River Ranger District
- Lincoln County Brand Inspector
- Teton County Brand Inspector
- Lincoln County Planning and Engineering
- USDA National Agricultural Statistics Service (NASS)

The methodology and data used for the previous Basin Plan livestock investigation were reviewed to determine whether the same approach could be implemented for this study. It was decided that a departure from the previous Basin Plan methodology was appropriate. A different method to estimate current and historic livestock numbers within the basin was used due to changes in livestock numbers and management.

The 2012 Update relied on county numbers obtained from USDA National Agricultural Statistics Service (NASS) as a starting point. Then, based on spatial associations along with information and evidence obtained from interviews with the aforementioned agencies, the county numbers were calibrated to more accurately describe average annual tallies of livestock within the basin. It was determined this approach would yield reasonable livestock counts that ultimately could be used to estimate current and future annual water demands for livestock within the basin.

The specific methodologies, anecdotal evidence, background data and assumptions made to determine historic and current livestock numbers, and to estimate future livestock counts are addressed in *Technical Memorandum, Tab I: Agricultural Water Use.*

5.1.8.1 CURRENT AND HISTORIC LIVESTOCK INVENTORY

The Snake/Salt River Basin in Wyoming encompasses all or parts of Teton, Lincoln, Sublette, and Fremont Counties. Data were obtained from the NASS website for Teton, Lincoln, and Sublette Counties with a period of record from 1975 to 2012 which provided a graphical picture of historic trends in each county (National Agricultural Statistics Service, 2012). Note that a small portion of the Snake/Salt River Basin is also located within Fremont County, primarily consisting of the upper portions of the Gros Ventre River and Buffalo Fork

Basins. This area, due to its relatively small extent and topography, was disregarded in terms of livestock occupancy within the basin. It also should be recognized that a certain number of livestock may reside on the western aspects of the Teton Range near Alta, Wyoming. There was no attempt in this analysis to separate livestock water use in the Teton River Sub-basin from use in the basin as a whole.

The data and analysis consisted of four livestock types: cattle, dairy cattle, sheep, and horses. Table 5-7 summarizes the estimated current inventory by county and livestock type within the Snake/Salt River Basin.

TABLE 5-7: CURRENT LIVESTOCK INVENTORY IN THE SNAKE/SALT RIVER BASIN BY COUNTY

County	Cattle (Head)	Dairy Cattle (Head)	Sheep (Head)	Horses (Head)
Teton	4,500	0	300	4,005
Lincoln	2,928	405	10,920	1,182
Sublette	1,855	0	300	162
Total: Snake/Salt River Basin	***9,283***	***405***	***11,520***	***5,349***

The following sections briefly describe the historic and current livestock counts for cattle, dairy cattle, sheep, and horses, respectively. Graphical representations of historic trends are also provided. Bear in mind that available historic data were limited to total county numbers. For Lincoln and Sublette Counties, livestock counts obtained from NASS included those residing outside of the Snake/Salt River Basin. Therefore, the overall shape of the lines for Lincoln and Sublette Counties on these graphs provides an indication of historic trending within those entire counties and not necessarily related to historic occurrences specific to the basin. Only the numbers have been calibrated to reflect current day inventories within the basin; the overall shape of each graph remains attached to historic trending in the entire county. Linear regression lines and equations are displayed on the graphs to help illustrate the historic inventory trend for each county. The slope of the line gives the approximate increase or decrease in annual livestock inventory over the historic period of record. Current year (2012) counts are also shown on the chart for each county.

CATTLE

Figure 5-7 illustrates the historic trends approximated for cattle inventories within the Snake/Salt River Basin distinguished by county. The figure shows an overall decline in cattle numbers since 1975 with most pronounced declines evident in Teton County. Cattle numbers in Lincoln and Sublette County remained fairly constant over the historic period of record. As indicated on the figure, it is estimated that 9,283 cattle currently reside within the Snake/Salt River Basin. Note that for this analysis, due to the very small numbers of dairy cattle located within Teton and Sublette Counties, dairy cattle counts were merged into the cattle counts for those counties.

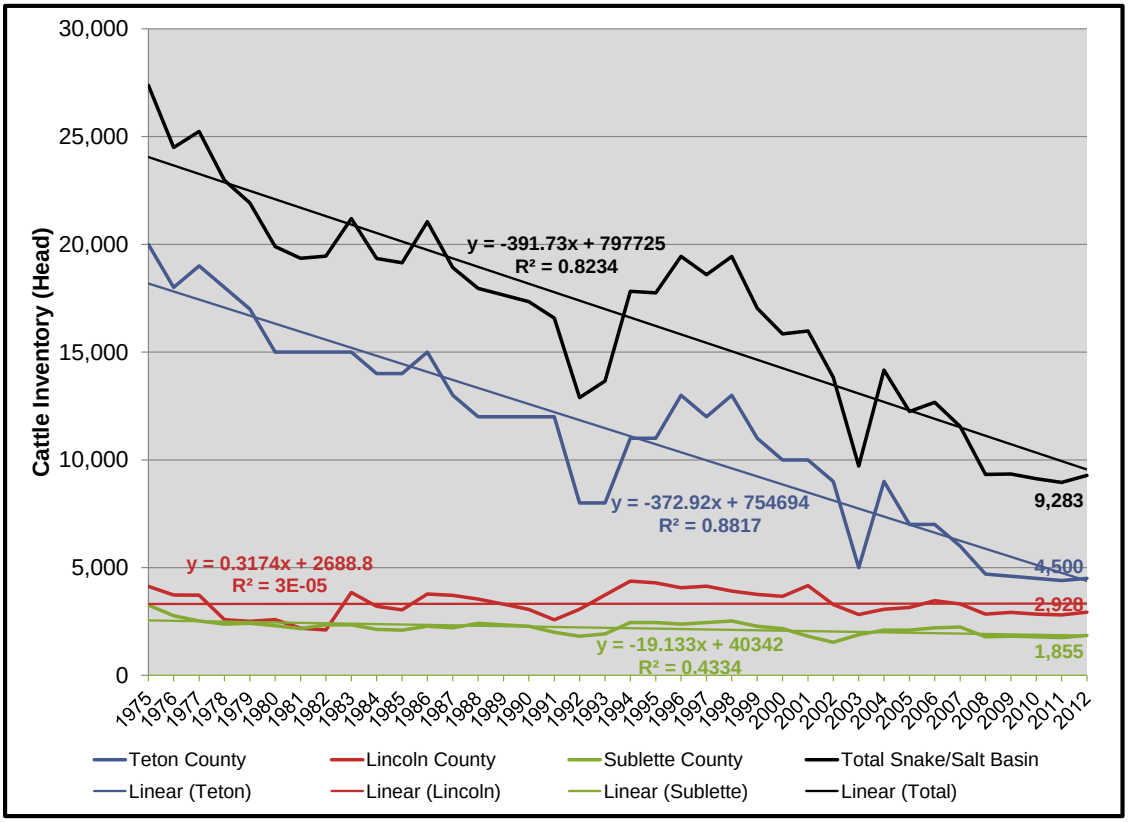


FIGURE 5-7: CATTLE INVENTORY AND HISTORIC TRENDS BY COUNTY WITHIN THE SNAKE/SALT RIVER BASIN

DAIRY CATTLE

The only portion of the Snake/Salt River Basin where notable numbers of dairy cattle are still found is in the Star Valley region of Lincoln County (Salt River Sub-basin). For many years, the Star Valley region was home to numerous dairies. In recent years, however, the cheese factory in Star Valley has closed along with a cheese factory and creamery in Rexburg, Idaho. This has forced many dairy operations to haul milk farther out of the valley to areas in Idaho. This situation, along with other compounding factors, has led to the shut-down of some dairies in the area. As such, there has been a shifting away from traditional dairy to small acreage operations involving various livestock (horses, cattle, alpaca, etc.). Despite the significant regional decline in the dairy industry, about four to six dairies still operate within the valley today. Four of these operations are in Wyoming (Lincoln Conservation District, 2012), (Lincoln County Planning and Engineering, 2012a), (Star Valley Conservation District, 2012).

Figure 5-8 illustrates the resulting historic trend of dairy cattle inventories within Lincoln County and within the Snake/Salt River Basin. The figure demonstrates the overall decline in dairy cattle numbers since 1975, peaking with nearly 2,000 head in 1985 and then dropping to an estimated 405 head in 2012. Dairy cattle located within Teton and Sublette Counties were merged into the cattle counts for those counties due to very small numbers.

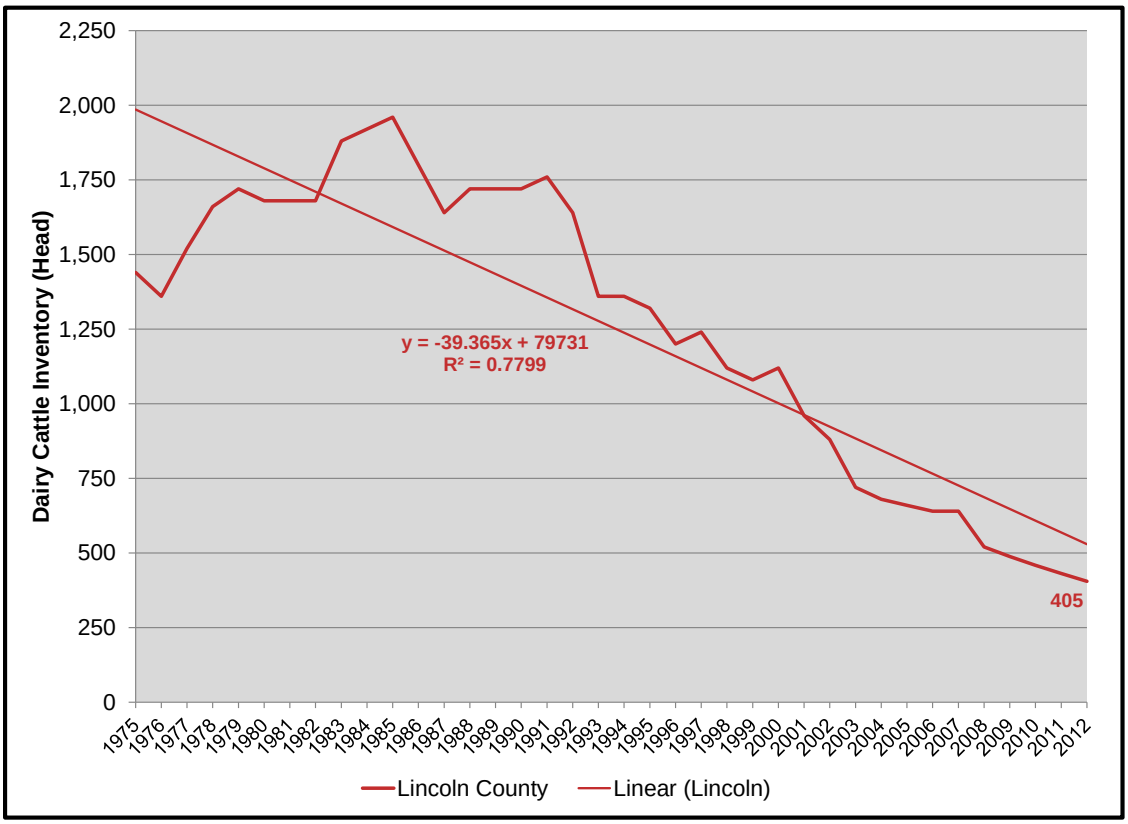


FIGURE 5-8: DAIRY CATTLE INVENTORY AND HISTORIC TRENDS IN LINCOLN COUNTY WITHIN THE SNAKE/SALT RIVER BASIN

SHEEP

Figure 5-9 illustrates the approximate historic trends for sheep inventories within the Snake/Salt River Basin by county. The figure shows a fairly steady sheep count for Teton and Sublette Counties throughout the period of record. Historic counts for sheep in Lincoln County have been sporadic, ranging from nearly 16,000 sheep in 1975, dropping to about 7,000 sheep in 1991, and increasing again to a current count of approximately 11,000 head. As indicated on the figure, it is estimated that 11,520 sheep currently reside within the Snake/Salt River Basin.

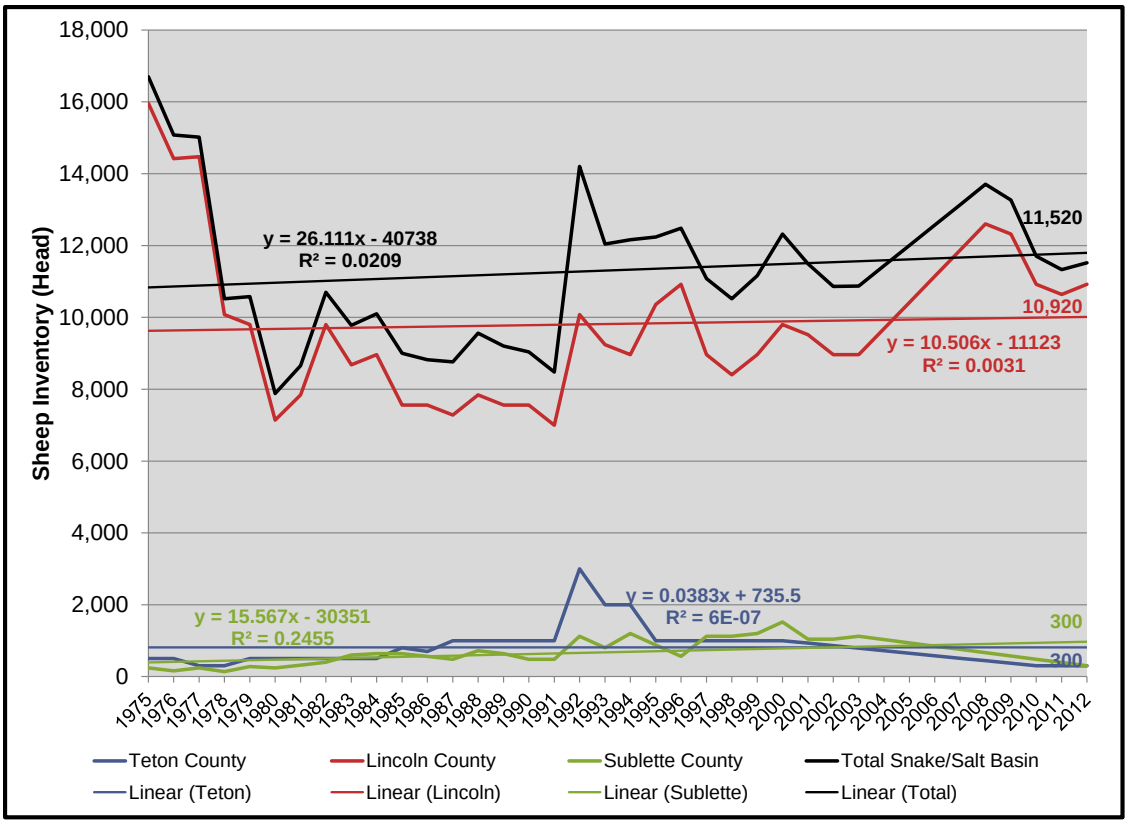


FIGURE 5-9: SHEEP INVENTORY AND HISTORIC TRENDS BY COUNTY WITHIN THE SNAKE/SALT RIVER BASIN

HORSES

Most horses within the Snake/Salt River Basin are being used for recreational riding, although some working ranch horses are still in use. There are private recreational horses and commercial recreational horses. Commercial recreational horses are those used by outfitters, recreational riding businesses, and dude ranches. Private recreational horses are those owned by individuals who reside on one of the numerous ranchettes in the basin. Historic and current horse counts described herein are comprised of all usage types.

Figure 5-10 illustrates the approximate historic trends of horse inventories within the Snake/Salt River Basin differentiated by county. The figure demonstrates a relatively strong increase in the number of horses in Teton County most likely related to the expansion of commercial riding sectors in the area. Horse numbers in Lincoln and Sublette Counties within the basin have also been increasing but at lower rates than in Teton County. As indicated on the figure, it is estimated that 5,349 horses currently reside within the Snake/Salt River Basin.

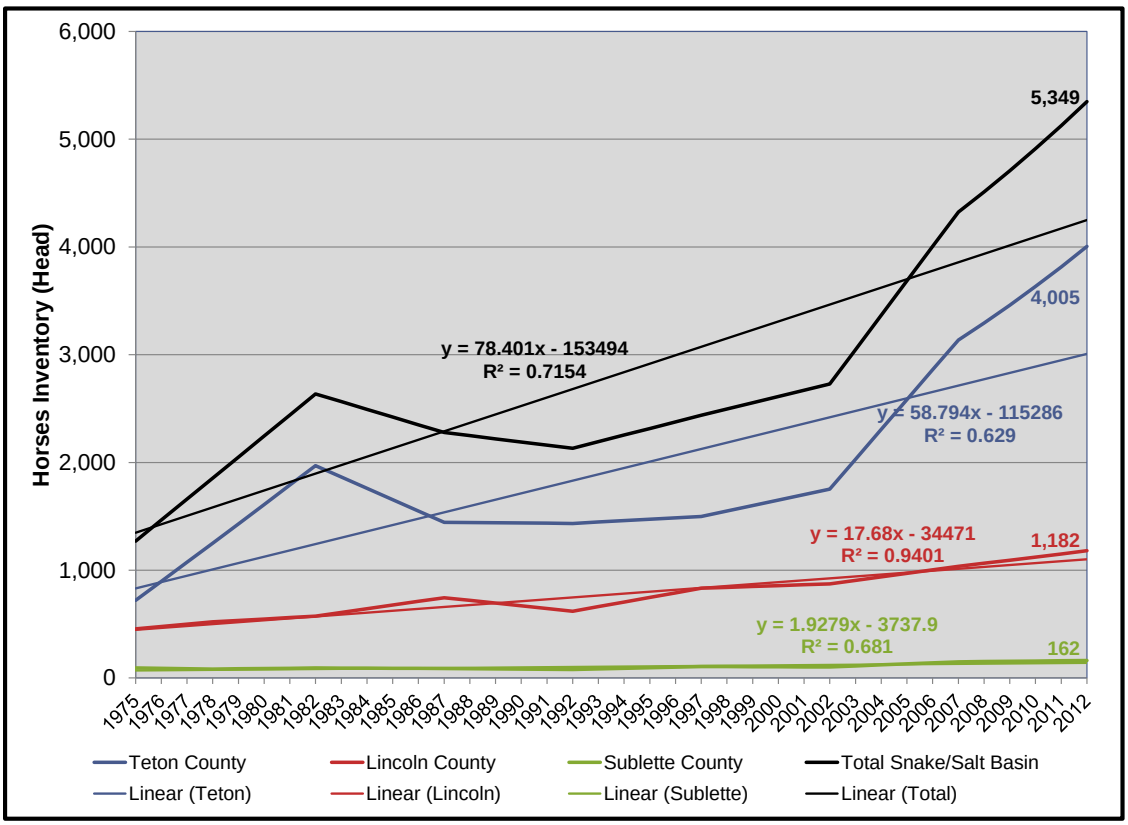


FIGURE 5-10: HORSE INVENTORY AND HISTORIC TRENDS BY COUNTY WITHIN THE SNAKE/SALT RIVER BASIN

5.1.8.2 LIVESTOCK CONSUMPTIVE WATER USE

To standardize the analysis on an animal unit basis, water use factors for cattle, sheep and horses were estimated. Animal unit (AU) estimates were calculated by multiplying estimated cattle inventories by one, dividing sheep inventories by five, and multiplying horse inventories by 1.2. As stated in the previous Basin Plan, range specialists for the Bridger Teton National Forest estimate a daily requirement of 17.5 gallons for each cow-calf pair. A cow-calf pair is a common definition of an animal unit. This study appropriately converted this rate and applied a livestock water use factor of 0.0196 acre-feet per animal unit per year, matching the factor that was used in the previous Basin Plan (BBC Research and Consulting, Inc., 2002).

Dairy cattle water use factors in the basin were estimated on a per head basis. The previous Basin Plan cited daily water use factors for dairy cattle at 35 gallons per head and between 22 and 46 gallons per head depending on the season. For the 2012 Update, the study team chose the same daily water use factor used in the previous Basin Plan: 35 gallons per head, which converts to 0.0392 acre-feet per head on an annual basis. It was assumed that all the Star Valley dairies are too small to have significant facility-cleaning water use requirements (BBC Research and Consulting, Inc., 2002).

A tabulation of 2012 livestock counts and corresponding animal units, water use factors, and annual livestock consumptive use quantities is presented in Table 5-8.

TABLE 5-8: LIVESTOCK ANNUAL CONSUMPTIVE WATER USE IN THE SNAKE/SALT RIVER BASIN

Livestock Type	Inventory (Head)	Animal Units (AU)	Water Use Factor	Annual Depletion (AFY)
Cattle	9,283	9,283	0.0196 AFY/AU	182
Dairy Cattle	405	--	0.0392 AFY/Head	16
Sheep	11,520	2,304	0.0196 AFY/AU	45
Horses	5,349	6,419	0.0196 AFY/AU	126
Total: Snake/Salt River Basin	***26,557***	**--**	**--**	***369***

5.2 MUNICIPAL AND DOMESTIC WATER USE

The DAIEAD provided population values for the basin that were used for population and water use estimates. However, the DAIEAD values did not provide specific population estimates for municipal and domestic users. In addition, the DAIEAD data did not provide average gallons per capita per day use (gpcpd). The municipal and domestic population estimates, as well as the gpcpd values, were developed using a separate method and then applied to the DAIEAD population. Municipal and domestic water users were determined by using the Environmental Protection Agency's (EPA) water system categories; the community public water system definition was used for municipal users; while EPA categories transient non-community and non-transient non-community were considered domestic water users. In addition, there are many smaller governmental districts in the basin that use water for municipal purposes and these were classified as municipal users. Water users living in rural areas with individual wells were considered domestic users. All of the users in Sublette County were defined as domestic and considered to be on individual wells.

Population estimates calculated using the municipal and domestic water use method were not the same as the DAIEAD population estimates, therefore, percentages of municipal and domestic users were applied to the DAIEAD population values. Calculated population estimates included transient visitors, part-time residents and seasonal residents, and for this analysis, only the permanent full-time population estimate was used. The following guidelines were used to develop the per capita water use estimates:

- Municipal water users are defined as EPA Community Water Systems per EPA Sanitary Surveys.
- Domestic water users are defined as EPA Transient Non-Community, EPA Non-Transient Non-Community and individual well users.
- Population and use information was provided in yearly, summer, or winter values.
- All summer/winter data were converted to a yearly value so there was a single value for population and use for all systems. This was done by weighting the populations based on the number of summer and winter days (summer is considered to be from the beginning of June to the end of September).
    - Summer days make up 33.4 percent of the year and winter days the remaining 66.6 percent of the year
- If yearly data were provided then that amount was used.
- If only seasonal data were provided then those data were converted to a yearly value based on the percentages from above.
- EPA defined domestic users were put into categories based on the type of system.
    - Campgrounds
    - Inns, motels, ranches
    - RV parks
    - Camps
    - Restaurants, stores, airport, gas stations
    - Schools, ranger stations

For the 2012 Update, municipal and domestic water use rates were determined either from actual reported values in the Sanitary Surveys or from a weighted average for those systems with no reported data. The water use rate for municipal systems was determined to be 262 gpcpd. Based on reported data and generated data for domestic water users, rates were found to range from 9 gpcpd to 317 gpcpd with rural users supplied by domestic wells estimated at 225 gpcpd. For this analysis, a weighted average of 121 gpcpd was assumed for all domestic users.

The total current population and estimated water use determined as part of the 2012 Update are presented on Table 5-9. Table 5-10 compares Updated values to the previous Basin Plan results. The decline in domestic water use between the previous Basin Plan and this 2012 Update is likely due to the difference in methodologies used.

TABLE 5-9: CURRENT POPULATION AND ESTIMATED WATER USE

Use Type	2012 Population	Use Rate (gpcpd)	Average Use (gpd)
Municipal	26,544	262	6,954,528
Domestic	7,929	121	959,409
Total	***34,473***	***--***	***7,913,937***

TABLE 5-10: TOTAL MUNICIPAL AND DOMESTIC WATER USE COMPARISONS

Description	Municipal Use (gpd)	Domestic Use (gpd)
2003 Plan	5,875,140	2,241,000
2012 Update	6,954,528	959,409
Difference	***+1,079,388***	***-1,281,591***

The municipal and domestic water use in the Snake/Salt River Basin is totally from groundwater. Using the data presented in Table 5-9, the annual groundwater use converts to 7,790 acre-feet for municipalities and 1,075 acre-feet for domestic users. This totals 8,865 acre-feet of groundwater use annually for the municipal and domestic sector.

5.3 INDUSTRIAL WATER USE

There was little industrial water use reported for the Snake/Salt River Basin in the previous Basin Plan (Sunrise Engineering, Inc., 2003). The three industries listed as using water within the basin were Star Valley Cheese Corporation, Northern Foods and Water Star Bottling Company, which were all located in the Salt River Sub-basin. They diverted a combined total of approximately 144 acre-feet a year and consumptively used about 48 acre-feet annually. All three industries used groundwater supplied through municipal systems. Water use by the Smokey Canyon Mine was also provided but was not counted as part of the industrial water use in Wyoming since the mine is located in Idaho on tributaries to the Salt River.

Currently there are no industrial water uses in the basin. The three industries that were listed in the previous Basin Plan have closed (Lincoln County Planning and Engineering, 2012b).

Hydropower generation was discussed in the previous Basin Plan. There were three hydropower plants listed including the Swift Creek plant, Strawberry Creek plant and the Salt River plant. At that time, only the Strawberry Creek plant was operating with a capacity of 1500 Kilowatts. Currently, the Strawberry Creek plant is operating as well as two new plants and a refurbished plant on Swift Creek. Operation of the new and refurbished facilities began in 2008, 2009, and 2010. The three generation facilities on Swift Creek produce a combined 1800 Kilowatts. All of these generation plants are operated by Lower Valley Power and Light. The Salt River generating plan is not in operating condition (Kinnington, 2012).

Hydropower generation is generally a nonconsumptive water use although it may require water storage or diversion from the stream. The two new generation facilities on Swift Creek have bypass flows of five cubic feet per second. The reactivated plant on Swift Creek does not have a bypass flow requirement because it operates in conjunction with Afton's water supply system.

5.4 ENVIRONMENTAL AND RECREATIONAL WATER USE

The analysis used to complete this section of the Snake/Salt River Basin Plan Update is different than was used in the previous Basin Plan. A summary of the analysis and results is presented in this chapter. For additional information, refer to *Technical Memorandum, Tab IV: Environmental and Recreational Water Use.*

5.4.1 ENVIRONMENTAL AND RECREATIONAL WATER USE ANALYSIS

River Basin plans were completed for the seven basins within the State of Wyoming between 2001 and 2006. Within those plans, water use across the state was broken down into five categories:

- Agricultural,
- Municipal and Rural Domestic,
- Industrial,
- Environmental, and
- Recreational.

Of the five categories, environmental and recreational water uses are the only water uses that are nonconsumptive. Therefore, traditional methods for quantifying these uses do not apply. As a result, the environmental and recreational analyses performed for each of the original basin plans were handled differently. Typically the previous basin plans described these uses without regard to how they interact with traditional uses. Environmental and recreational water uses were instead described in short summaries designed to present a broad picture of their impact on basin water resources.

In order to develop a more unified approach that gives a more detailed picture of the interaction between traditional and nonconsumptive uses, the WWDC obtained funding from the 2010 Legislature for an environmental and recreational water use study to develop a method that could be applied in all the basins. Harvey Economics was contracted to complete the study and their report was completed in the spring of 2012 (Harvey Economics, 2012).

Harvey Economics' approach for developing a method to quantify recreational and environmental uses began with a description of the fundamental differences between consumptive and nonconsumptive uses in Wyoming Water Law. Historically, traditional consumptive uses have been easier to analyze because they have an assigned water right that is diverted from a stream or reservoir and can be easily quantified. Whereas, environmental or recreational water use, such as a high quality fishing segment, may be taking advantage of water moving through a stream segment on its way to a senior water rights holder. This use does not have a diversion and is not be easily quantified.

Data that describes these uses also needed to be identified. Data sources in the previous plans were limited, hard to find, and often did not adequately capture utilization of Wyoming's water resources within the environmental and recreational sector. Therefore, a second task assigned to Harvey Economics was to compile a list of data needed and their data sources.

Utilizing data gathered was the next steps in Harvey Economics methodology. The goal was to determine the relationship environmental and recreational uses have with the traditional uses in any given stream segment. It became apparent that the easiest way to evaluate these relationships was through Geographic Information System (GIS). GIS mapping quickly became a critical component of this analysis. More information on the GIS analysis is available in *Technical Memorandum, Tab IV: Environmental and Recreational Water Use.* After uses are mapped, the interaction between traditional, environmental and recreational use can be analyzed and classified according to the following categories:

Protected Water Uses: These are water uses that are both recognized and protected in some way from incursions by traditional water uses. An obvious example is an instream flow water right. However, protected wetlands, protected bypass flows, or any environmental water uses protected by federal agencies through permit or water right, fall into the protected category. In addition, protected water uses may have a senior traditional water use diversion in a location that ensures the continuation of the nonconsumptive use.

For this update, water rights were not mapped, and as a result, priority dates were not considered when analyzing environmental and recreational uses. Instead, relationships were analyzed between these uses and the points of diversion that were represented as demand nodes within the water availability spreadsheet models. Additional information on the spreadsheet models and model nodes is presented in Chapter 7.

Complementary Water Uses: These are environmental and recreational water uses that exist without explicit protection, but exist and will continue to exist by virtue of their location or linkage with a traditional water use. Environmental water uses located in a national forest or high in the watershed are unlikely to be disturbed by traditional water users below. Without future intervening water uses, those complementary water uses are likely to continue and should be recognized as such in the river basin planning process.

Another sub-category of complementary water use stems from the incidental linkage of certain environmental or recreational water uses to traditional uses. For example, fisheries and spawning habitat may be supported by subsurface irrigation return flows, which would be lost if irrigation stops or the method is changed. These incidentally linked water uses are without explicit protection and will expand or contract with the linked traditional use.

Competing uses: Competing uses are those environmental or recreational water uses that are not protected and are in a location where other traditional water use diversions may constrain or eliminate the environmental or recreational use at any time. These uses should be recognized in the basin planning process, but with the explicit understanding that they can and will disappear when and if future traditional uses are developed.

For the purposes of this study, a subcategory has been added to the Competing Use Designation. Uses that exist with traditional uses without conflict may be designated as "Potentially Competing". Potentially Competing uses are defined as any use that is currently complementary, but with the potential to become competing in the future. Competing uses are unprotected and could disappear if future appropriators obtain rights to water currently meeting a recreational or environmental need.

5.4.1.1 GEOGRAPHICAL INFORMATION SYSTEM (GIS) SOURCES

Several GIS layers were used in this study to analyze the environmental and recreational uses within the Snake/Salt River Basin. These layers are listed in Table 5-11. All GIS layers were provided by the source agency in 2012.

5.4.1.2 PROCEDURES UNIQUE TO THE SNAKE/SALT RIVER BASIN

Using the GIS layers listed in Table 5-11, maps were developed to begin analyzing the relationships between environmental, recreational and traditional uses. It quickly became apparent that there were too many uses to display on a single map that covered the entire basin, so the analysis was broken down to a sub-basin level. The sub-basins defined for use in this analysis are shown on Figure 5-11and listed below:

1. Salt River Basin,
2. Greys River Basin,
3. Hoback River Basin,
4. Lower Snake River and Palisades Sub-basins,
5. Gros Ventre River Basin,
6. Snake River Headwaters Sub-basin,
7. Teton River Sub-basin, and
8. Upper and Lower Henrys Fork Sub-basins.

SALT RIVER NEAR AFTON

TABLE 5-11: GIS LAYERS AND SOURCES USED IN THE ENVIRONMENTAL AND RECREATIONAL WATER USE ANALYSIS

GIS Layer Name	Source
Aquatic Habitat Priority Areas	Wyoming Game and Fish Dept.
Bridger-Teton Sites	Bridger-Teton National Forest
Bridger-Teton Trails	Bridger-Teton National Forest
Caribou-Targhee Dispersed Areas	Caribou-Targhee National Forest
Caribou-Targhee Dispersed Sites	Caribou-Targhee National Forest
Caribou-Targhee Sites	Caribou-Targhee National Forest
Critical Streams Corridors	Wyoming Game and Fish Dept.
Elk Feed Grounds	Wyoming Game and Fish Dept.
Fishing Spots	WyGISC
Game and Fish Stream Classifications	Wyoming Game and Fish Dept.
Golf Courses	WyGISC
Grand Teton National Park Resources	National Park Service
Instream Flows	WWDO, SEO, Wyoming Game & Fish Dept.
Lakes	WSGS
Landownership	BLM
Model Demand Nodes	WWDO
National Wetlands Inventory	U.S. Fish and Wildlife Service
Nature Conservancy Easements	The Nature Conservancy
Non-Nature Conservancy Easements	The Nature Conservancy
Palisades Wilderness Study Area	Bridger-Teton and Caribou-Targhee National Forests
Scenic Highways and Byways	WyGISC and ESRI
Shoal Creek Wilderness Study Area	Bridger-Teton National Forest
Ski Areas	WyGISC
Streams	WSGS
Teton County Ponds	SEO
Trout Unlimited Projects	Trout Unlimited
Wild and Scenic Rivers	WyGISC & SEO
Wilderness Areas	WyGISC
Yellowstone National Park Resources	National Park Service

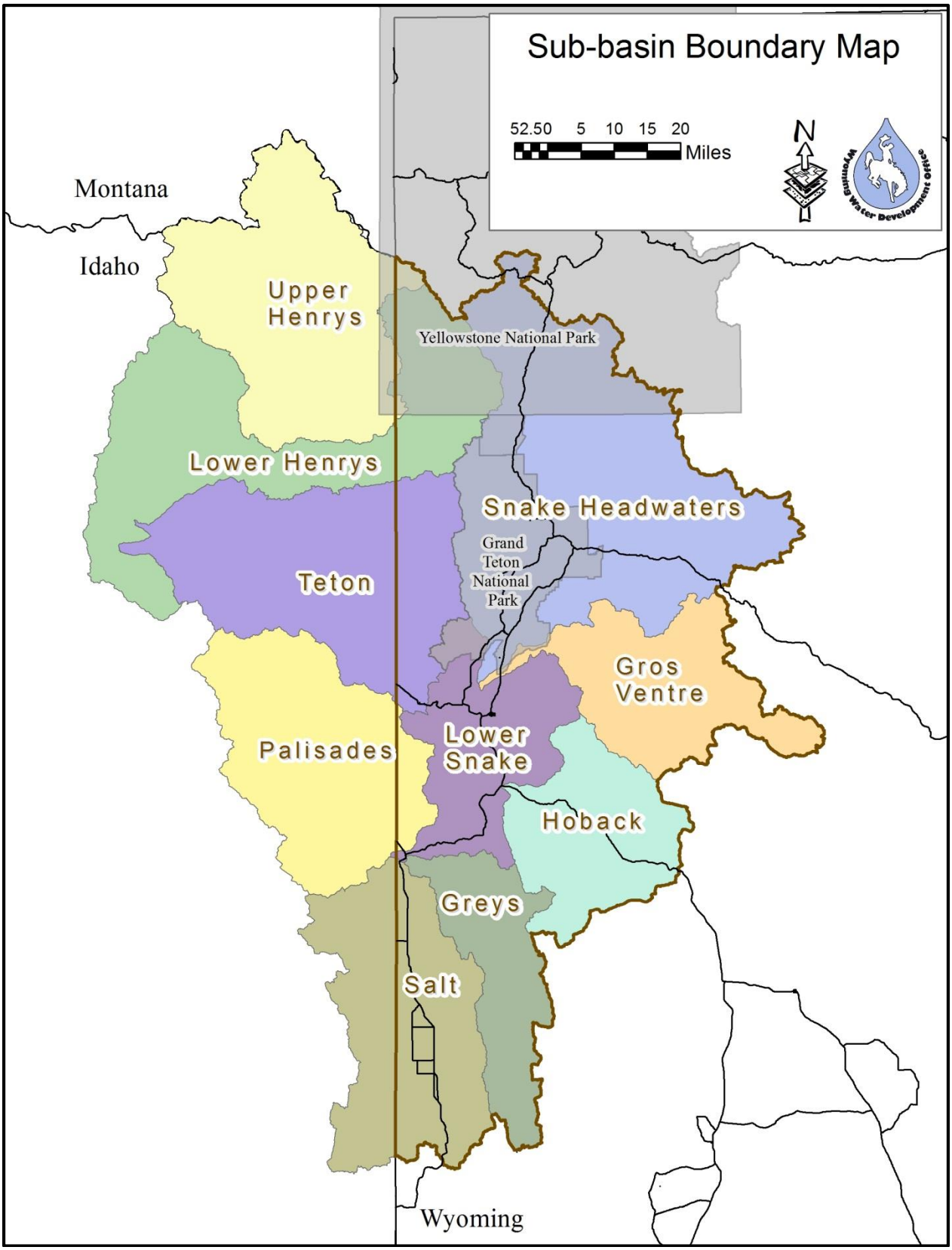


FIGURE 5-11: SUB-BASINS DEFINED FOR THE ENVIRONMENTAL AND RECREATIONAL ANALYSIS

Even with the consolidated grouping levels described above, there remained too much information to display on a single map. Therefore, each sub-basin was divided into the following three maps:

1. **Recreational Sites Map.**
2. **Environmental Sites Map.**
3. **Miscellaneous Sites Map.**

The following information is included on the Recreational Sites Sub-basin Maps:

1. Recreational Sites Maps

- Elk Feed Grounds
- Wilderness Areas and Wilderness Study Areas
- Cross-Country and Downhill Ski areas
- Golf Courses
- Fishing spots
- Forest Service Sites
  - Boating
  - Campgrounds
  - Information
  - Interpretive
  - Observation
  - Picnicking
  - Swimming
  - Trailheads
- Bridger-Teton National Forest Trails
- Wyoming Game and Fish Dept. Stream Classifications
- Caribou-Targhee National Forest Dispersed Camping Sites

The Environmental Sites Maps include the following information:

2. Environmental Sites Maps

- Trout Unlimited Projects
- Wild River Segments
- Scenic River Segments
- Recreation River Segments
- Instream Flow Segments
- Wilderness Areas and Wilderness Study Areas
- Aquatic Habitat Priority Areas

The Miscellaneous Environmental and Recreational Sites Map includes sites that would not fit on the previous maps. They include the following layers:

3. Miscellaneous Sites Maps

- Scenic Highways and Byways
- Teton County Ponds

- Non-Nature Conservancy Easements
- Nature Conservancy Easements
- National Wetlands Inventory

There are many environmental and recreational uses in the Study Area that overlap, such as Wild and Scenic River Segments, Instream Flow Segments, and Wyoming Game and Fish Stream Classifications. As a result, it was necessary to develop a method to quantify and display the levels of use within stream segments that have overlapping water uses. A similar problem was encountered with the levels of protection. To aid in this investigation, two raster based GIS analyses were conducted. The first analysis used five GIS layers to display different stream uses. The second analysis used three GIS layers to identify different areas where an environmental or recreational use receives protection from development changes. An example would be those uses within wilderness areas. The layers used are identified below. For additional information on how this analysis was completed, refer to *Technical Memorandum, Tab IV: Environmental and Recreational Water Use.*

Use Layers

- Wyoming Game and Fish Dept. Stream Classifications
- Instream Flow Segments
- Wyoming Game and Fish Dept. Critical Streams
- National Wild and Scenic Rivers
- Land Ownership

Protection Layers

- Permitted Instream Flow Segments
- National Wild and Scenic River Segments
- Land Ownership

Products of the analyses described above are two GIS maps to be used in addition to the recreational, environmental and miscellaneous sites maps. Each map is presented in *Technical Memorandum, Tab IV: Environmental and Recreational Water Use* where, Figure 35 is the Use Map and Figure 36 is the Protection Map.

It is important to note that the Use and Protection Maps described above (Figures 35 and 36 within the technical memorandum) do not include any of the site-specific uses identified on the Environmental and Recreational Sites Map described earlier. They are not intended to replace other maps in the analysis. They are intended to be used in conjunction with the Recreational Sites, Environmental Sites, and Miscellaneous Sites Maps. The Use and Protection Maps were only intended to quantify and display the effects of a very few recreational, environmental, and landownership layers that overlap and as a result are difficult to display simultaneously.

The Use Map is color coded to show stream segments with low levels of use as blue, medium levels of use as green, medium-high levels of use as yellow, and high levels of use as red. The Protection Map is color coded to show levels of protection with low levels as light gray, medium levels of protection as medium gray and high levels of protection as black. One

example of protected use would be a boating or rafting segment in the forest below a wilderness area. The boating segment can be considered protected because no changes will be made upstream.

Harvey Economics also concluded, interaction with traditional water uses is critical for determining the likelihood of an environmental or recreational use becoming competing. To aid in classifying these interactions, the diversion nodes used within the water availability spreadsheet models were added to the Use and Protection Maps. As an example, if irrigation practices upstream from blue ribbon fishing segments change from flood irrigation to sprinkler irrigation, late season return flow may also change. This type of change often reduces late season irrigation return flows that result in drier streams late in the season, affecting fishing segments.

The Use and Protection Maps, in conjunction with the site maps described above, allow the reader to gain an understanding of the types of environmental and recreational uses in the basin and their relationship with institutional considerations and historical uses. Figures 5-12 and 5-13 are examples of Use and Protection Maps for the Salt River Basin developed from the raster based GIS analysis.

RAFTING ON THE SNAKE RIVER NEAR ALPINE

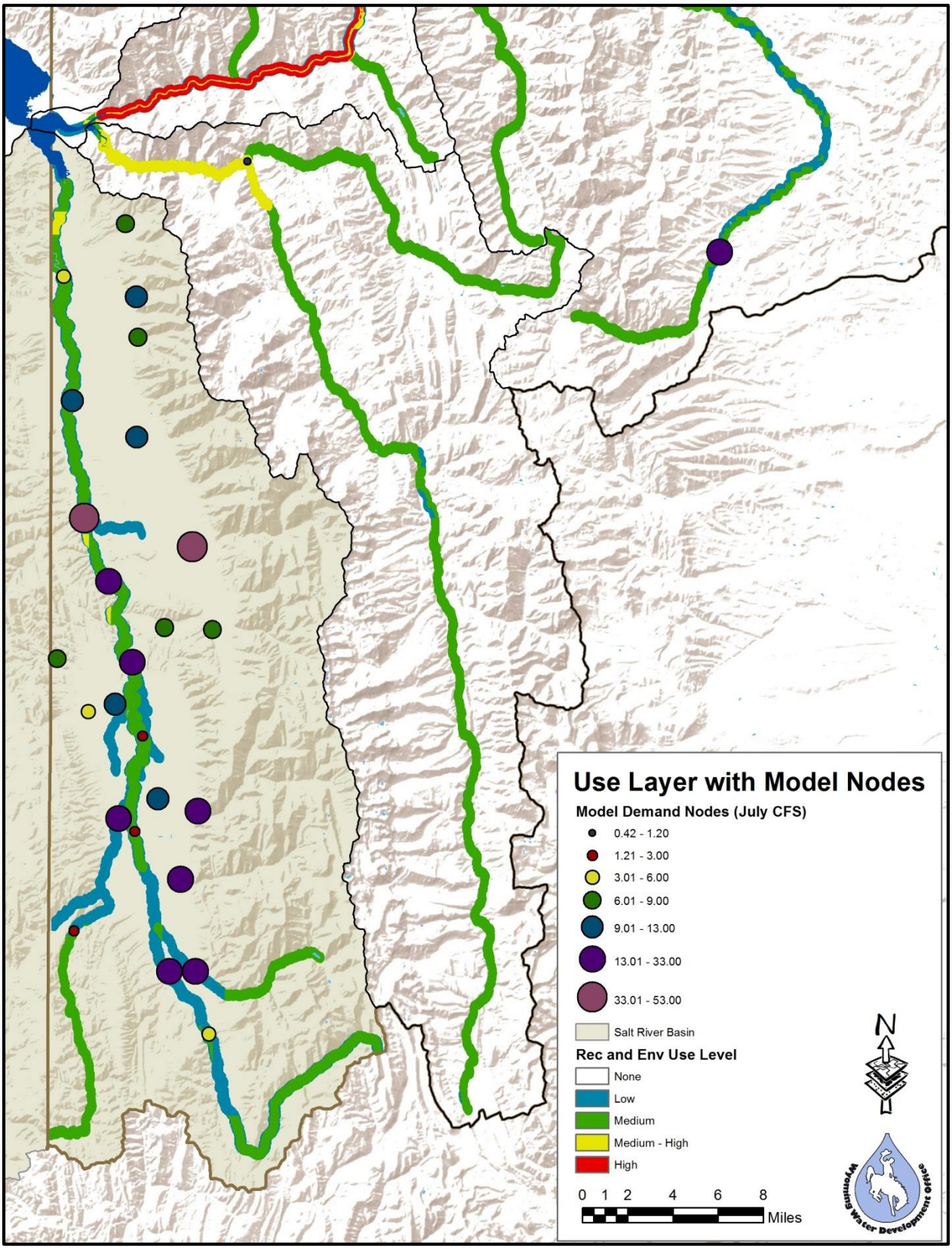


FIGURE 5-12: SALT RIVER BASIN USE LAYER MAP

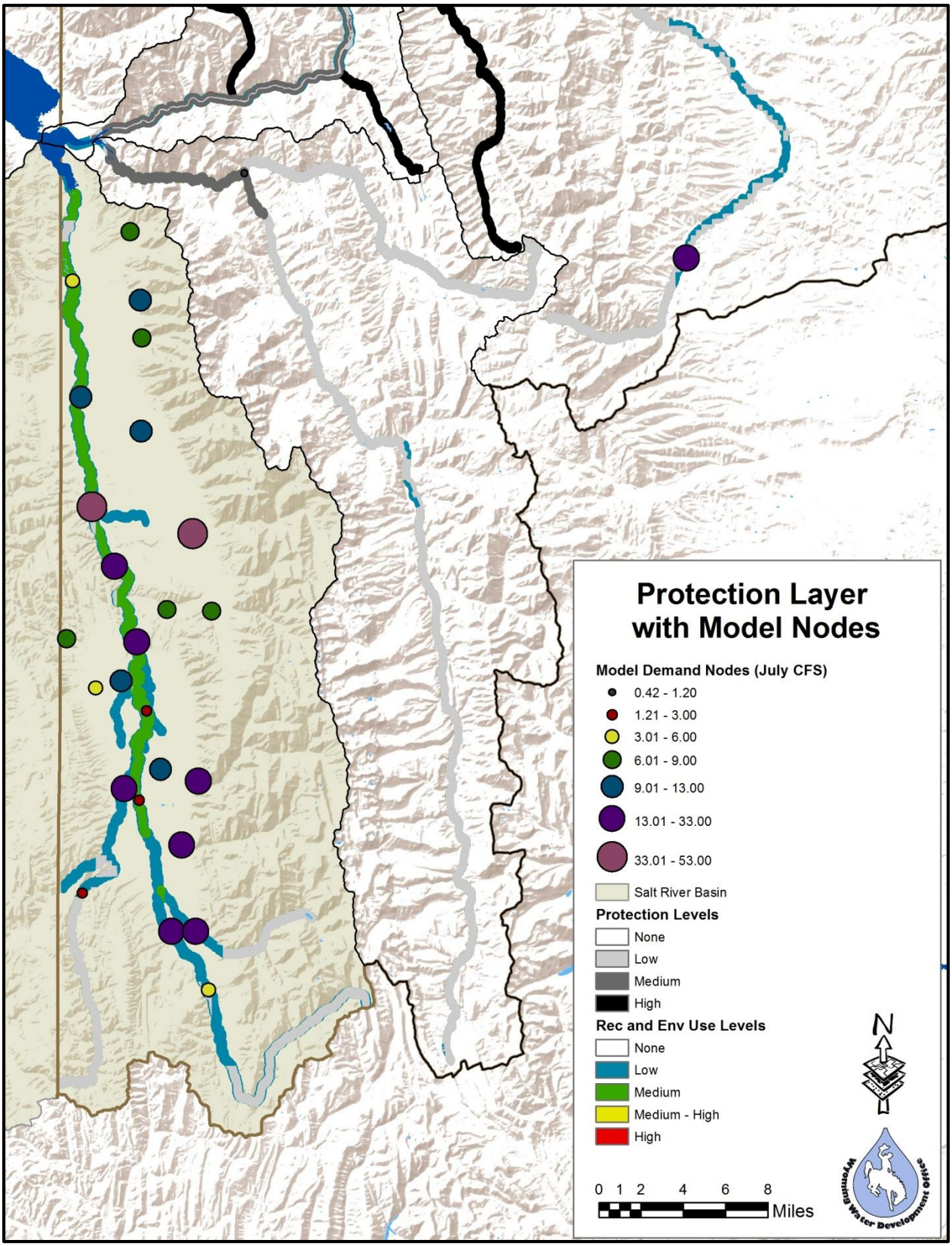


FIGURE 5-13: SALT RIVER BASIN PROTECTION LAYER MAP

5.4.2 ENVIRONMENTAL AND RECREATIONAL WATER USE ANALYSIS RESULTS

The following sections describe the results of the Environmental and Recreational Water Use Analysis. Maps and analysis for the entire Snake/Salt River Basin study area can be found in *Technical Memorandum, Tab IV: Environmental and Recreational Water Use*.

5.4.2.1 SUMMARY TABLES AND SAMPLE MAPS

Environmental and recreational sites for the study area were mapped for the sub-basins as described in Section 5.4.3. As examples, Figures 5-14, 5-15, and 5-16 show the Recreational, Environmental, and Miscellaneous Sites Maps developed for the Snake Headwaters Sub-basin.

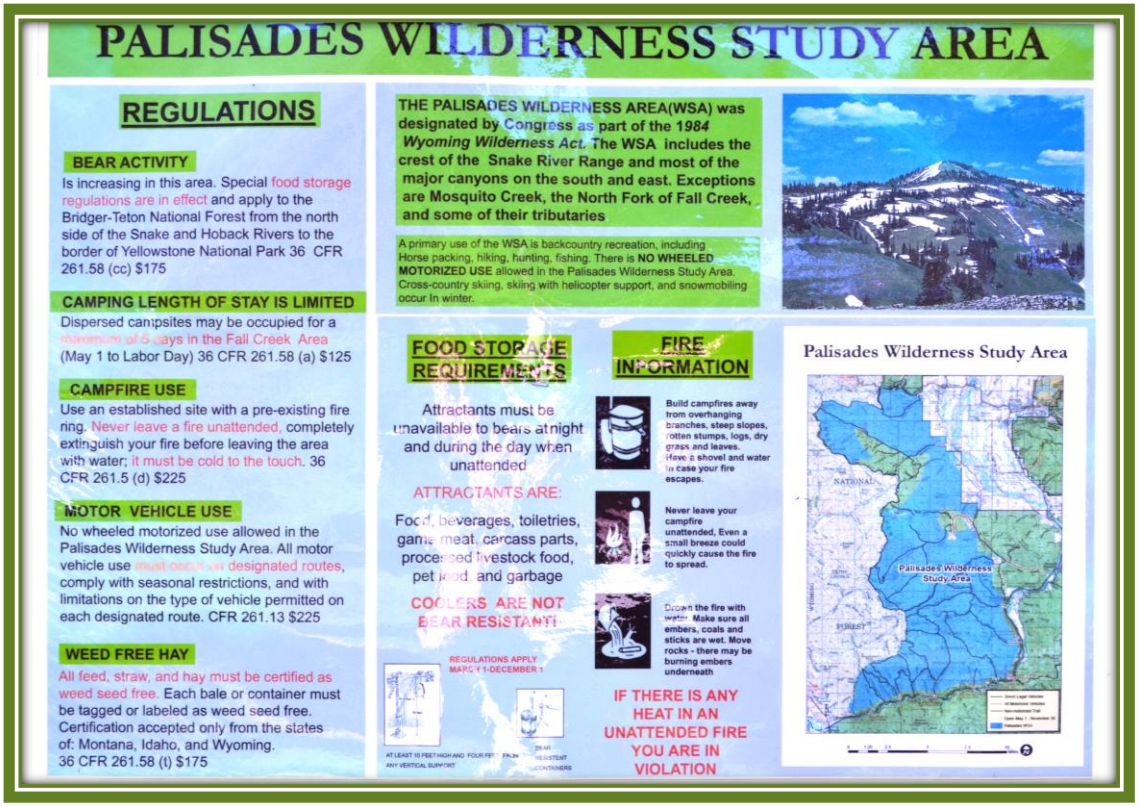
Utilizing the Recreational Sites Maps, the next step in the analysis was to inventory the recreational uses. Table 5-12 includes the number of recreational sites included in the study area for each sub-basin. Each of the sites included in the table can be found on maps included in the technical memorandum. The environmental sites were also inventoried and mapped. Table 5-13 lists the environmental sites for each of the sub-basins.

TABLE 5-12: RECREATION SITES INVENTORY BY SUB-BASIN

Recreation Site Type	Salt	Greys	Hoback	Lower Snake & Palisades	Gros Ventre	Snake Headwaters	Teton	Henrys	*Total:*
Elk Feed Grounds	1	1	3	4	3	0	0	0	***12***
Cross-Country Ski Area	1	1	0	0	0	0	0	0	***2***
Down Hill Ski Area	0	0	0	2	0	0	1	0	***3***
Golf Courses	5	1	0	1	1	0	1	0	***9***
Boating Sites	1	2	0	6	1	19	0	0	***29***
Campgrounds	2	4	3	12	3	40	3	1	***68***
Fishing Spots	0	1	2	2	3	10	3	0	***21***
Visitors Center	0	0	0	1	0	0	0	0	***1***
Fire Lookouts / Cabins	0	4	1	0	0	5	0	1	***11***
Information Center	0	1	0	0	0	0	0	0	***1***
Interpretive Site	0	0	0	1	3	3	0	0	***7***
Observation Site	0	0	0	3	1	52	1	0	***57***
Picnic Area	3	1	1	1	0	11	0	0	***17***
Swimming	0	0	1	0	0	0	0	0	***1***
Trailhead	1	0	3	11	2	22	4	1	***44***
Wildlife Viewing	1	0	0	0	0	0	0	0	***1***

TABLE 5-13: ENVIRONMENTAL SITES INVENTORY BY SUB-BASIN

Environmental Site Type	Salt	Greys	Hoback	Lower Snake & Palisades	Gros Ventre	Snake Headwaters	Teton	Henrys	*Total:*
Trout Unlimited Projects	3	0	0	1	1	1	0	0	***6***
Wild River Segments	0	0	3	1	2	6	0	0	***12***
Scenic River Segments	0	0	1	0	2	5	0	0	***8***
Recreation River Segments	0	0	1	1	0	0	0	0	***2***
Instream Flow Segments (Permitted)	0	1	0	0	0	0	0	0	***1***
Instream Flow Segments (Applications)	1	1	9	2	0	0	0	0	***13***
Wilderness Areas	0	0	1	1	1	1	1	2	***7***
Wilderness Study Areas	0	0	1	1	0	0	1	0	***3***



U.S. FOREST SERVICE SIGN AT ENTRY TO PALISADES WILDERNESS STUDY AREA AT WOLF CREEK

U.S. FOREST SERVICE WELCOME SIGN AT CLIFF CREEK USE AREA

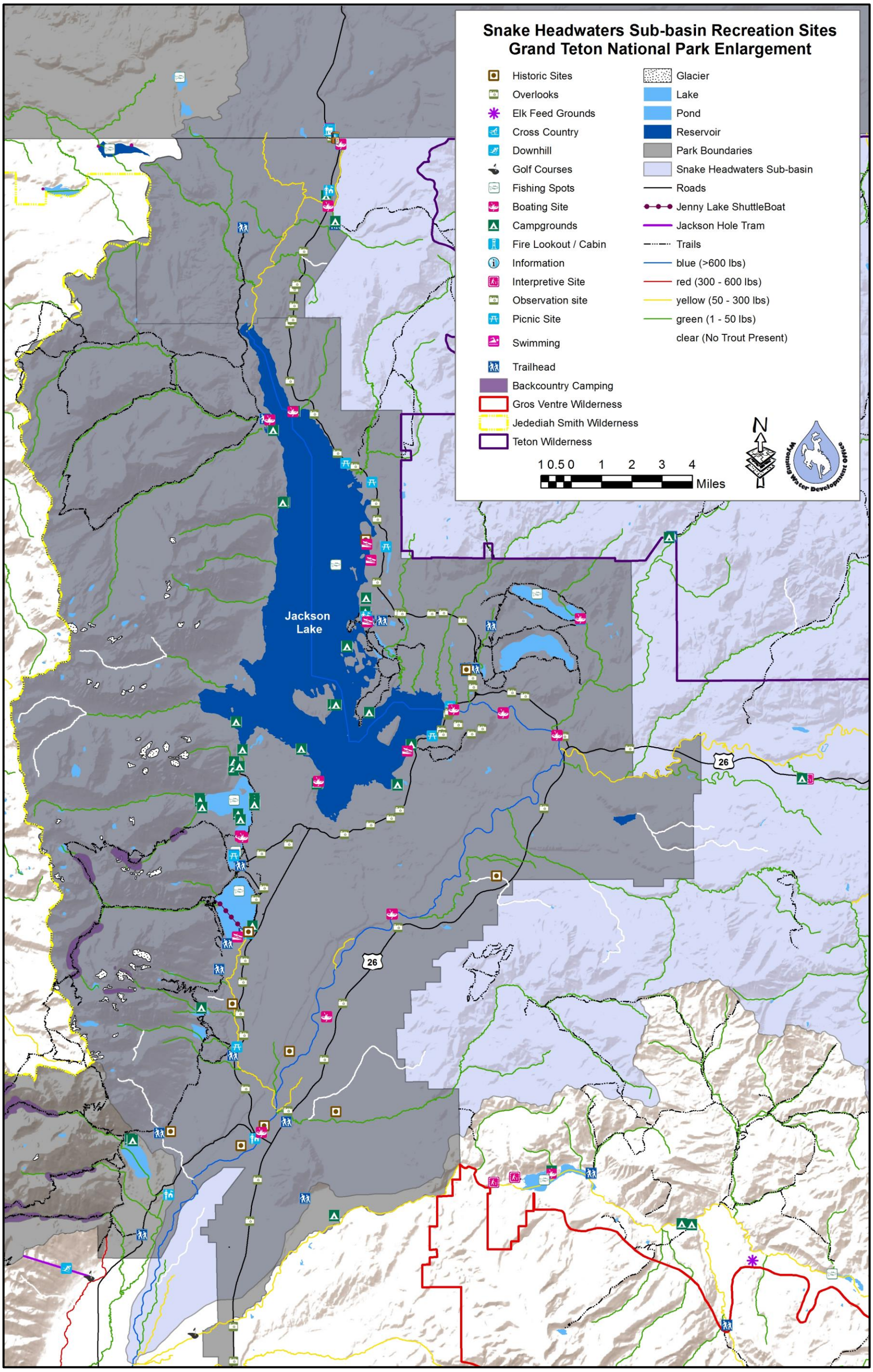


FIGURE 5-14: SNAKE HEADWATERS SUB-BASIN RECREATIONAL SITES MAP, GRAND TETON NATIONAL PARK ENLARGEMENT

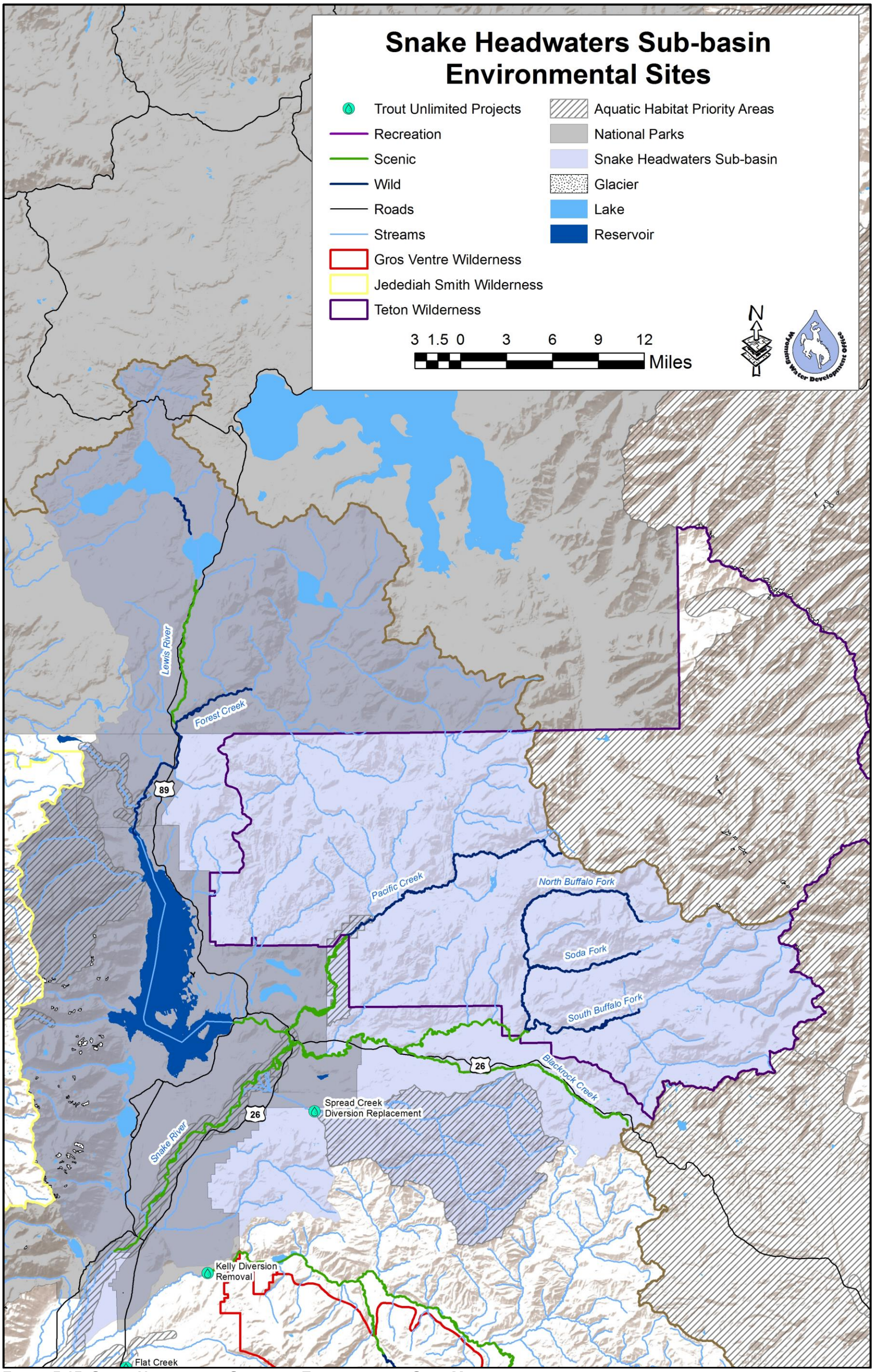


FIGURE 5-15: SNAKE HEADWATERS SUB-BASIN ENVIRONMENTAL SITES MAP

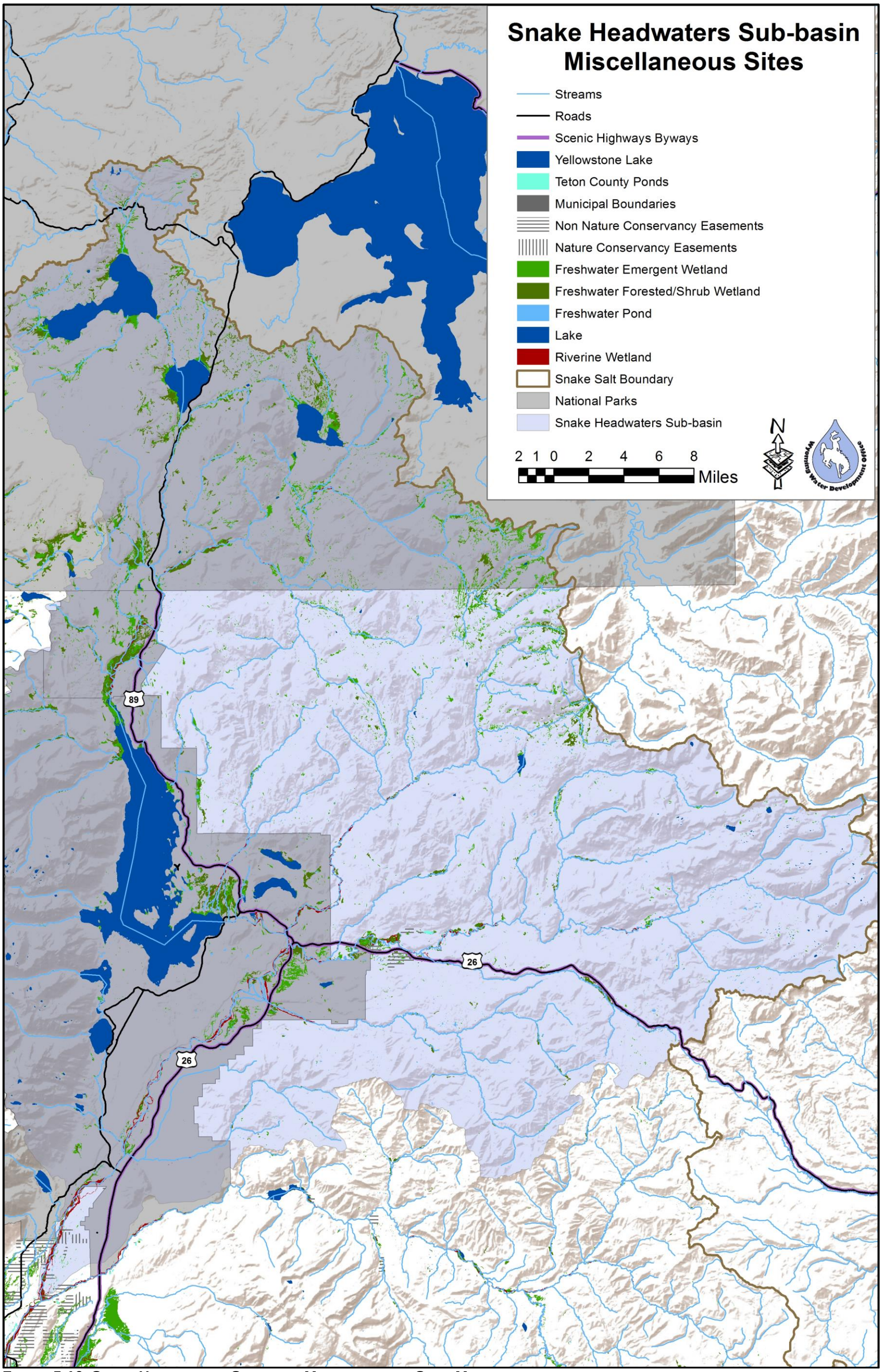


FIGURE 5-16: SNAKE HEADWATERS SUB-BASIN MISCELLANEOUS SITES MAP

5.4.2.2 USE CLASSIFICATION ANALYSIS RESULTS

Salt River Basin
All but two of the environmental and recreational uses in this basin are currently complementary. Levels of use from the Use Map range from low to medium-high with most of the segments being classified at a medium use level. Levels of protection from the Protection Map in this basin range from none on private land to low on state and federal land. There is one stream segment and one Trout Unlimited site that have the potential to become competing if new water uses are developed or agricultural practices change. The stream segment runs through state land and is located at the lower end of Salt River before it enters Palisades Reservoir. It is listed as having a medium-high level of use. The Trout Unlimited site is below most of the current irrigation diversions.

Greys River Basin
The Use Map shows uses throughout the Greys River Basin ranging from medium in the upper reaches to medium-high above the confluence with the Snake River. The levels of protection from the Protection Map ranges from a few small areas on private land with no protection to low on USFS land and medium through the instream flow segment. All of the uses are complementary at this time, except for the golf course at the confluence with Palisades Reservoir. This use is protected because it would have a water right to irrigate the course.

Hoback River Basin
Use levels from the Use Map show ranges from low in the upper reaches along private lands to medium-high on the mainstem below Granite Creek. Levels of protection from the Protection Map vary from none on private lands to high on designated wild stream segments and in the wilderness areas.

Most of the uses are complementary. However due to the Gros Ventre Wilderness Area and Shoal Creek Wilderness Study Area, there are several uses that have been classified as protected. One fishing site is located in the wilderness area and is therefore protected. Just below the wilderness area and adjacent to the border of the wilderness study area are the following uses; because of their proximity to the wilderness area and wilderness study area, these uses have also been designated as protected:

- One Swimming Site
- One Picnic Site
- One Camping Area
- One Trailhead

Lower Snake River and Palisades Sub-basins
Levels of use from the Use Map range from high in the Snake River Canyon to low on some of the tributaries northwest of Jackson. Levels of protection from the Protection Map also range from no protection on private lands to highly protected on federal lands. The highly protected stream segments are located in Grand Teton National Park (GTNP), the Gros Ventre Wilderness Area, or on a segment classified as a wild river.

Most of the uses in this sub-basin are complementary. However, there are seven uses that are classified as protected. The two ski areas have been classified as protected. If they use snowmaking they would be required to have a water right. The golf course northwest of Jackson has also been classified as protected for the same reason. If its water system is independent then it would require a permit; if it is not then it would most likely be associated with a municipal system that has a water right. The fourth protected use is the Elk Feed Grounds at the National Elk Refuge. The remaining three protected uses are back country lake camping sites located in GTNP.

Gros Ventre River Basin

Use within this basin as shown on the Use Map shows ranges from low on the private lands near the confluence with the Snake River to medium-high on the mainstem and Crystal Creek. The levels of protection on the Protection Map also vary from no protection to highly protected in the wilderness area and in the small stretch of the mainstem that runs through GTNP.

The Recreational and Environmental Uses are all complementary except for the trail system that starts at the edge of the Gros Ventre Wilderness Area and the golf course at the western edge of the basin. The trail system is in the wilderness area and is therefore considered protected. The golf course is considered protected because it would require a water right to irrigate.

Snake River Headwaters Sub-basin

The Use Map for this sub-basin shows a range from low on the lower portions of Spread Creek to high on the Snake River mainstem below Jackson Lake Dam. The use levels drop for those segments within Yellowstone National Park (YNP). This is because the Wyoming Game and Fish Department classifications don't extend into the Park; it is likely that the use classifications would have been higher on the Lewis River and the segment of the Snake River within YNP if Wyoming Game and Fish Department classifications had been made.

The Protection Map for the Snake Headwaters stream segments resulted in a high classification for most all segments. This is a result of much of the sub-basin being within the National Parks and Teton Wilderness Area. One exception is Cottonwood Creek which runs primarily through private land, which results in no protection for most of its length. Additionally, the Snake River below GTNP runs through private land, thus no protection in this section. Blackrock Creek has medium protection and Spread Creek has low protection.

Most of the uses in this basin are protected. All of the uses in GTNP, J.D. Rockefeller Memorial Parkway, and YNP are classified as protected. Outside of the parks there are five recreational uses that are classified as complementary, six recreational uses that are classified as protected, and one environmental use that is classified as potentially competing The protected uses are located adjacent to wilderness areas or on wild or scenic river segments. The aquatic habitat priority area on Spread Creek has been designated as potentially competing. The diversions on Spread Creek are in the lower portion of the watershed. As a result, they may prevent fish passage up stream if not properly constructed.

Teton Sub-basin
The Use Map shows consistent results for the Teton Sub-basin with all of the modeled streams having a medium use level. The Protection Map shows more variation. Streams in the wilderness areas are classified as highly protected and streams below the wilderness area are classified with a low level of protection.

The environmental and recreational uses in the basin are all classified as complementary except for the golf course and the ski area. These uses are classified as protected, since under Wyoming water law, they would be required to have a water right.

Upper and Lower Henrys Sub-basins
None of the streams in the Upper and Lower Henrys sub-basins were included in the Use and Protection Maps. Most of the Wyoming portion of these sub-basins are contained within YNP. There are three fishing sites, one trailhead, one camping site, and one lookout tower. Two of the fishing sites are in YNP and are therefore, considered protected. The camping site is also considered protected because it is on the border of the Winegar Hole Wilderness Area and YNP. The rest of the uses are considered complementary.

5.5 RESERVOIR EVAPORATION

Evaporation from reservoirs or lakes is not typically considered a consumptive water use. However, the increased surface area of pooled water provides ideal conditions for evaporation. Because of water loss to river basin systems, reservoir and lake evaporation has been considered in many of the river basin plans and in the Framework Water Plan (WWC Engineering, Inc, 2007) and has been addressed as reservoir evaporation.

The 2003 Snake/Salt River Basin Plan did not consider reservoir evaporation, but the reservoir evaporation was estimated for the basin in the Framework Water Plan. Data from the *Technical Memorandum, Basin Water Use Profile – Major Reservoirs* (Sunrise Engineering, Inc., 2003) were used to estimate the Framework Water Plan and in this plan update. Table 5-14 shows the estimated evaporative loss for the basin to be 72,175 acre-feet annually. For more information, refer to *Technical Memorandum, Tab XII: Major Reservoirs and Reservoir Evaporation*.

TABLE 5-14: CALCULATION OF RESERVOIR EVAPORATION

Reservoir Name	Evaporation (inches/year)	Reservoir Surface Area (Acres)	Calculated Evaporation Depletion (AFY)	Notes
Afton Electric	40	5	16.67	
Baldwin	31	3	7.75	
Beaver Pond			0.00	Not Built 12/2012
Bergman Lake	33	37	101.75	
Cottonwood Lake	41	32	109.33	
Cottonwood	37	28.4	87.57	
Teton Meadows Ranch	37	14.5	44.71	
Flat Creek Ranch	34	46	130.33	
Four Shadows	37	5.98	18.44	
Grassy Lake	32	313	834.67	
Hardeman			0.00	Breached
Hardeman #2			0.00	Breached
Indian Lake	31	252	651.00	
Jackson Lake	32	25,530	68,080.00	
Jackson Wastewater Treatment Plant	36	20	60.00	
Leidy Lake	33	14	38.50	
Leland's	37	4.77	14.71	
McLean	37	3	9.25	
Melody Ranch Pond	37	6	18.5	
Porter	32	7	18.67	
Strawberry Creek	39	3	9.75	
Teal	40	32	106.67	
Timber Creek	37	1	3.08	
Tracy Lake	32	47	125.33	
Tucker Ranch No. 23	37	11	33.92	
Tucker Ranch No. 24	37	16	49.33	
Two Ocean	32	512	1365.33	
Uhl	32	83	221.33	
West Borrow Area Lake	37	6	18.50	
Woodward			0.00	Not Built 12/2012
Total			***72,175.09***	

5.6 SUMMARY OF CURRENT WATER USE

Water uses in the Snake/Salt River Basin include consumptive and nonconsumptive water uses. Consumptive water uses include agricultural water uses (irrigated agriculture and livestock watering), municipal and domestic water uses, industrial water uses, and reservoir evaporation. Nonconsumptive uses are environmental and recreational water uses.

Table 5-15 presents a summary of the current consumptive water uses within the basin for surface water and groundwater. Irrigated agriculture is the largest water use within the basin. Although reservoir evaporation may not be considered a beneficial consumptive use, it represents the second largest consumption of water. It is considered in the planning efforts because it is a loss to the river system. Municipal water use is the third largest water use but is much smaller than agricultural irrigation and reservoir evaporation. Livestock watering and rural domestic water uses are small in comparison to other uses. Currently there are no significant industrial water uses in the basin.

TABLE 5-15: SUMMARY OF CURRENT CONSUMPTIVE WATER USE IN THE SNAKE/SALT RIVER BASIN

Type/Use	Surface Water (AFY)	Groundwater (AFY)
Agricultural Irrigation[1]	84,671	0
Livestock Watering	369	0
Municipal	0	7,790
Domestic	0	1,075
Industrial	0	0
Reservoir Evaporation	72,175	--
Total	***157,215***	***8,865***

1. Includes 3,908 AFY of consumptive irrigation water use in the Teton Irrigation Zone

Consumptive surface water use totals 157,215 acre-feet per year in the Snake/Salt River Basin including uses in the Teton River and Greys River Sub-basins. Municipalities and rural domestic water users consume 8,865 acre-feet of groundwater annually. In addition, to municipal and domestic groundwater uses there are other miscellaneous groundwater uses within the basin. As of October 2012, there were 6,156 SEO groundwater permits in the Snake/Salt River Basin. These wells or small springs are permitted for a variety of uses. To account for the additional groundwater use, the municipal and domestic use total was increased by 10 percent. This allows approximately 886 acre-feet per year for other miscellaneous groundwater uses and brings the total consumptive groundwater use to 9,751 acre-feet annually.

Although the source for livestock watering may be from either surface water or groundwater, the quantity is small and was tallied with surface water. While there has been previous industrial water use in the basin, there are currently no industrial water users. Hydroelectric plants operate in the Salt River Sub-basin, but these plants are nonconsumptive water users.

Environmental and recreational water uses are nonconsumptive and have not been considered interactively with traditional consumptive water uses previously. However, through a project with Harvey Economics, a method was developed to map environmental and recreational water uses and to relate them to traditional consumptive water uses (Harvey Economics, 2012). Three

categories of environmental and recreational water uses were established: *protected, complementary and competing*. *Protected* uses are guarded either by legal standing, such as an instream flow, or by their location in a wilderness area or national park. *Complementary* environmental and recreational water uses exist with traditional water uses without conflict. *Competing* environmental and recreational uses compete with traditional water uses. A fourth category *"Potentially Competing"* was added in this study to designate uses that are between complementary and competing. These environmental or recreational uses are not as secure as complementary uses but are not competing with traditional uses at this time. Currently the majority of environmental and recreational uses within the Snake/Salt River Basin are either protected or complementary with most uses being complementary. Complementary and potentially competing uses could become competing uses if there are new water uses or if existing traditional water uses change.

5.6.1 COMPARISON TO PREVIOUS BASIN PLAN

Total consumptive water use calculated for this update differs from the estimates developed for the previous Basin Plan. The differences can be attributed to changes in the basin population and economics as well as different approaches used to gather data and calculate resulting water use. The change in methodology that resulted in the greatest impact on estimated water use is most evident in the estimation of agricultural irrigation water use. For the 2012 Update, the StateCU consumptive use model was used along with different methodologies for estimating crop irrigation requirements, updated climate and steam flow data and changes in the irrigation zone delineations. These changes resulted in a significant reduction in irrigation water consumed from roughly 102,414 acre-feet per year in 2003 to 84,487 acre-feet per year in 2012, a 17 percent decline. The methodology used for this Update was considered an improvement over the earlier processes and can lead to development of a decision support system simulation model for the basin when needed. Further discussion and comparison of the results for agricultural irrigation to those reported in the previous Basin Plan is presented in Section 5.1.7 as well as *Technical Memorandum, Tab VII: Crop Water Requirements, Appendix B.* Table 5-16 summarizes the differences between the consumptive use estimates from the 2003 Plan and this Update for all water use sectors.

TABLE 5-16: CONSUMPTIVE WATER USE IN THE SNAKE/SALT RIVER BASIN, COMPARISON TO THE 2003 BASIN PLAN

Type/Use	Surface Water (AFY)		Groundwater (AFY)	
	2012	2003	2012	2003
Agricultural Irrigation[1]	84,487	102,414	0	0
Livestock Watering	369	470	0	0
Municipal	0	0	7,790	6,581
Domestic	0	0	1,075	2,510
Industrial	0	0	0	48
Reservoir Evaporation	72,175	72,200	0	0
Total	***157,031***	***175,084***	***8,865***	***9,139***

1. Since the previous Basin Plan did not analyze the Greys River Sub-basin and for direct comparison purposes, the 2012 quantity of 84,487 AFY excludes the Greys Sub-basin. Consumptive water use in the Greys River Sub-basin equals 185 AFY.

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6.0 WATER USE PROJECTIONS

6.0 WATER USE PROJECTIONS

TABLE OF CONTENTS

6.1 Population and Economic Projections 98
6.1.1 Population Projections 98
6.1.2 Economic Projections 100
6.2 Agricultural Water Use 101
6.2.1 Approach for Developing Agricultural Projections 101
6.2.2 Irrigation 102
6.2.3 Livestock 105
6.2.4 Future Water Demand Projections 115
6.2.4.1 Water Use Factors 115
6.2.4.2 Projected Annual Water Demands by Scenario 116
6.3 Municipal and Domestic Water Use 117
6.4 Industrial Water Use 118
6.5 Environmental and Recreational Water Use 119
6.5.1 Grand Teton and Yellowstone National Parks Entrance Data 119
6.5.2 Leisure Tax Trends 121
6.5.3 Lodging Tax Changes 121
6.5.4 Population Relationship to Environmental and Recreational Trends 121
6.5.5 Environmental and Recreational Water Use on Federal Land 122
6.6 Reservoir Evaporation 122
6.7 Summary of Projected Water Use 122
References 125

6.0 WATER USE PROJECTIONS

This chapter presents a discussion of future water use in the Snake/Salt River Basin. Population changes and economic conditions are discussed as well as future water demands for the consumptive and non-consumptive water uses. Consumptive water uses include agricultural (irrigation and livestock water use), municipal and domestic, industrial, and reservoir evaporation. Non-consumptive uses are environmental and recreational water uses.

Three growth scenarios are used to estimate future consumptive water demands for the planning period to 2032. Growth estimates were made for a high-growth scenario, a mid-growth scenario and a low-growth scenario, for the four consumptive water use sectors. Potential changes in environmental and recreational water uses are also discussed.

6.1 POPULATION AND ECONOMIC PROJECTIONS

For the 2012 Update, the approach used to project future population and economic trends differed from the approach used in the previous Basin Plan where an economic-based approach was used (BBC Research and Consulting, Inc., 2002b). The previous plan examined potential economic growth and then projected population growth from proposed economic drivers. An inverse and simpler approach was used in this evaluation. Population estimates were used as the driver, and economic growth projections were developed from these data and basin-specific economic information. This method worked well for the Snake/Salt River Basin because of the three main economic sectors; agriculture, industry and tourism, only tourism seems to be expanding. Tourism and associated recreational activities do not directly consume water except through use by people and by facilities such as golf courses and ski areas. Therefore, growth in tourism can be reflected in municipal and rural domestic water use and in environmental and recreational water use.

6.1.1 POPULATION PROJECTIONS

Population of the three counties that make up a majority of the Snake/Salt River Basin (Lincoln, Sublette and Teton) remained constant during the 1950s and 1960s; grew rapidly in the 1970s; showed slow but steady growth during the 1980s; and grew rapidly again in the 1990s (Sunrise Engineering, Inc., 2003) (BBC Research and Consulting, Inc., 2002a). Historically, population changes in Teton and Lincoln Counties have been driven by immigration to meet increasing job opportunities.

The 2002 basin population was estimated to be 26,370 in the previous Basin Plan, and the Wyoming Department of Administration and Information Economic Analysis Division (DAIEAD) estimated the basin population to be 34,473 in 2012. This shows a moderate growth rate of about three percent annually over approximately ten years. Spatially, the area of each county located within the Snake/Salt River Basin varies. All of Teton County is within the basin while twenty-eight percent of Lincoln County is in the basin. The portion of Sublette County residing within the basin is small (8 percent) and has little impact on the total population of the basin. Teton County showed the greatest population growth over the period from 2003 to 2012 and has the highest projected growth to 2032. Sublette County showed limited growth from 2003 to 2012, and this low trend growth is projected to continue to 2032. It should be noted that

DAIEAD projections were only made to 2030 and have been extended linearly to 2032 for this analysis.

High, mid, and low-growth projections for this plan update are shown in Figure 6-1 and presented in Table 6-1. The high-growth scenario assumes the 3.1 percent growth rate seen between 2002 and 2012 will continue, resulting in a basin population of 50,679 in 2032. This is equivalent to a 2.35 percent growth rate over the 20-year projection. The mid-growth scenario, which was developed from the DAIEAD population projection for the year 2030, shows a growth rate of 1.1 percent over the 20-year period and results in a population of 42,033 in 2032. The low-growth scenario is taken from the low-growth projection in the 2003 Plan and assumes a growth rate of 0.3 percent per year over the 20-year period from 2012 to 2032 equaling a population of 36,413.

Percentage of the basin population from each of the three counties remains the same as the population grows. Lincoln County makes up 36.9 percent of the basin population; Teton County equals 62.4 percent; and Sublette County equals 0.7 percent. In the 2032 mid-growth scenario, Lincoln County's basin population is estimated to be 15,510, Teton County's population is estimated to be 26,229, and Sublette County's basin population is estimated to be 294. County population estimates for 2032 under the three growth scenarios are shown in Table 6-2.

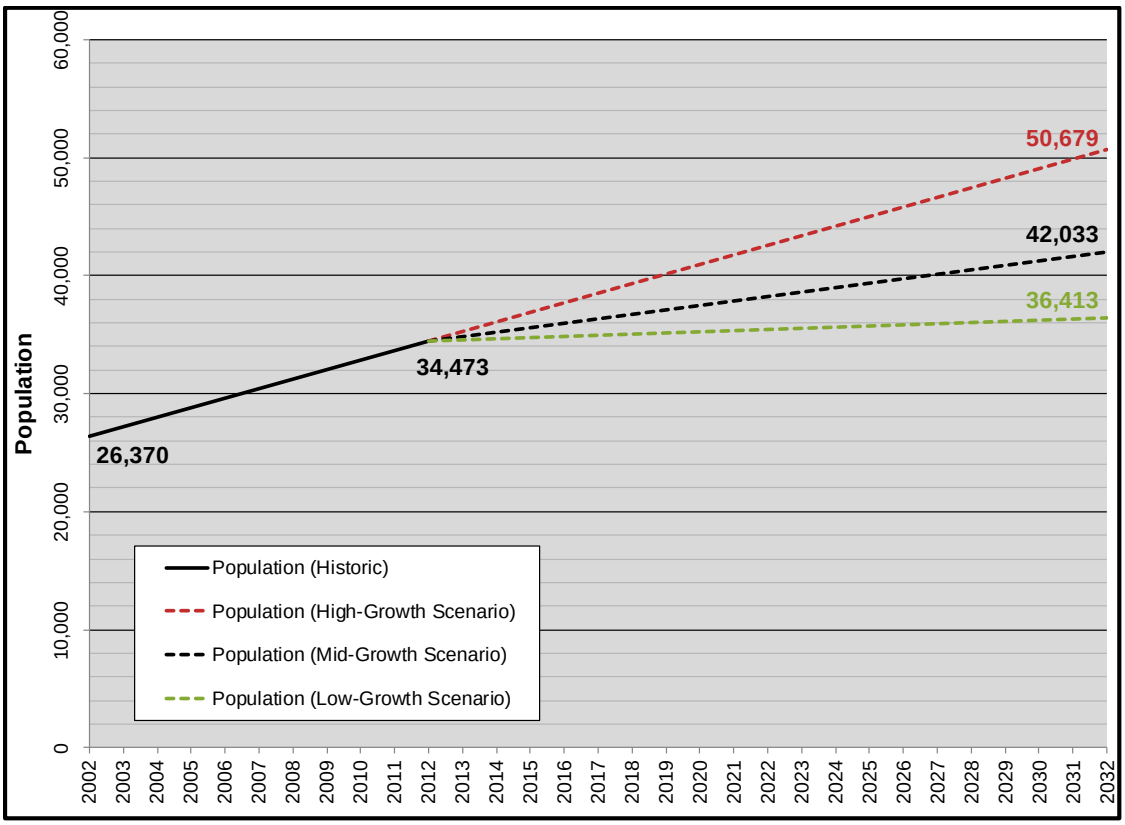

FIGURE 6-1: POPULATION PROJECTIONS FOR THE SNAKE/SALT RIVER BASIN

TABLE 6-1: POPULATION PROJECTIONS BY GROWTH SCENARIO

Growth Scenario	2002	2012	2032
High-Growth	26,370	34,473	50,679
Mid-Growth			42,033
Low-Growth			36,413

TABLE 6-2: ESTIMATED POPULATION PROJECTIONS BY COUNTY AND GROWTH SCENARIO

County	Growth Scenario	2032 Population
Teton	High	31,624
	Mid	26.229
	Low	22,722
Lincoln	High	18,700
	Mid	15,510
	Low	13,436
Sublette	High	355
	Mid	294
	Low	255
Population Total: Snake/Salt River Basin	***High***	***50,679***
	Mid	***42,033***
	Low	***36,413***

6.1.2 ECONOMIC PROJECTIONS

Historically, agriculture and tourism have been the major economic sectors of the Snake/Salt River Basin. In the 2003 Plan, these were the two most important economic sectors considered. Industry was a minor economic sector consisting of only three businesses; Star Valley Cheese Corporation, Northern Foods and Water Star Bottling Company.

Although agriculture was an important portion of the economy and the largest water use sector in the basin, tourism was the economic engine for the basin (Sunrise Engineering, Inc., 2003). Second home construction and development of subdivisions has been a portion of the economy in recent years, but it is difficult to determine the overall economic impact.

Currently, agriculture and tourism remain important economic sectors, and agriculture is the largest water use sector. However, agriculture is decreasing in importance and tourism is the main economic driver. Industry has been a minor part of the economy in the basin and has decreased with the closing of the three businesses mentioned above.

The economy and population grew steadily from 2002 to 2008 and slowed during the recession from 2008 to 2012. County and city planners within the basin indicate that the economy is beginning to pick-up again in 2012 (Lincoln County Planning and Engineering, 2012) (Teton County, 2012) (Town of Jackson, 2012).

Projections for growth in the individual water use sectors are presented in the following sections. Water use sectors generally align with the economic sectors except for tourism. Growth or change in tourism can only be translated to water use through population change (municipal and rural domestic water uses) and environmental and recreational water demands.

6.2 AGRICULTURAL WATER USE

This section discusses the future projections of agricultural activity and water use within the Snake/Salt River Basin in terms of irrigation and livestock. Section 6.2.1 summarizes the approach used to develop the projections. Section 6.2.2 discusses irrigation projections in terms of future acreage quantifications. Section 6.2.3 discusses projections in terms of future livestock numbers for cattle, dairy cattle, sheep, and horses. Lastly, Section 6.2.4 equates projected irrigated acreages and livestock quantities with water use factors to estimate future water demands. A discussion of current agricultural water use is presented in Chapter 5. More comprehensive information on current agricultural water use and projections is presented in *Technical Memorandum, Tab I: Agricultural Water Use.*

6.2.1 APPROACH FOR DEVELOPING AGRICULTURAL PROJECTIONS

Future projections utilized a 20-year planning horizon, forecasting agricultural activity and water use to year 2032 under the same three scenarios used in the previous Basin Plan; high-growth, mid-growth, and low-growth (BBC Research and Consulting, Inc., 2002b). The high-growth scenario incorporates the study team's views of the most growth that could occur over the forecast horizon, while the low-growth scenario represents the least growth expected to occur. The mid-growth scenario embodies the study team's view of the most likely level of growth likely to occur within the projection period.

Irrigation projections were applied to the estimated irrigated acres. Using trend analyses on historic data beginning in 1975, livestock numbers were projected from the last year of historic data (2012) to the end of the planning horizon (2032). A key assumption in this approach was that future changes in livestock inventories will more or less follow similar time-trends as historic inventories.

Projection rates used in this study consider information presented in the previous Basin Plan regarding potential future constraints on agricultural growth (BBC Research and Consulting, Inc., 2002b). In addition, to ascertain factors that may affect future numbers, the WWDO planning staff interviewed relevant personnel and collected data from a variety of federal and state land management, conservation, and agricultural agencies, including the following:

- Star Valley Conservation District
- Lincoln County Conservation District
- Sublette County Conservation District
- Teton County Conservation District
- USFS Buffalo Ranger District
- USFS Jackson Ranger District
- USFS Greys River Ranger District
- Lincoln County Brand Inspector
- Teton County Brand Inspector
- Lincoln County Planning and Engineering
- USDA National Agricultural Statistics Service (NASS)

All projections were calculated, for each year in the planning horizon, based on the straight-line projection method as expressed in Equation 6-1.

EQUATION 6-1

$$P_{FUTURE} = \frac{Rate * P_{INITIAL}}{100} + P_{PREVIOUS}$$

where,
P_{FUTURE} *= future, or next year's population*
Rate = projection rate in percent
$P_{INITIAL}$ *= initial population (in this case, year 2012 population)*
$P_{PREVIOUS}$ *= previous year's population*

6.2.2 IRRIGATION

The study team reviewed the previous Basin Plan in terms of future irrigation levels based on projections by county and believed all assumptions, statements and estimates of future irrigation are still valid. Therefore, similar projection rates were applied and assumptions were carried forward. High, low, and mid-growth scenarios were projected for irrigated acres within the basin based on historic trends and assumptions about 1) the rate of continued residential development in the basin; 2) future land management policies; and 3) the degree to which Lincoln County irrigated hay producers will export hay to meet demand in Teton County.

The general aim for estimating irrigation rates in the mid-growth scenario was to slightly reduce the acreage numbers from the 2012 count. For the low-growth scenario, irrigated acreage was assumed to decrease even further from the mid-growth scenario. The high-growth scenario assumed a slight increase in irrigated acres, slightly increasing the irrigation rate.

For this analysis, individual projection rates for future irrigated acres were assigned to each irrigation zone established for the 2012 Update (Refer to Chapter 5, Figure 5-1). However, in order to maintain consistency with the previous Basin Plan, the assigned rates were maintained within each county. As an example, Irrigation Zones 1 through 3 are all located in Teton County and thus were assigned the same projection rates. It is important to note that Irrigation Zone 1 (Teton) is located on the western aspect of the Teton Range near Alta, Wyoming. Irrigation within this zone does not deplete surface water from the Snake River mainstem or its tributaries, it is supplied water from the Teton River Sub-basin.

The following sections further describe assumptions made to estimate future irrigated acreages for the high, mid, and low-growth scenarios along with the resulting acreage predictions.

High-Growth Scenario: Under the high-growth scenario, irrigated acres within the basin will increase only slightly from current levels for the duration of the 20-year projection period. Specifically, a total of about 103,600 irrigated acres is projected for the year 2032. In this scenario, it is assumed that irrigated acres in Teton County will remain at the current levels and that irrigated acres in Lincoln and Sublette Counties will increase at an annual rate of 0.33 percent.

Mid-Growth Scenario: Under the mid-growth scenario, irrigated acres within the basin will decrease slightly from the current levels for the duration of the planning horizon. Specifically, a total of about 94,600 irrigated acres is projected for the year 2032. In this scenario, it is assumed that irrigated acres in Teton County will decrease at an annual rate of 0.75 percent, reflecting the likelihood of continued residential development within the county. Lincoln and Sublette County irrigated acres will remain at current levels.

Low-Growth Scenario: For the low-growth scenario, irrigated acres within the basin will decrease from the current levels for the duration of the 20-year projection period. Specifically, a total of about 83,200 irrigated acres is projected for the year 2032. In this scenario, it is assumed that irrigated acres in Teton County will decrease at an annual rate of 1.50 percent, reflecting further residential development within the county. In Lincoln and Sublette Counties irrigated acres are assumed to decrease at an annual rate of 0.50 percent.

Table 6-3 summarizes the growth rates assumed for each irrigation zone and each growth scenario along with the current (2012) and projected (2032) irrigated acres. Annual increases or decreases in irrigated acres are also indicated.

Figure 6-2 presents a summary of the projections from a basin-wide perspective. Current and projected acres for the entire Snake/Salt River Basin are indicated along with the resulting aggregated projection rates that are comprised from the individual rates that were assumed for each irrigation zone. Refer to *Technical Memorandum, Tab I: Agricultural Water Use* for additional figures that illustrate the projected irrigated acres for each individual irrigation zone.

TYPICAL WHEEL LINE IRRIGATION SYSTEM

TABLE 6-3: IRRIGATED ACREAGE PROJECTIONS SUMMARY

Irrigation Zone	County	2012 Acres	Growth Scenario	Rate[1]	2032 Acres	Annual Increase or Decrease (Acres)
Zone 1 Teton	Teton	4,647	High	0.00%	4,647	0
			Mid	-0.75%	3,950	-35
			Low	-1.50%	3,253	-70
Zone 2 Upper Snake	Teton	6,967	High	0.00%	6,967	0
			Mid	-0.75%	5,922	-52
			Low	-1.50%	4,877	-105
Zone 3 Lower Snake	Teton	18,017	High	0.00%	18,017	0
			Mid	-0.75%	15,314	-135
			Low	-1.50%	12,612	-270
Zone 4 Hoback	Sublette	3,979	High	0.33%	4,242	13
			Mid	0.00%	3,979	0
			Low	-0.50%	3,581	-20
Zone 5 Lower Salt	Lincoln	33,811	High	0.33%	36,043	112
			Mid	0.00%	33,811	0
			Low	-0.50%	30,430	-169
Zone 6 Upper Salt	Lincoln	31,379	High	0.33%	33,450	104
			Mid	0.00%	31,379	0
			Low	-0.50%	28,241	-157
Zone 7 Greys	Lincoln	229	High	0.33%	244	1
			Mid	0.00%	229	0
			Low	-0.50%	206	-1
Acres Total: Snake/Salt River Basin		***99,029***	***High***	***0.23%***	***103,609***	***229***
			Mid	***-0.22%***	***94,584***	***-222***
			Low	***-0.80%***	***83,200***	***-791***

1. Rates shown in Total rows (in italics) represent the resulting rates based on aggregating the individual rates used for each irrigation zone.

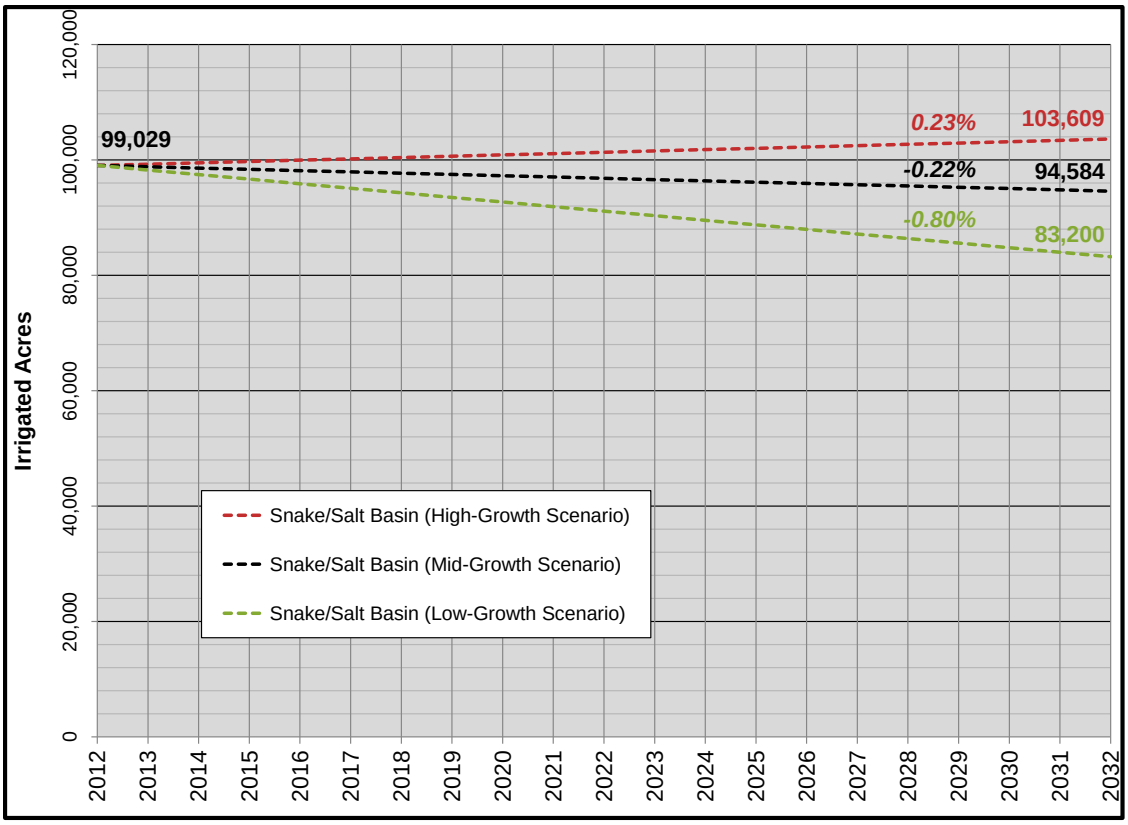

FIGURE 6-2: IRRIGATED ACREAGE PROJECTIONS FOR THE SNAKE/SALT RIVER BASIN

6.2.3 LIVESTOCK

Individual cattle, dairy cattle and sheep projection rates were assumed for each county within the Snake/Salt River Basin. For example, the projection rate used for sheep in Lincoln County was different than the projection rate used for sheep in Teton County. Additionally, individual projection rates for horses were assumed for three different usage categories; private, commercial and working horses.

The general aim in assigning mid-growth livestock projection rates was to keep the numbers similar to the 2012 numbers, with only modest increases or decreases, which reflect historic trends and information from interviews. For the low-growth scenarios, rates were assumed that resulted in slightly decreased livestock numbers. The high-growth scenarios assumed rates that resulted in slightly increased livestock numbers.

It is important to note that a certain number of livestock reside on the western aspects of the Teton Range near Alta, Wyoming. These livestock do not deplete surface water from the main stem of the Snake River or its tributaries; instead, they draw upon surface water supplies from the Teton River Sub-basin. This analysis did not distinguish projections between livestock residing in either of these sub-basins.

The following sections describe the information used and assumptions made to estimate future projections for cattle, dairy cattle, sheep, and horse inventories. Graphical representations of future inventory projections are also provided.

Although straight-line projections were employed in this study, it should be recognized that actual future livestock increases or decreases will likely be more varied in nature, similar to that represented in historic trends presented in Chapter 5, Section 5.1.8.1. The estimated annual increases or decreases in livestock numbers presented in the following sections should be interpreted from an overall perspective covering the 20-year planning horizon.

CATTLE

Regression analysis of historic data (1975 – 2012) was used to approximate the change in cattle numbers within the Snake/Salt River Basin. The rates of change in cattle numbers for Teton, Lincoln, and Sublette Counties were -2.05 percent, zero percent, and 0.75 percent, respectively. This equates to a -1.63 percent rate of change in cattle numbers historically for the entire basin (refer to Figure 6-3 and Figure 5-7 in Chapter 5).

For Teton County, a -1.00 percent rate of change was assumed for the mid-growth scenario to reflect the study team's anticipated overall reduction of approximately 45 head of cattle each year during the next 20 years. A -2.00 percent rate was used for the low-growth scenario to suggest a more significant decrease of 90 head annually. For the high-growth scenario, a 0.50 percent rate was assumed, representing a potential for a slight annual increase of approximately 23 head of cattle.

For Lincoln County, a zero percent rate of change was used for the mid-growth scenario, predicating that cattle numbers will be roughly constant during the next 20 years. A -0.50 percent rate was used for the low-growth scenario to suggest a slight overall decrease of about 15 head annually. Similarly, for the high-growth scenario, a 0.50 percent rate was assumed to suggest a slight annual increase of approximately 15 head of cattle.

For Sublette County, a zero percent rate of change was used for the mid-growth scenario which assumes that cattle numbers will be roughly constant over the planning horizon. A minus 0.50 percent rate was used for the low-growth scenario to suggest a slight annual overall decrease of about 9 head. Similarly, a 0.50 percent rate was assumed for the high-growth scenario to suggest a slight increase of about 9 head annually.

Table 6-4 summarizes the rates of change assumed for cattle along with the current (2012) and projected (2032) inventories of cattle by county. Annual overall increases or decreases in cattle inventories are also shown. Figure 6-3 illustrates the projected cattle inventories within the basin for the high, mid, and low-growth scenarios. The historic cattle inventory, trend line and rate of change are also displayed. Current and projected population numbers are shown along with the resulting aggregated projection rates, which are comprised of the individual rates assumed for Teton, Lincoln, and Sublette Counties.

TABLE 6-4: CATTLE POPULATION PROJECTIONS SUMMARY BY COUNTY

County	2012 Inventory (Head)	Growth Scenario	Rate[1]	2032 Inventory (Head)	Annual Increase or Decrease (Head)[2]
Teton	4,500	High	0.50%	4,950	23
		Mid	-1.00%	3,600	-45
		Low	-2.00%	2,700	-90
Lincoln	2,928	High	0.50%	3,220	15
		Mid	0.00%	2,928	0
		Low	-0.50%	2,635	-15
Sublette	1,855	High	0.50%	2,041	9
		Mid	0.00%	1,855	0
		Low	-0.50%	1,670	-9
Cattle Total: Snake/Salt River Basin	***9,283***	***High***	***0.50%***	***10,211***	***46***
		Mid	***-0.48%***	***8,383***	***-45***
		Low	***-1.23%***	***7,004***	***-114***

1. Rates shown in Total rows (in italics) represent the resulting rates based on aggregating the individual rates used for Teton, Lincoln, and Sublette Counties.
2. Annual increases or decreases in cattle should be interpreted from an overall perspective throughout the planning horizon. Actual increases or decreases are expected to be more varied in nature, similar to historic tendencies.

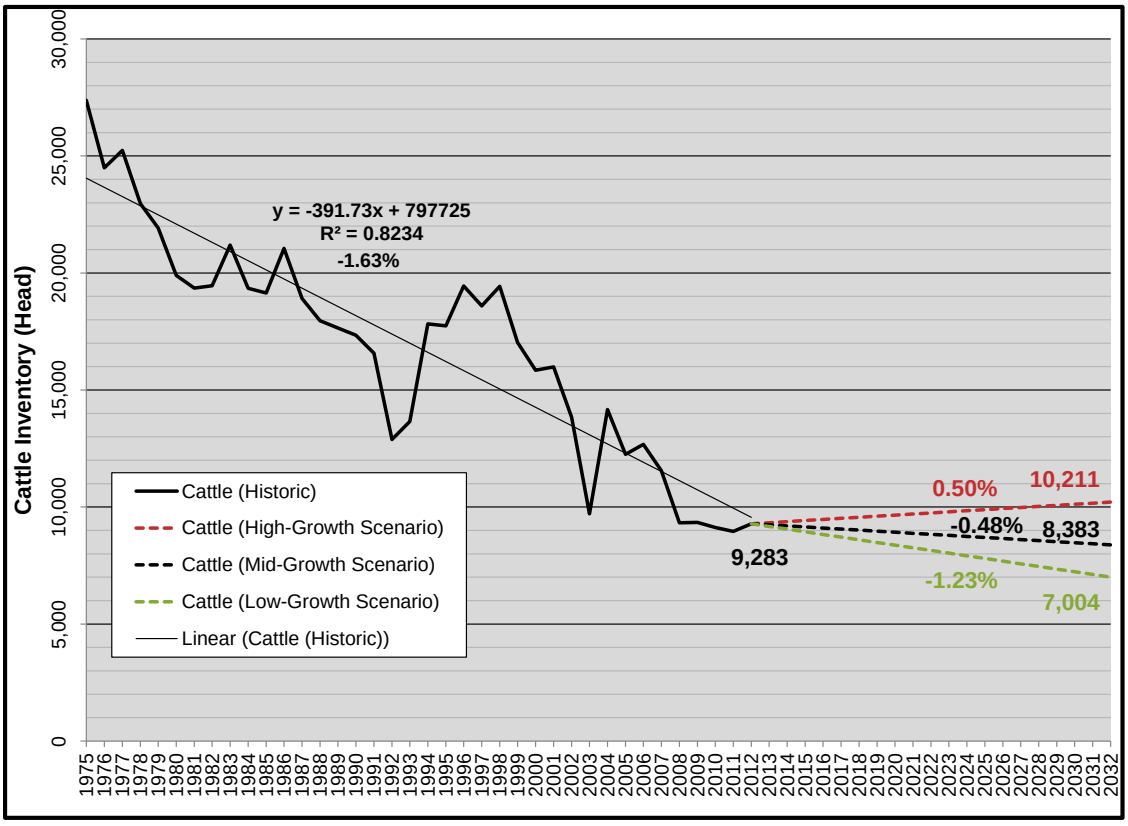

FIGURE 6-3: CATTLE POPULATION PROJECTIONS FOR THE SNAKE/SALT RIVER BASIN

DAIRY CATTLE

The only portion of the Snake/Salt River Basin where notable numbers of dairy cattle are still found is in the Star Valley region in Lincoln County. Therefore, projections for dairy cattle were limited to Lincoln County. Linear regression of historic data from 1975 through 2012 approximated a growth rate for dairy cattle as -1.98 percent per year (Refer to Figure 6-4 and Figure 5-8 in Chapter 5.)

A -0.50 percent growth rate was assumed for the mid-growth scenario to reflect the study team's anticipation of a slight overall decline of about 2 head of dairy cattle per year over the next 20 years. A -2.00 percent growth rate was used for the low-growth scenario to suggest a more significant decrease of approximately 8 head of dairy cattle annually. For the high-growth scenario, a 1.00 percent growth rate was assumed, representing a potential for a slight increase of about 4 dairy cattle per year.

Table 6-5 summarizes the growth rates assumed for dairy cattle along with the current (2012) and projected (2032) inventories within the Snake/Salt River Basin. Annual increases or decreases in overall dairy cattle populations are also shown. Figure 6-4 illustrates the projected dairy cattle inventories within the basin for the high, mid, and low-growth scenarios. The historic dairy cattle inventory, trend line, and growth rate are also displayed. Current and projected population counts are also shown.

DAIRY CATTLE CAN STILL BE FOUND IN STAR VALLEY, ALTHOUGH THEIR NUMBERS ARE DECREASING.

TABLE 6-5: DAIRY CATTLE POPULATION PROJECTIONS SUMMARY

County	2012 Inventory (Head)	Growth Scenario	Rate	2032 Inventory (Head)	Annual Increase or Decrease (Head)[1]
Lincoln	405	High	1.00%	486	4
		Mid	-0.50%	365	-2
		Low	-2.00%	243	-8

1. Annual increases or decreases in dairy cattle should be interpreted from an overall perspective throughout the planning horizon. Actual increases or decreases are expected to be more varied in nature, similar to historic tendencies.

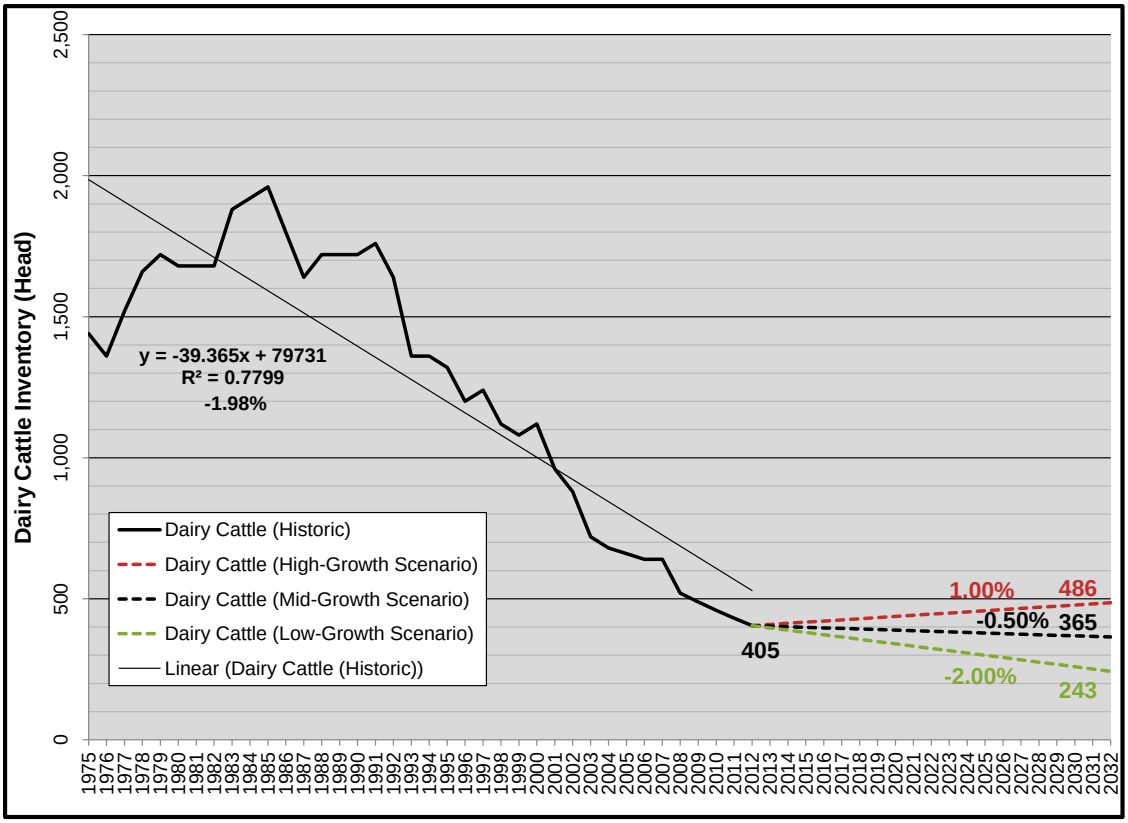

FIGURE 6-4: DAIRY CATTLE POPULATION PROJECTIONS FOR THE SNAKE/SALT RIVER BASIN

SHEEP

A linear regression, using historic data, estimated sheep populations in Teton, Lincoln, and Sublette Counties within the Snake/Salt River Basin as zero percent, 0.11 percent and 3.94 percent, respectively. This equates to an aggregate historic growth rate of approximately 0.24 percent for the entire basin. (Refer to Figure 6-5 and Figure 5-9 in Chapter 5.)

For Teton and Sublette Counties, a 0.50 percent growth rate was used for the mid-growth scenarios which assume a slight overall increase of about two sheep each year over the planning horizon. For the high-growth scenario, a 1.00 percent growth rate was assumed, representing a slightly higher increase of approximately three sheep per year. A -0.25 percent growth rate was used for the low-growth scenario to suggest a slight decrease of about one head annually.

For Lincoln County, the mid-growth scenario was based on a 0.50 percent growth rate, predicating that sheep numbers would generally increase annually by about 55 sheep. The high-growth scenario assumed a 1.00 percent growth rate which results in sheep numbers increasing by about 109 per year. The low-growth scenario used a zero percent growth rate that assumed sheep numbers would remain roughly the same for the next 20 years.

Table 6-6 summarizes the growth rates assumed for sheep along with the current (2012) and projected (2032) inventories of sheep by county within the Snake/Salt River Basin. Annual increases or decreases in overall sheep populations are also shown. Figure 6-5 illustrates the projected sheep inventories within the basin for the high, mid, and low-growth scenarios. The historic sheep inventory, trend line, and growth rate are also displayed. Current and projected population counts are also shown along with the resulting aggregated projection rates that reflect the individual rates assumed for Teton, Lincoln, and Sublette Counties.

A MODERATE INCREASE IN SHEEP NUMBERS WITHIN THE BASIN IS PROJECTED UNDER THE HIGH AND MID-GROWTH SCENARIOS.

TABLE 6-6: SHEEP POPULATION PROJECTIONS SUMMARY BY COUNTY

County	2012 Inventory (Head)	Growth Scenario	Rate[1]	2032 Inventory (Head)	Annual Increase or Decrease (Head)[2]
Teton	300	High	1.00%	360	3
		Mid	0.50%	330	2
		Low	-0.25%	285	-1
Lincoln	10,920	High	1.00%	13,104	109
		Mid	0.50%	12,012	55
		Low	0.00%	10,920	0
Sublette	300	High	1.00%	360	3
		Mid	0.50%	330	2
		Low	-0.25%	285	-1
Sheep Total: Snake/Salt River Basin	***11,520***	***High***	***1.00%***	***13,824***	***115***
		Mid	***0.50%***	***12,672***	***58***
		Low	***-0.01%***	***11,490***	***-2***

1. Rates shown in Total rows (in italics) represent the resulting rates based on aggregating the individual rates used for Teton, Lincoln, and Sublette Counties.
2. Annual increases or decreases in sheep should be interpreted from an overall perspective throughout the planning horizon. Actual increases or decreases are expected to be more varied in nature, similar to historic tendencies.

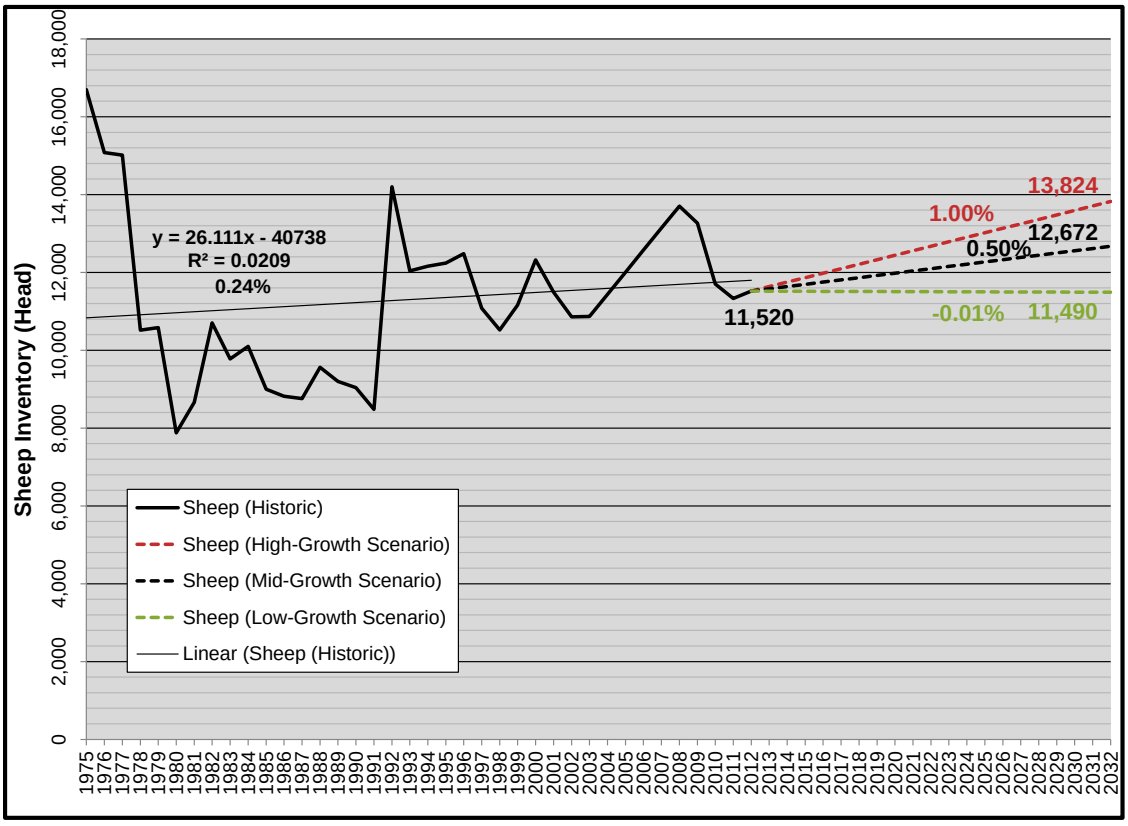

FIGURE 6-5: SHEEP POPULATION PROJECTIONS FOR THE SNAKE/SALT RIVER BASIN

HORSES

A linear regression of historic data approximated the increase in horse numbers in Teton, Lincoln, and Sublette Counties within the Snake/Salt River Basin as 7.07 percent, 3.96 percent, and 2.77 percent, respectively. This equates to an aggregate historic increase of approximately 5.82 percent for the entire basin. (Refer to Figure 6-6 and Figure 5-10 in Chapter 5.)

Rather than by county, future horse numbers were predicted based on three different usage categories; private, commercial, and working horses. Private horses were defined as those owned by individuals. Commercial horses were those used by riding businesses such as dude ranches and outfitters. Working horses were those owned and used on ranches in a traditional working horse environment.

The study team felt that grouping horses into these use categories would help formulate a more tangible basis for projections. A better impression of future horse numbers throughout the basin could be established through this approach, rather than developing projections by county. For instance, commercial horses, which represent the largest sector of horses within the basin, are commonly relocated to different counties throughout different times of the year, thereby making projections by county problematic.

A current year (2012) total count of 5,349 horses within the Snake/Salt River Basin was established in Chapter 5 Section 5.1.8.1. From this total count, percentages of private, commercial and working horses were assumed as follows:

- Private Horses .....20 Percent (or 1,070 horses for year 2012)
- Commercial Horses.....65 Percent (or 3,477 horses for year 2012)
- Working Horses .....15 Percent (or 802 horses for year 2012)

Projection rates for private horses are tied to the projection rates developed for human population growth, predicating that horse numbers would increase at more or less the same rate as the population of individuals residing within rural areas in the basin. A 1.00 percent growth rate was assumed for the mid-growth scenario, which equates to an overall increase of about 11 horses per year. The low-growth scenario assumed a 0.30 percent growth rate or an increase of approximately three horses each year. For the high-growth scenario, a 2.30 percent growth rate was used, equating to an overall increase of about 25 horses per year. These projection rates generally match the rates assumed for population growth within the basin. (Refer to Section 6.1 along with *Technical Memorandum, Tab XVII: Population Projections and Economic Conditions*.)

Commercial horses represent the largest sector of the horse population within the basin. This is primarily due to the increased demand for commercial horses. A 1.00 percent growth rate was used for the mid-growth scenario to reflect the study team's assumption that commercial horse counts will generally increase by about 35 horses annually during the next 20 years. A zero percent growth rate was used for the low-growth scenario to suggest no change in commercial horse numbers within the planning horizon. For the high-growth scenario, a 2.00

percent growth rate was assumed to suggest an overall annual increase in commercial horse numbers by about 70 horses.

For working horses, a zero percent growth rate was used for the mid-growth scenario to suggest that the number of traditional working horses within the basin would remain roughly the same during the next 20 years. A -1.00 percent growth rate was used for the low-growth scenario to suggest an overall decline in working ranch horse numbers of about 8 horses per year. For the high-growth scenario, a 0.50 percent growth rate was assumed to propose a slight increase in working horse numbers of about 4 per year.

Table 6-7 summarizes the growth rates assumed for horses along with the current (2012) and projected (2032) inventories of horses by usage type within the Snake/Salt River Basin. Annual increases or decreases in overall horse populations are also shown. Figure 6-6 illustrates the projected horse inventories for the high, mid, and low-growth scenarios. The historic horse inventory, trend line and growth rate are also displayed. Current and projected populations are shown along with the resulting aggregated projection rates that are comprised of individual rates assumed for private, commercial and working horses.

HORSE NUMBERS WITHIN THE BASIN ARE PREDICTED TO INCREASE UNDER THE HIGH AND MID-GROWTH SCENARIOS.

TABLE 6-7: HORSE POPULATION PROJECTIONS SUMMARY BY CATEGORY

Use Category	2012 Inventory (Head)	Growth Scenario	Rate[1]	2032 Inventory (Head)	Annual Increase or Decrease (Head)[2]
Private Horses	1,070	High	2.30%	1,562	25
		Mid	1.00%	1,284	11
		Low	0.30%	1,134	3
Commercial Horses	3,477	High	2.00%	4,868	70
		Mid	1.00%	4,172	35
		Low	0.00%	3,477	0
Working Horses	802	High	0.50%	883	4
		Mid	0.00%	802	0
		Low	-1.00%	642	-8
Horses Total: Snake/Salt River Basin	***5,349***	***High***	***1.83%***	***7,312***	***98***
		Mid	***0.85%***	***6,258***	***45***
		Low	***-0.09%***	***5,253***	***-5***

1. Rates shown in Total rows (in italics) represent the resulting rates based on aggregating the individual rates used for private, commercial, and working horses.
2. Annual increases or decreases in horses should be interpreted from an overall perspective throughout the planning horizon. Actual increases or decreases are expected to be more varied in nature, similar to historic tendencies.

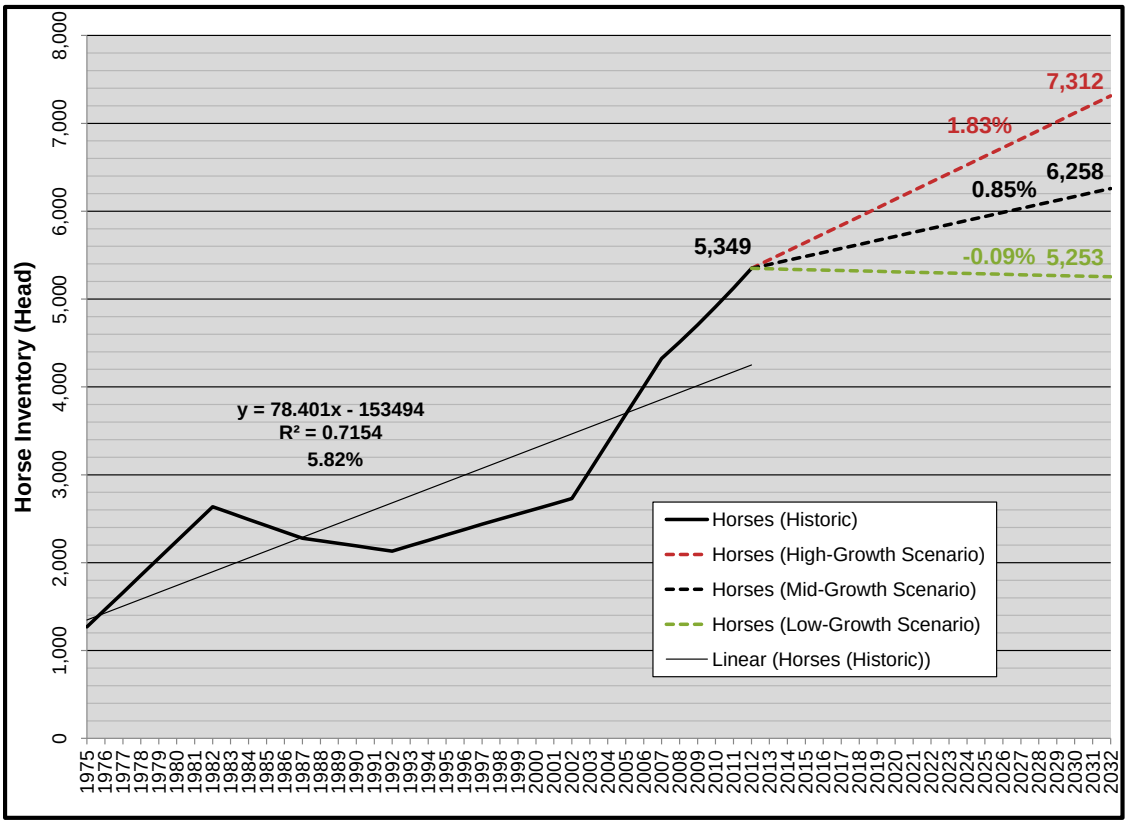

FIGURE 6-6: HORSE POPULATION PROJECTIONS FOR THE SNAKE/SALT RIVER BASIN

6.2.4 FUTURE WATER DEMAND PROJECTIONS

This section presents future agricultural water demand projections for irrigation and livestock within the Snake/Salt River Basin under the three previously discussed scenarios. Water use factors used to determine water demands are presented, followed by the projected annual water demands by scenario. Current day water demand estimates are also provided. It was assumed that all water used by the agricultural sector within the basin comes from surface water diversions.

6.2.4.1 WATER USE FACTORS

Estimates of the two agricultural water use factors (irrigation and livestock use) are described in this section. Water use factors are presented in terms of consumptive use, or depletion, for determining current and future water demands.

IRRIGATION

Crop irrigation requirements (CIR), specific to each irrigation zone for the study period (1971 through 2010), were calculated as part of this Update as described in Chapter 5. CIR numbers represent depletion estimates or full-supply diversions within the spreadsheet models. These numbers were subsequently used to establish the annual water use factors for irrigation in acre-feet per acre (AF/acre). Water use factors were determined by dividing the annual depletion of each irrigation zone by the acres within each irrigation zone. Table 6-8 summarizes the acreage, annual depletion quantity, and water use factor for each irrigation zone. These water use factors were multiplied by future projected acres to establish future water demands in acre-feet per year (AFY).

TABLE 6-8: WATER USE FACTORS FOR IRRIGATION

Irrigation Zone	Acres[1]	Annual Depletion (AFY)[1]	Water Use Factor (AF/Acre)
Zone 1: Teton	4,647	3,908	0.8410
Zone 2: Upper Snake	6,967	5,531	0.7938
Zone 3: Lower Snake	18,017	17,694	0.9821
Zone 4: Hoback	3,979	3,060	0.7690
Zone 5: Lower Salt	33,811	27,860	0.8240
Zone 6: Upper Salt	31,379	26,434	0.8424
Zone 7: Greys	229	185	0.8077
Total: Snake/Salt River Basin	***99,029***	***84,671***	***0.8550***

1. Refer to Table 5-5 in Chapter 5.

LIVESTOCK

To standardize the analysis in terms of livestock forage levels, water use factors for cattle, sheep, and horses were estimated on an animal unit basis. Animal unit estimates were calculated by multiplying estimated cattle inventories by one, dividing sheep inventories by five, and multiplying horse inventories by 1.2. As stated in the previous Basin Plan, range specialists for the Bridger-Teton National Forest estimate a daily requirement of 17.5 gallons for each cow-calf pair. A cow-calf pair is a common definition of an animal unit. This study applied a livestock water use factor of 0.0196 acre-feet per animal unit per year,

matching the factor that was used in the previous Basin Plan (BBC Research and Consulting, Inc., 2002c).

Dairy cattle water use factors were estimated on a per head basis. The previous Basin Plan cited daily water use factors for dairy cattle at 35 gallons per head and between 22 and 46 gallons per head depending on the season. For this Update, the study team chose the same daily water use factor used in the previous Basin Plan, 35 gallons per head. This converts to 0.0392 acre-feet per head on an annual basis. It was assumed that all the Star Valley dairies are too small to have significant facility-cleaning water use requirements (BBC Research and Consulting, Inc., 2002c).

6.2.4.2 PROJECTED ANNUAL WATER DEMANDS BY SCENARIO

This section presents irrigation and livestock annual water demand projections for the three growth scenarios over a 20-year planning horizon. Water demand projections for irrigation were derived by multiplying predicted acres by the irrigation water use factors. Livestock water demand projections were derived by multiplying or dividing the predicted livestock inventories by each respective water use factor.

Tables 6-9 and 6-10 present the current and future annual water demand projections by growth scenario for irrigation and livestock, respectively. Table 6-11 summarizes the current and future annual water demand projections for the entire Snake/Salt River Basin. Note the quantities presented in the tables should be interpreted as depletions. Unlike the previous Basin Plan, diversion quantities were not estimated as part of the 2012 Update.

TABLE 6-9: ANNUAL WATER DEMAND PROJECTIONS FOR IRRIGATION

Irrigation Zone	Current (2012) (AFY)	Projected (2032) (AFY)		
		High-Growth Scenario	Mid-Growth Scenario	Low-Growth Scenario
Zone 1: Teton	3,908	3,908	3,322	2,736
Zone 2: Upper Snake	5,531	5,531	4,701	3,871
Zone 3: Lower Snake	17,694	17,694	15,040	12,386
Zone 4: Hoback	3,060	3,262	3,060	2,754
Zone 5: Lower Salt	27,860	29,698	27,860	25,074
Zone 6: Upper Salt	26,434	28,179	26,434	23,791
Zone 7: Greys	185	197	185	166
Irrigation Total: Snake/Salt River Basin	***84,671***	***88,468***	***80,601***	***70,777***

TABLE 6-10: ANNUAL WATER DEMAND PROJECTIONS FOR LIVESTOCK

Livestock Type	Current (2012) (AFY)	Projected (2032) (AFY)		
		High-Growth Scenario	Mid-Growth Scenario	Low-Growth Scenario
Cattle	182	200	164	137
Sheep	45	54	50	45
Horses	126	172	147	124
Dairy Cattle	16	19	14	10
Livestock Total: Snake/Salt River Basin	***369***	***445***	***376***	***315***

TABLE 6-11: ANNUAL AGRICULTURAL WATER DEMAND PROJECTIONS FOR THE SNAKE/SALT RIVER BASIN

Agricultural Sector	Current (2012) (AFY)	Projected (2032) (AFY)		
		High-Growth Scenario	Mid-Growth Scenario	Low-Growth Scenario
Livestock	369	445	376	315
Irrigation	84,671	88,468	80,601	70,777
Agricultural Total: Snake/Salt River Basin	***85,040***	***88,913***	***80,977***	***71,092***

Under the high-growth scenario, total annual agricultural water demand within the basin grows by about 4.6 percent over the projection period of 20 years. Under the mid-growth scenario, total annual agricultural water demand declines by roughly 4.8 percent over the projection period. For the low-growth scenario, total annual agricultural water demand declines by approximately 16.4 percent over the projection period. Under all three scenarios, the vast majority of agricultural water demand remains in irrigated crop production, with less than one percent of total projected agricultural consumptive use going to direct livestock sustenance. For a comparison of the results of this 2012 Update to the results and methodology from the previous Basin Plan, refer to *Technical Memorandum, Tab I: Agricultural Water Use*.

6.3 MUNICIPAL AND DOMESTIC WATER USE

Municipal and rural domestic water in the Snake/Salt River Basin is from groundwater and is considered almost entirely consumptive since return flows are limited. Water use in municipalities is estimated to be 262 gpcpd and 121 gpcpd for rural domestic residents. Current water use in the basin is 7,790 AF annually for municipalities and 1,075 AF per year for rural domestic uses. This totals 8,865 AF of groundwater use annually.

Municipal and rural domestic water use will change as the population changes. All three growth scenarios developed for this plan update show an increase in the basin population. In the high-growth scenario, the basin population is estimated to increase to 50,679 by 2032. The mid-growth scenario has an estimated population of 42,033 by 2032, while the low-growth scenario has an estimated population increase to 36,413 by 2032. For this analysis, the ratio between residents living in municipalities or districts with central water systems and rural domestic

residents remains the same as the current ratio. Approximately 77 percent of the basin residents live in cities, towns, or within communities with central water systems, and about 23 percent live in rural areas served by individual wells.

Table 6-12 presents the basin population for the three growth scenarios and the projected estimated annual groundwater use.

6-12. SNAKE/SALT RIVER BASIN PROJECTED MUNICIPAL AND DOMESTIC ANNUAL CONSUMPTIVE GROUNDWATER USE IN 2032

Sector	High Scenario		Mid Scenario		Low Scenario	
	Population	Water Use (AFY)	Population	Water Use (AFY)	Population	Water Use (AFY)
Municipal	39,023	11,452	32,365	9,498	28,038	8,228
Domestic	11,656	1,579	9,668	1,310	8,375	1,135
Total	***50,679***	***13,031***	***42,033***	***10,808***	***36,413***	***9,363***

6.4 INDUSTRIAL WATER USE

Industrial water use is very limited in the Snake/Salt River Basin. As reported in the 2003 Plan, there were approximately 48 acre-feet consumed annually by three industries (Sunrise Engineering, Inc., 2003). These industries, which were located in the Salt River Sub-basin, have all since closed, and industrial water use is currently zero. One hydropower plant was operating in 2003, and there are now four plants running, producing about 3,300 kilowatts. Hydropower plants do not consume water and return the diverted water to the stream.

There is potential for industrial development to increase in the basin. Dairies in the Salt River Sub-basin provide milk resources that could supply associated industries. Additionally, potential oil and gas resource development could occur in the Hoback River drainage of the Greys Hoback River Sub-basin (U.S. Forest Service, 2010). However, the Trust for Public Land along with other groups purchased leases from Plains Exploration and Production, which were in the Bridger-Teton National Forest near Bondurant, eliminating the potential for oil and gas development in the area in the near term (Voge, 2013).

The high, mid and low-growth scenarios were developed from past industrial water use. Assumptions for each of these scenarios are presented below. Results are presented in Table 6-13. Hydropower production is assumed to remain stable in all three scenarios.

Assumptions for the High-Growth Scenario:

- One dairy related industry is established in the Salt River Sub-basin in 2014 consuming 24 acre-feet of groundwater per year.
- A second industry becomes established in the Salt River Sub-basin consuming 16 acre-feet annually (16 acre-feet of water was consumptively used annually by Water Star Bottling in the 2003 Plan). Total industrial groundwater consumption in the Salt River Sub-basin would be 40 acre-feet annually.

Assumptions for the Mid-Growth Scenario:

- One dairy related industry is established in the Salt River Sub-basin in 2014 consuming 24 acre-feet of groundwater per year (24 acre-feet of water was consumptively used annually by Star Valley Cheese in the 2003 Plan).

Assumptions for the Low-Growth Scenario:

- No dairy related industries develop. Industrial water use in Snake/Salt River Basin remains at zero through the planning period.

TABLE 6-13: ANNUAL INDUSTRIAL WATER DEMAND PROJECTIONS FOR THE SNAKE/SALT RIVER BASIN

Source	Current (2012) (AFY)	Projected (2032) (AFY)		
		High Scenario	Mid Scenario	Low Scenario
Surface Water	0	0	0	0
Groundwater	0	40	24	0
Industrial Total: Snake/Salt River Basin	***0***	***40***	***24***	***0***

6.5 ENVIRONMENTAL AND RECREATIONAL WATER USE

With Grand Teton National Park and the South Entrance to Yellowstone National Park residing within the Snake/Salt River Basin, environmental and recreational water uses are important components of the basin's economy. This section of the report summarizes the trends for this water use sector.

6.5.1 GRAND TETON AND YELLOWSTONE NATIONAL PARKS ENTRANCE DATA

Visitor totals have been kept for Grand Teton National Park (GTNP) since 1929 and for Yellowstone National Park (YNP) since 1904. The number of visitors to National Parks has gone up and down over the years with the most recent trend being towards increased visitation (National Park Service, 2012). Figures 6-7 and 6-8 illustrate park visitation by year for GTNP and YNP.

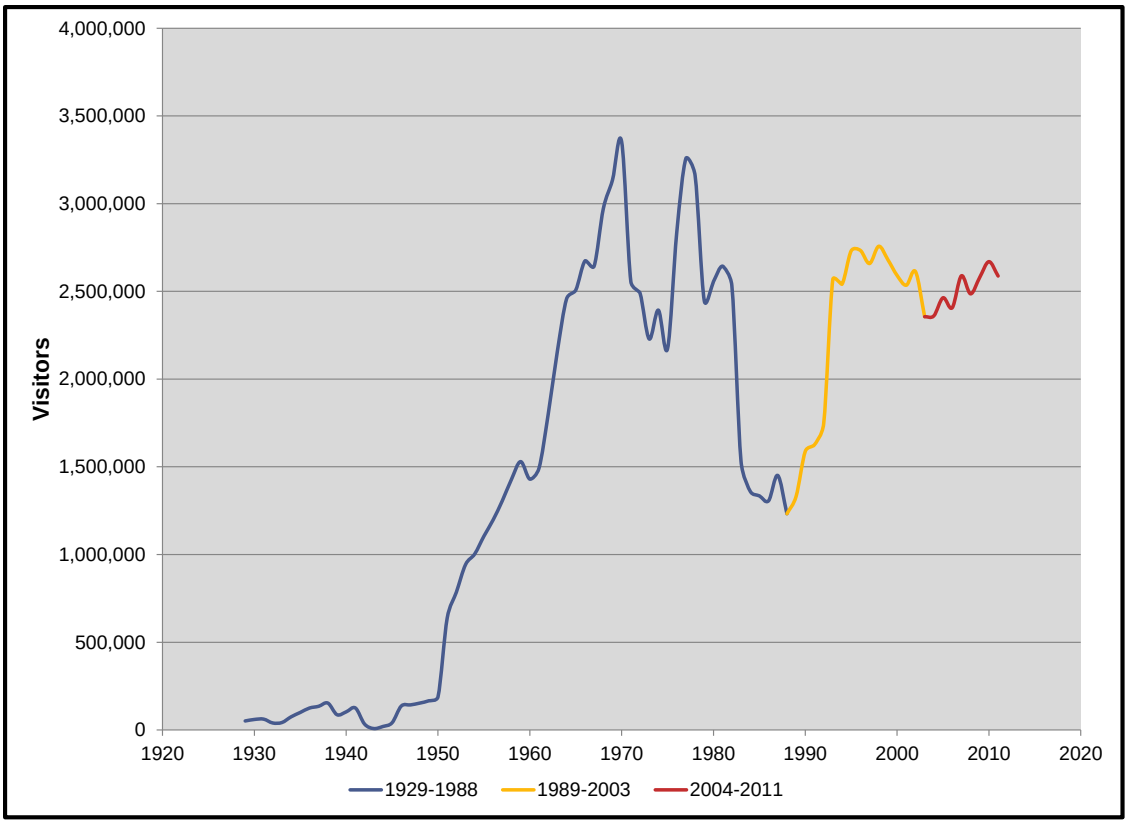

FIGURE 6-7: GRAND TETON NATIONAL PARK VISITATION BY YEAR

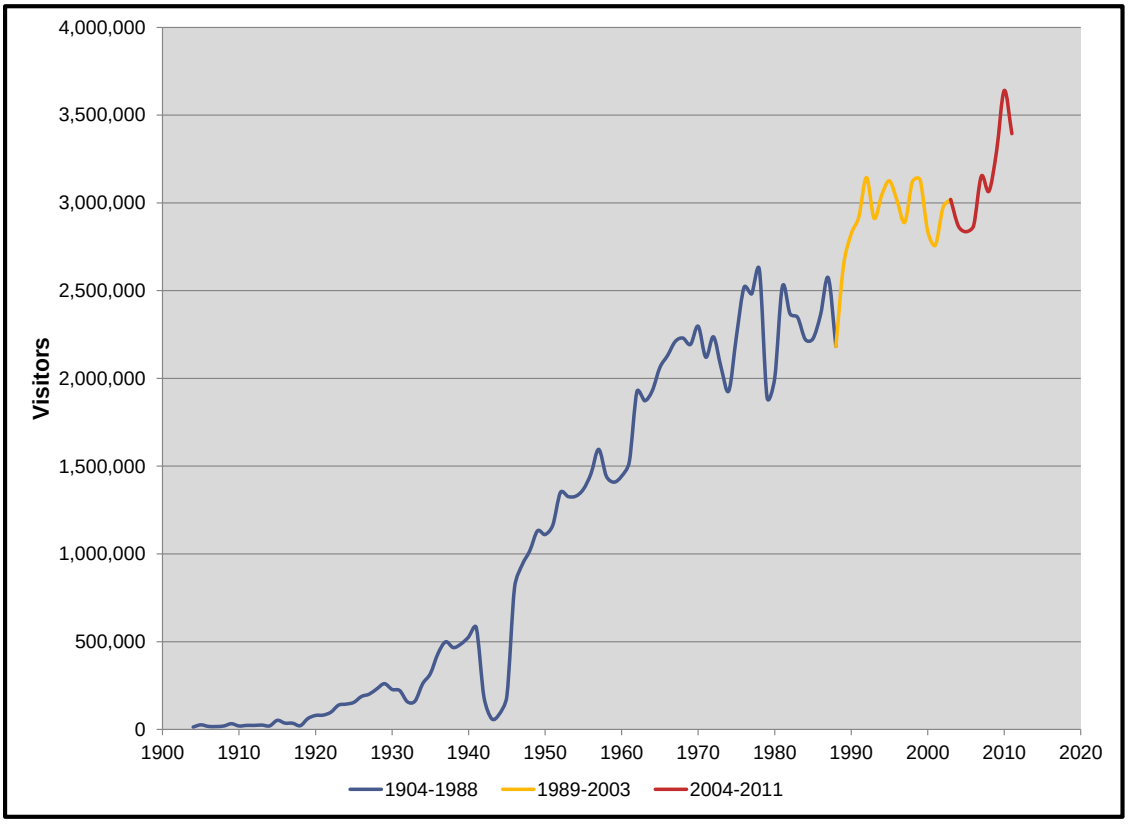

FIGURE 6-8: YELLOWSTONE NATIONAL PARK VISITATION BY YEAR

6.5.2 LEISURE TAX TRENDS

Leisure and hospitality taxes are collected along with state sales tax on arts, entertainment, recreation, accommodations, and food services (DAIEAD, 2011). Leisure and hospitality tax data were analyzed for Teton County to help show the trend in tourism. Sales tax data are available for all counties in Wyoming; however Teton County is the only county that is located completely within the Snake/Salt study area, so it was selected to represent trends within the basin. Figure 6-9 shows that revenues collected by this sector in Teton County have been on the rise for the last several years.

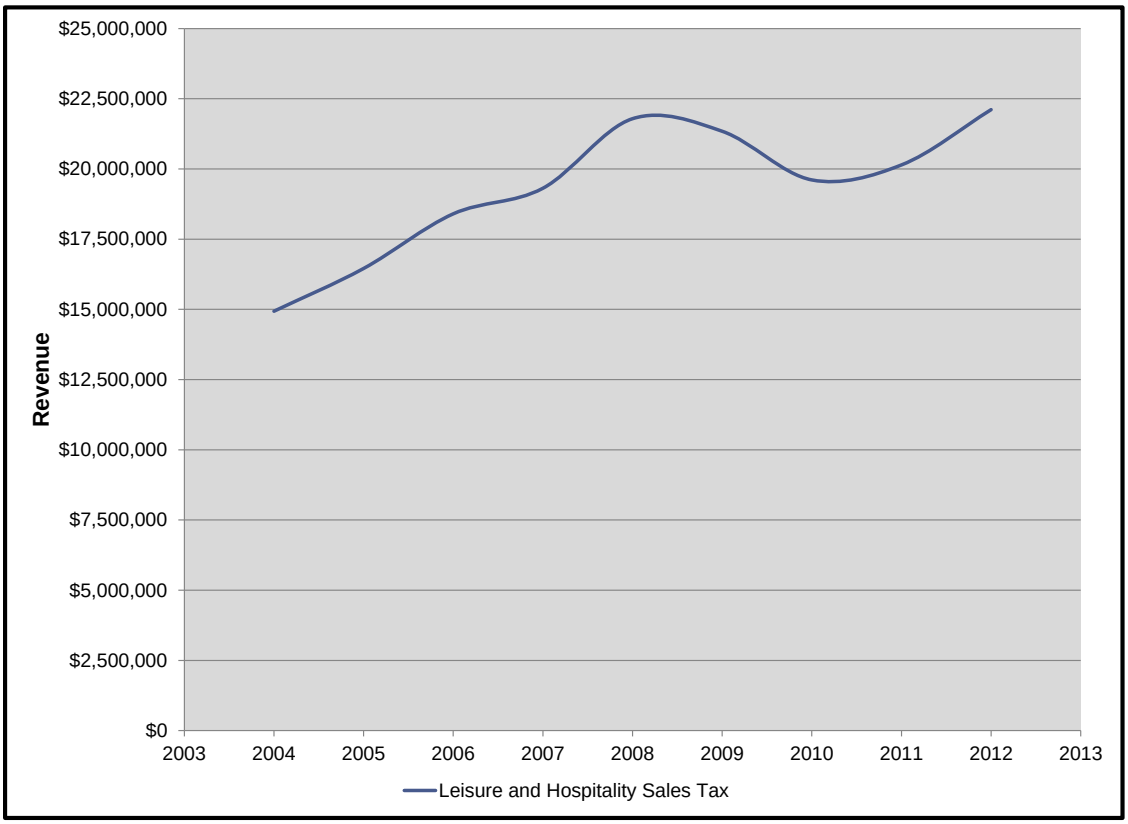

FIGURE 6-9: TETON COUNTY LEISURE AND HOSPITALITY SALES TAX REVENUE

6.5.3 LODGING TAX CHANGES

In November 2010, voters in Teton County approved a 2 percent lodging tax Because there was only one complete year of data on this new tax, it was not considered as a part of the trend analysis.

6.5.4 POPULATION RELATIONSHIP TO ENVIRONMENTAL AND RECREATIONAL TRENDS

As described in *Technical Memorandum, Tab XVII: Population Projections and Economic Conditions*, there is a link between the population of the basin and the demand for environmental and recreational water uses. Despite the fact that irrigation water use has remained relatively constant, the basin population has continued to increase. Because tourism is the basin's largest industry, it can be concluded that the increase in population is related to the tourism industry. In many ways this industry is tied to the environmental and recreational uses of the basin. Refer to

Technical Memorandum, Tab XVII: Population Projections and Economic Conditions for further information.

6.5.5 ENVIRONMENTAL AND RECREATIONAL WATER USE ON FEDERAL LAND

As shown on the Land Ownership map in Chapter 3 (Figure 3.2) and described in *Technical Memorandum, Tab IV: Environmental and Recreational Water Use*, much of the land within the basin is federally owned. This has a significant effect on the environmental and recreational water uses of the basin. Most of the environmental and recreational water uses in the basin are on federal land, largely because of public access to these areas. As a result of federal ownership and oversight, it is safe to assume access to the basin's public environmental and recreational uses will remain unchanged and therefore the available opportunities will also remain unchanged in the future. These uses will increase and become more important as the population and tourism increase in the basin. Although, environmental and recreational water uses are nonconsumptive, demands for these water uses are expected to increase in all growth scenarios. The demands should follow the growth projections and would be somewhat limited in the low-growth scenario due to limited population growth.

6.6 RESERVOIR EVAPORATION

Reservoir evaporation was discussed in Chapter 5 as part of current water use. It is not expected that reservoir evaporation will change significantly over the planning period. Major reservoir operations are not expected to change over the planning period, and therefore, evaporation from these reservoirs will remain approximately the same. Additionally, it is assumed that the loss or development of smaller reservoirs within the basin will not substantially change the volume of reservoir evaporation over the planning period.

Reservoir evaporation is estimated to be 72,175 acre-feet annually for all three of the growth scenarios.

6.7 SUMMARY OF PROJECTED WATER USE

The Snake/Salt River Basin population is predicted to grow over the 20 year planning period from 2012 to 2032. Growth is likely due to the strength of tourism and second home development and the associated growth in the service industries. Population is projected to increase in all growth scenarios, although the population increase is limited in the low-growth scenario. Increases in groundwater use will accompany the growth in population, since municipal and rural domestic water uses are supplied from groundwater.

Surface water use is estimated to increase only in the high-growth scenario, due to increases in agricultural irrigation in the Salt River Sub-basin (Lower Salt and Upper Salt Irrigation Zones) and in the Hoback and Greys Irrigation Zones. Surface water use would increase from 157,215 acre-feet to 161,088 acre-feet annually. In the mid and low-growth scenarios, irrigated acres would decrease as the lands are converted to other uses, reducing surface water use.

Industrial water use is projected to remain a minor use in the basin over the planning period. There are limited increases in industrial water use in the high and mid-growth scenarios and no industrial water use in the low-growth scenario.

Environmental and recreational water uses are nonconsumptive but are important uses because of the basin's dependence on environmental aesthetics for tourism, outdoor recreation and second home development. These uses will generally remain constant because of the protection afforded environmental and recreational water uses in much of the basin. However, some conflicts could develop if irrigated acres increase, if access to lands and stream segments decreases as parcels are developed, or as an increasing population drives greater demand for environmental and recreational water uses. This could change stream segments that currently have the status of complementary water uses to having competing water uses.

Municipal, rural domestic and industrial groundwater uses consume 13,072 AFY in the high-growth scenario, 10,832 AFY in the mid-growth scenario, and 9,364 AFY in the low-growth scenario in 2032. In addition to these uses, there are other miscellaneous groundwater uses in the basin. An estimate of the current miscellaneous groundwater uses was presented in Chapter 5 and equaled 886 AFY. If, allowing for growth, 900 AFY is added to the high and mid-growth scenarios, total consumptive groundwater use would equal 13,972 AFY for the high-growth scenario and 11,732 AFY for the mid-growth scenario in 2032. Total groundwater consumptive use for the low-growth scenario in 2032 would be 10,250 AFY, if no change in miscellaneous groundwater use is assumed to be (886 AFY).

Tables 6-14, 6-15, and 6-16 present the projected consumptive water use by sector for the three growth scenarios high, mid and low. The tables show both surface water and groundwater use for the Snake/Salt River Basin.

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TABLE 6-14: PROJECTED WATER USE FOR THE HIGH-GROWTH SCENARIO, 2032 (AFY)

Type/Use	Agricultural Irrigation[1]	Livestock Watering	Municipal	Domestic	Industrial	Reservoir Evaporation	*Total*
Surface Water	88,468	445	0	0	0	72,175	***161,088***
Groundwater	0	0	11,452	1,580	40	0	***13,072***

1. Agricultural Irrigation includes the Teton River Basin. Total Agricultural Irrigation consumptive use for the Teton River Basin equals 3,908 AFY in the High-Growth Scenario.

TABLE 6-15: PROJECTED WATER USE FOR THE MID-GROWTH SCENARIO, 2032 (AFY)

Type/Use	Agricultural Irrigation[1]	Livestock Watering	Municipal	Domestic	Industrial	Reservoir Evaporation	*Total*
Surface Water	80,601	376	0	0	0	72,175	***153,152***
Groundwater	0	0	9,498	1,310	24	0	***10,832***

1. Agricultural Irrigation includes the Teton River Basin. Total Agricultural Irrigation consumptive use for the Teton River Basin equals 3,322 AFY in the Mid-Growth Scenario.

TABLE 6-16: PROJECTED WATER USE FOR THE LOW-GROWTH SCENARIO, 2032 (AFY)

Type/Use	Agricultural Irrigation[1]	Livestock Watering	Municipal	Domestic	Industrial	Reservoir Evaporation	*Total*
Surface Water	70,777	315	0	0	0	72,175	***143,267***
Groundwater	0	0	8,229	1,135	0	0	***9,364***

1. Agricultural Irrigation includes the Teton River Basin. Total Agricultural Irrigation consumptive use for the Teton River Basin equals 2,736 AFY in the Low-Growth Scenario.

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7.0 WATER AVAILABILITY

7.0 WATER AVAILABILITY

TABLE OF CONTENTS

7.1 Surface Water Model....126
7.1.1 Streamflow Gage Data....130
7.1.1.1 Gage Filling and Data Extension....130
7.1.2 Dry, Average, and Wet Years Classification....131
7.1.3 Ungaged Tributary Inflow Estimation....131
7.1.4 Diversion Data....133
7.2 Surface Water Availability....133
7.2.1 Physically Available Flow from Spreadsheet Models....134
7.2.2 Adjusted Physically Available Flow....135
7.2.2.1 Jackson Lake Operations....135
7.2.2.2 Instream Flow Requirements....137
7.2.2.3 Summary of Adjusted Physically Available Flow....138
7.2.3 Available Flow per Compact Limitations....138
7.2.4 Available Flow Summary....140
7.3 Groundwater Availability....145
7.4 Water Conservation....146
7.5 Summary of Water Availability....148
References....153

7.0 WATER AVAILABILITY

This chapter presents a discussion of the spreadsheet models and results of the modeling efforts for the Snake/Salt River Basin. Surface water and groundwater availability are estimated for three growth scenarios, high, mid and low-growth. Additionally, water conservation is discussed and a summary of water available for future development is presented.

7.1 SURFACE WATER MODEL

Spreadsheet models were developed to determine average monthly streamflow in the Snake/Salt River Basin during dry, average, and wet years. The purpose of these models is to validate existing basin uses, assist in determining the timing and location of water availability for future development, and to help assess impacts of future water supply alternatives. Each spreadsheet model represents one calendar year of flows on a monthly time-step and relies on historic gage data to identify the hydrologic conditions for each year in the study period. The models were built on the Microsoft Excel platform.

Because historic diversion data were unavailable, total diversions and resulting return flows were not explicitly included in the models. In the models, only the consumptive use portion of the diversions is taken out of the stream. Therefore, streamflow and consumptive use are the basic model inputs. The models do not explicitly account for water rights, appropriations or Compact allocations, nor are the models operated based on these legal constraints. It is assumed limitations that may be placed on users due to water right restrictions are reflected in the number of irrigation days included in the consumptive use calculations.

The spreadsheet models developed for the 2003 Snake/Salt River Basin Plan were used as a basis for the 2012 Update. Except for updates to input data sets, which reflect the new period of record of 1971 through 2010, and the changes documented below, the spreadsheet models remain mostly unchanged. Since most of the spreadsheet model descriptions and operations remain the same and rather than repeating information herein, the reader can refer to the final report and associated technical memoranda from the previous Basin Plan (Sunrise Engineering, Inc., 2003).

As in the previous Basin Plan, for both the Snake and Salt River Basins, three 12-month spreadsheet models, each representing a dry, average, and wet year, constituted an appropriate level of detail for a modeling tool to assess existing uses and determine surface water availability. Inflows used in the spreadsheet models were developed by averaging observed or estimated streamflow that occurred during historic dry, average and wet years. Accordingly, a total of six separate spreadsheet models were updated and analyzed.

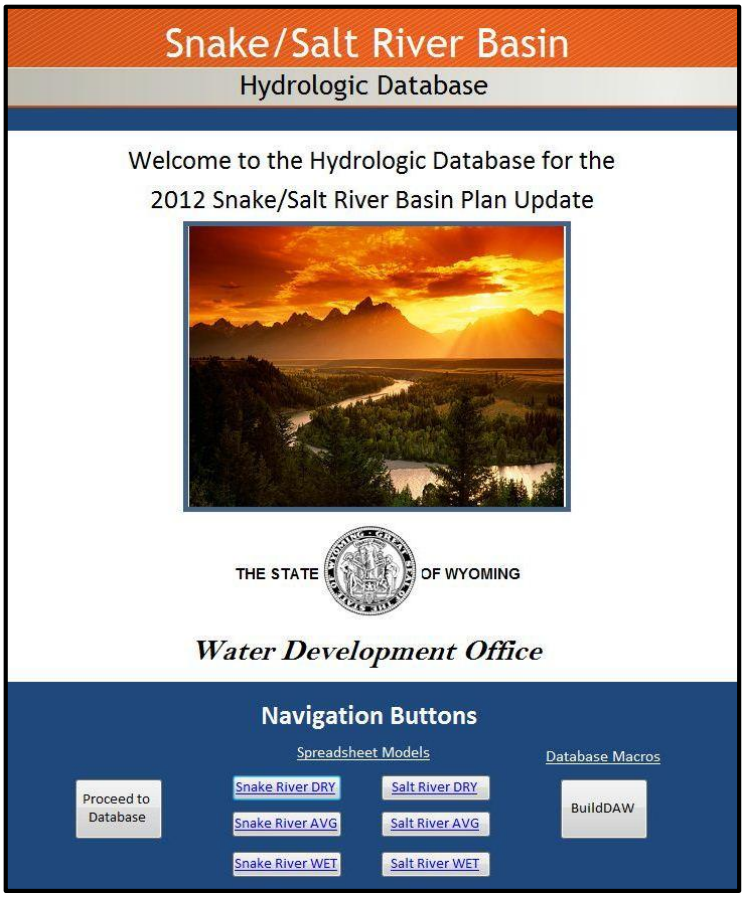
Snake River Basin Models
- Dry Year
- Average Year
- Wet Year

Salt River Basin Models
- Dry Year
- Average Year
- Wet Year

Objectives of the 2012 Update to the spreadsheet models involved the following:

- Update hydrology records by collecting and extending historic streamflow data through 2010 and, establish a new study period of record from 1971 through 2010.
- Conduct gage filling and data extension for missing data.
- Develop dry, average, and wet year flow estimates for the Snake and Salt River Basins based on the extended study period and selected indicator gages.
- Estimate the inflow from ungaged tributaries.
- Update irrigation diversion estimates.

A significant modification to the spreadsheet models for the 2012 Update involved development of a hydrologic database built within a Microsoft Access framework to house the hydrologic datasets required for input to the spreadsheet models. A macro coded in Visual Basic for Applications was built within the database to develop the dry, average and wet year hydrologic datasets. Other calculations required to process the datasets were built using standard Microsoft Access query techniques. The database contains and processes historical streamflow and natural flow estimations, and diversions as estimated by consumptive use. Key output from the database is linked directly into the models using external "Pivot Table" links in each spreadsheet model. For a complete description of the new hydrologic database, refer to *Technical Memorandum, Tab IX: Spreadsheet Models and Hydrologic Database.*



SCREEN SHOT OF HYDROLOGIC DATABASE

An update to the model map network and corresponding calculations reflecting the addition of Greys River into the Salt River Basin spreadsheet models was completed. Basin Node Numbers were also modified in the spreadsheet models to facilitate the connection and relationship to the hydrologic database. The revised model networks for the Snake and Salt River Basins are presented on Figures 7-1 and 7-2, respectively.

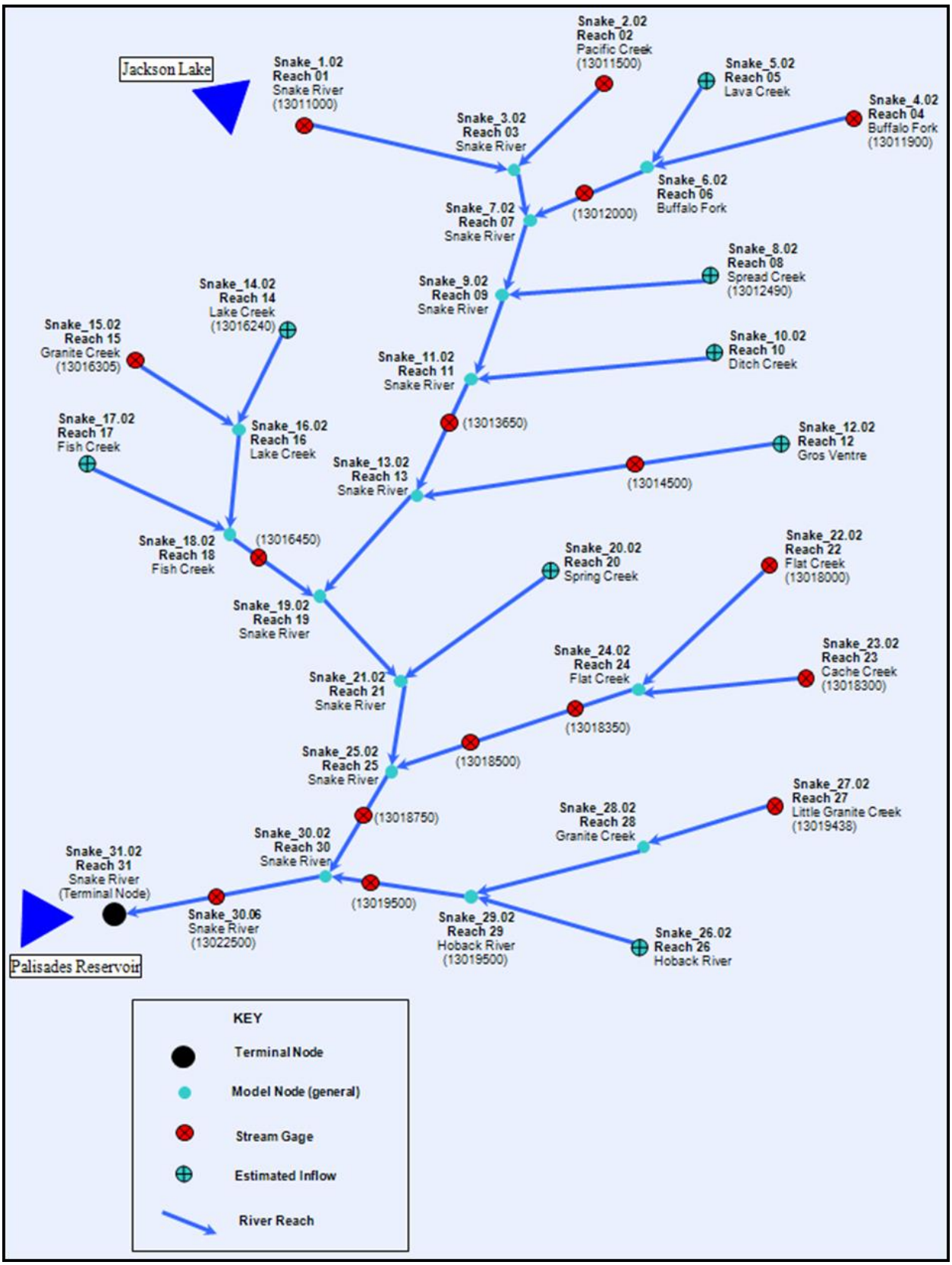


FIGURE 7-1: SNAKE RIVER BASIN MODEL NETWORK

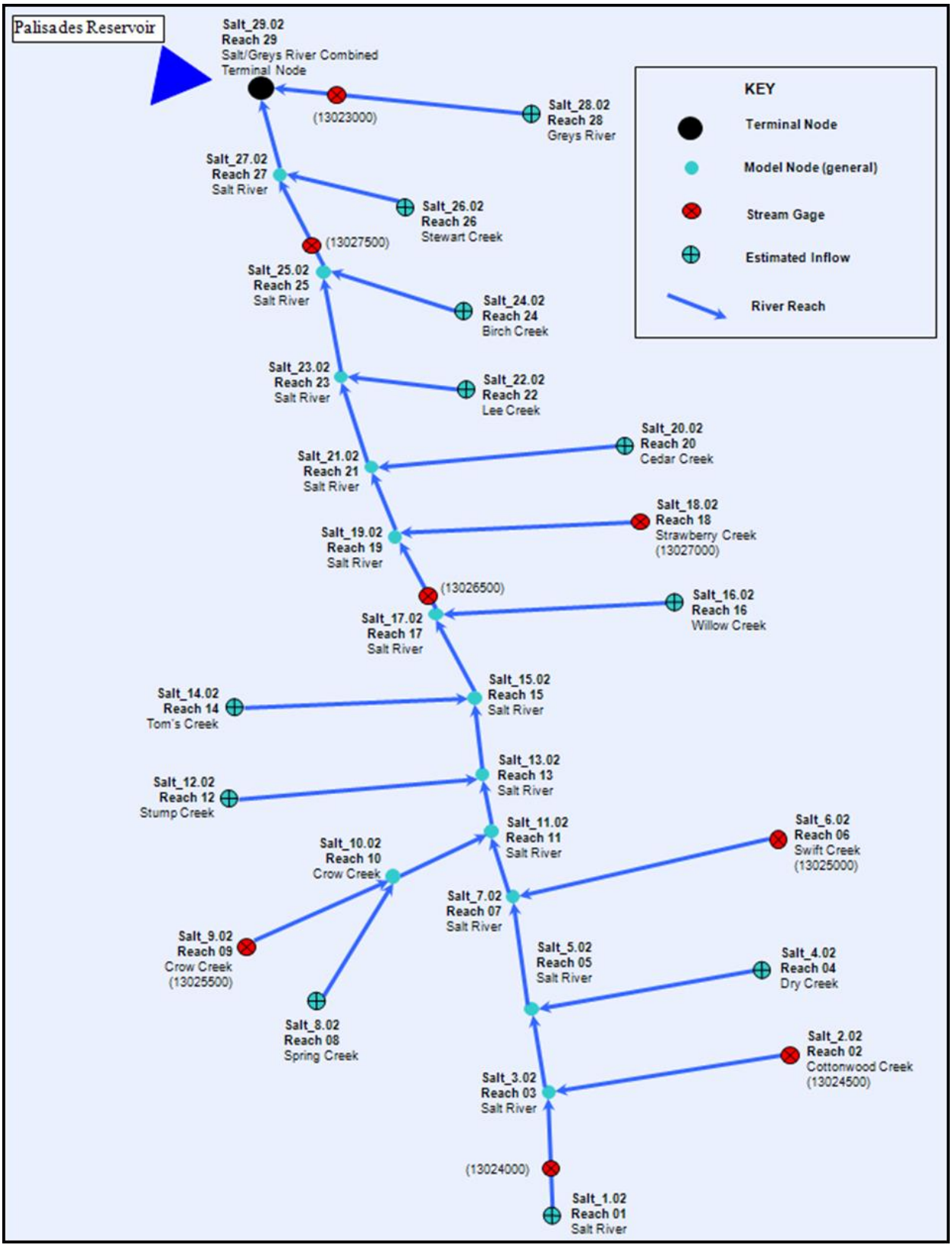


FIGURE 7-2: SALT RIVER BASIN MODEL NETWORK

7.1.1 STREAMFLOW GAGE DATA

The source of raw streamflow data used to build the historic streamflow records was the United States Geological Survey (USGS) daily streamflow data available from the internet. Daily streamflow data were automatically down loaded from the internet to a newly developed "web-query" spreadsheet, where a macro is run to transfer the data to the new hydrologic database. Queries run within the database convert the daily data to monthly data. Table 7-1 lists the USGS gage sites used in this analysis and summarizes the available periods of record. For a complete description of the web-query spreadsheet and hydrologic database, refer to *Technical Memorandum, Tab IX: Spreadsheet Models and Hydrologic Database.*

TABLE 7-1: STREAMFLOW RECORDS SUMMARY

Basin	USGS Site No.	Station Name	Period of Record	
			Start	End
Snake	13011000	Snake River near Moran, WY	10/1/1903	Current
	13011500	Pacific Creek at Moran, WY	7/20/1917	Current
	13011900	Buffalo Fork above Lava Creek near Moran, WY	9/22/1965	Current
	13012000	Buffalo Fork near Moran, WY	7/9/1917	9/4/1960
	13013650	Snake River at Moose, WY	4/6/1995	Current
	13014500	Gros Ventre River at Kelly, WY	6/16/1918	Current
	13016305	Granite Creek above Granite Creek Supp. near Moose, WY	6/2/1995	Current
	13016450	Fish Creek at Wilson, WY	3/24/1994	Current
	13018000	Flat Creek near Jackson, WY	6/23/1933	9/30/1993
	13018300	Cache Creek near Jackson, WY	7/1/1962	Current
	13018350	Flat Creek below Cache Creek, near Jackson, WY	4/1/1989	12/27/2010
	13018500	Flat Creek near Cheney, WY	7/1/1917	9/30/1993
	13018750	Snake River below Flat Creek near Jackson, WY	11/12/1975	Current
	13019438	Little Granite Creek at mouth near Bondurant, WY	12/11/1981	10/31/1992
	13019500	Hoback River near Jackson, WY	7/9/1917	9/30/1958
	13022500	Snake River above Reservoir near Alpine, WY	3/16/1937	Current
Salt	13023000	Greys River above Reservoir Near Alpine, WY	7/6/1917	Current
	13024000	Salt River near Smoot, WY	6/1/1932	9/30/1957
	13024500	Cottonwood Creek near Smoot, WY	10/1/1932	9/30/1957
	13025000	Swift Creek near Afton, WY	10/1/1942	9/30/1980
	13025500	Crow Creek near Fairview, WY	4/1/1946	9/30/1967
	13026500	Salt River near Thayne, WY	7/1/1932	9/30/1967
	13027000	Strawberry Creek near Bedford, WY	6/1/1932	9/30/1943
	13027500	Salt River above Reservoir near Etna, WY	10/1/1953	Current

7.1.1.1 GAGE FILLING AND DATA EXTENSION

Three gages in the basin had complete records over the new study period of 1971 through 2010. The remaining gages required data filling or extension for all or part of the study period. As in the previous Basin Plan, the Mixed Station Model, originally described by Alley and Burns, was used to fill the gage records (Alley & Burns, 1981). This model has the capability to fill several sites using data from all available stations. Stations are labeled dependent or independent according to whether they are being filled or used to fill at any

given time-step (Frick & Wellborn, 1999). The Mixed Station Model program was acquired by the WDO for use in this task. For additional information on the Mixed Station Model, refer to *Technical Memorandum, Tab VIII: Surface Water Data Collection and Estimation*.

7.1.2 DRY, AVERAGE, AND WET YEARS CLASSIFICATION

Indicator gages within the Snake/Salt River Basin were identified to provide annual flow characteristics to classify the study period years into dry, average, or wet years. The study period years were from 1971 through 2010. The approach and selection criteria used in the previous Basin Plan to choose indicator gages were considered adequate with no further evaluation required. Table 7-2 presents the two indicator gages used in the previous Basin Plan and in this Update

TABLE 7-2: INDICATOR GAGES SELECTED FOR THE SNAKE AND SALT RIVER BASINS

Basin	USGS Site No.	Station Name	Drainage Area (mi^2)	Period of Record	
				Start	End
Snake	13011900	Buffalo Fork above Lava Creek near Moran, WY	323.0	9/22/1965	Current
Salt	13023000	Greys River above Reservoir near Alpine, WY	448.0	7/6/1917	Current

After acquiring the updated gage records and performing the necessary data filling, the wettest and driest 20 percent of the study period years, on an annual flow basis, were identified for each indicator gage. Classification of the dry, average, and wet years was performed within the hydrologic database. The resulting classifications for the Snake and Salt Basins are shown on Table 7-3. For additional information on classification of the dry, average, and wet years, refer to *Technical Memorandum, Tab VIII: Surface Water Data Collection and Estimation*.

TABLE 7-3: CLASSIFICATION OF DRY, AVERAGE, AND WET YEARS

Basin	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Snake	Wet	Wet	Avg	Wet	Avg	Avg	Dry	Avg	Avg	Avg	Avg	Wet	Avg	Avg	Avg	Avg	Dry	Dry	Avg	Avg
Salt	Wet	Wet	Avg	Wet	Avg	Avg	Dry	Avg	Avg	Avg	Dry	Avg	Wet	Wet	Avg	Wet	Dry	Avg	Avg	Dry

(cont'd

Basin	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Snake	Avg	Dry	Avg	Dry	Avg	Wet	Wet	Avg	Wet	Avg	Dry	Avg	Avg	Dry	Avg	Avg	Dry	Avg	Wet	Avg
Salt	Avg	Dry	Avg	Avg	Avg	Wet	Wet	Avg	Avg	Avg	Dry	Dry	Avg	Avg	Avg	Avg	Dry	Avg	Avg	Avg

7.1.3 UNGAGED TRIBUTARY INFLOW ESTIMATION

Several tributaries to the Snake and Salt Rivers, while included in the model network, did not have gaging station records. Therefore, it was necessary to estimate inflows for these tributaries.

As in the previous Basin Plan, natural inflows were estimated for tributaries with sizeable diversion rights; whereas, flow contributions from tributaries without modeled diversions were accounted for in the spreadsheet model basin gain calculations.

Ungaged tributary natural inflows were estimated using characteristics, including basin area and mean basin elevation. Mean annual flow for these tributaries was estimated using a regression equation derived for mountainous regions of Wyoming published in *USGS WRIR 88-4045* as defined by Equation 7-1 (Lowham, 1988).

EQUATION 7-1

$$Q_a = 0.0015A^{1.01}\left(\frac{Elev}{1000}\right)^{2.88}$$

where,
Q_a = mean annual flow (cfs).
A = contributing area (mi^2).
Elev = mean basin elevation (feet).

Drainage areas and mean basin elevations were updated for this study based on GIS data derived from the USGS National Elevation Dataset (NED). Once mean annual inflows were estimated for each ungaged tributary using Equation 7-1, monthly values were derived. This was done by correlation to a nearby gaging station having similar topographic characteristics. The correlation gages used in the previous Basin Plan were considered appropriate for use in this study. The process to estimate monthly flows for each ungaged tributary is automated through built-in queries within the hydrologic database (*Technical Memorandum, Tab IX: Spreadsheet Models and Hydrologic Database).*

In some cases, the annual flow estimates appeared low in comparison to nearby gaged basins. This resulted in shortages to diversions in the spreadsheet model. Under these circumstances, a second estimation method was used involving a simple area weighting of monthly flows for a similar watershed in close proximity. This was the case in Cedar Creek, Lee Creek, Birch Creek, and Stewart Creek in the Salt River Basin models. These tributary flows were estimated by correlating to gaged flows in Strawberry Creek using the Simple Basin Area Method as described by Equation 7-2. Calculations involving the correlation of these four tributaries to Strawberry Creek flows are automated within the hydrologic database and further explained in *Technical Memorandum, Tab IX: Spreadsheet Models and Hydrologic Database*. For additional information on ungaged tributary inflow estimates, refer to *Technical Memorandum, Tab VIII: Surface Water Data Collection and Estimation*.

EQUATION 7-2

$$Monthly\ Ungaged Tributary Flow = Strawberry Creek\ Monthly\ Flow \times \left(\frac{Area Ungaged Tributary}{Area Strawberry Creek} \right)$$

where,
"Monthly Ungaged Tributary Flow" is the derived monthly flow estimate for each ungaged tributary.
"Strawberry Creek Monthly Flow" is based on gage records from Strawberry Creek (13027000).
"Area Ungaged Tributary" is the drainage basin area of the ungaged tributary.
"Area Strawberry Creek" is the drainage basin area of Strawberry Creek, upstream of its gage site.

7.1.4 DIVERSION DATA

The spreadsheet models require monthly diversion data. Surface water diversions in the Snake/Salt River Basin Models are entirely for agricultural use; municipal, industrial and rural domestic uses are supplied from groundwater. Because actual diversion records were unavailable for the basin, the models simulate the depletions or the consumptive portion of the stream diversions. The model treats this quantity as the diverted amount. However, for consistency with other basin spreadsheets, this information is referred to as "diversion data", although it is actually a depletion or consumptive use quantity.

The underlying basis for the diversion data was the StateCU model that was created for this study. StateCU is public domain software developed by the State of Colorado as part of Colorado's Decision Support System tools (State of Colorado, 2011). For each demand node in the spreadsheet models, diversions were calculated as the product of the irrigated acres, the monthly crop irrigation requirement (CIR) determined by the StateCU model, and the fraction of the month in which diversions were made as described by Equation 7-3. The methodology used to estimate crop irrigation requirements and diversion data is further discussed in Chapter 5 and fully described in *Technical Memorandum, Tab VII, Crop Water Requirements*.

EQUATION 7-3

$$Diversion = CIR * Acres * Fraction$$

where,
Diversion = agricultural depletion quantity (acre-feet per month)
CIR = crop irrigation requirement (feet per month)
Areas = number of irrigated acres
Fraction = fraction of month irrigated

7.2 SURFACE WATER AVAILABILITY

This section summarizes the results of the available surface water analysis performed as part of the 2012 Update. An overview of the spreadsheet model results and adjustments that account for instream flow requirements and Jackson Lake operations is provided. Available flow with respect to the Snake River Compact limitations is also presented.

Available flow analysis and methodologies developed for the previous Basin Plan were used as the basis for the 2012 Update (Sunrise Engineering, Inc., 2003). The purpose of this analysis was to estimate quantity, timing and location of surface water flows available to Wyoming for future development. The estimation of available surface water is three-pronged, including results predicted by the spreadsheet models, Jackson Lake operations and instream flow rights, and Snake River Compact limitations.

SPREADSHEET MODELS

The Snake/Salt River Basin spreadsheet models reveal available flows, or "Reach Outflows," that constitute the physical supply as constrained by hydrologic supply and current water use within the basin. The spreadsheet models represent conditions in each basin under current levels of development for three hydrologic conditions; dry, average and wet year water supply. Availability is a function of location analyzed within the model at "reach" levels and timing at a monthly level.

JACKSON LAKE OPERATION AND INSTREAM FLOW ADJUSTMENT

"Reach Outflows" predicted by the spreadsheet models are further subject to Jackson Lake operations and existing instream flow rights. Storage water deliveries from Jackson Lake to Palisades Reservoir occur throughout the Snake River mainstem. Additional flows are released from Jackson Lake to satisfy fishery requirements. These reservoir releases, as well as existing instream flow rights within the basins, are not accounted for in the spreadsheet models. Therefore, adjustments were made to the "Reach Outflows" provided by the spreadsheet models.

SNAKE RIVER COMPACT

It is necessary to determine available flows for development as permitted under the terms of the Snake River Compact. The Compact limitation is imposed on annual use throughout the basin based on the total annual flow at the Idaho state line. As a practical matter, Wyoming's current post-Compact diversions of approximately 20,000 acre-feet annually can increase by five to ten times before the Compact becomes limiting. However, in some parts of the basin, particularly on the Snake River mainstem, the Compact is much more limiting than the amount of water unappropriated within Wyoming. In addition, when considering the Compact, availability across the entire basin is much less than the combined available supplies of the Snake and Salt Rivers as predicted by the spreadsheet models, even after adjusting the results to account for Jackson Lake operations and instream flow requirements.

7.2.1 PHYSICALLY AVAILABLE FLOW FROM SPREADSHEET MODELS

Each spreadsheet model is divided into a series of reaches, each composed of several nodes, or water balance points. Reaches are typically defined by gages or confluences, and represent tributary basins or subsections of the mainstem. An output worksheet within each spreadsheet model summarizes monthly flow at the downstream end of each reach and provides the basis of this analysis.

In the spreadsheet models, simulated flow at the reach terminus indicates how much water is physically present, but may not reflect flow that is available for future appropriations. This apparent "available flow" may already be appropriated to a downstream water user, may be

satisfying an instream flow right, or may result from reservoir storage water being delivered to specific points downstream. It is important to acknowledge these matters when examining the results predicted by the spreadsheet models (Table 7-4). The table summarizes the "Reach Outflow" results from the spreadsheet models for each hydrologic condition at the most downstream reach within each basin (or where flows enter Palisades Reservoir and leave Wyoming). Refer to *Technical Memorandum, Tab X: Available Surface Water Determination* for a complete series of tables that show all the "Reach Outflows" taken directly from the "Outflow Summary" worksheet within each spreadsheet model.

TABLE 7-4: PHYSICALLY AVAILABLE FLOWS PREDICTED BY SPREADSHEET MODELS AT THE MOST DOWNSTREAM REACH (REACH OUTFLOWS)

Description	Dry Year (AFY)	Average Year (AFY)	Wet Year (AFY)
Snake River	2,428,571	3,124,912	4,438,246
Salt River	359,119	570,725	861,600
Greys River	291,336	452,418	662,485
Total	***3,079,026***	***4,148,055***	***5,962,331***

7.2.2 ADJUSTED PHYSICALLY AVAILABLE FLOW

Adjusted physical supply (APS) equals the spreadsheet modeled flow less Jackson Lake releases and/or instream flow rights. The adjusted physically available flow (APAF) equals the APS or the available water at the next downstream reach, whichever amount is smaller.

APS = Spreadsheet Modeled Flow - minus - Jackson Lake releases and/or instream flow rights.
APAF = APS or Available water at the next downstream reach -- whichever is less.

7.2.2.1 JACKSON LAKE OPERATIONS

Accounting for storage water releases within the Snake River mainstem requires a understanding of Jackson Lake and Minidoka Project operations as well as some assumptions about operating conditions during dry, average, and wet years. These topics were formerly addressed for the previous Basin Plan in *Technical Memorandum – Task 3D Available Surface Water Determination* as repeated below (Boyle Engineering, 2003):

> *Jackson Lake is the most upstream mainstem feature of the U.S. Bureau of Reclamation (USBR) Minidoka Project, which serves irrigators generally located along the Snake River from the Wyoming border to south central Idaho near Twin Falls. Service areas for all "spaceholders" in Jackson Lake are downstream of Palisades Reservoir, the next downstream storage feature. Palisades Reservoir is located at the Idaho state line, just below the downstream limit of the spreadsheet models. The project operates under flexible administration which allows water in storage to be credited to whichever water right has access to it regardless of where the water is stored. For instance, water generated above Palisades Reservoir can be stored there under the more senior downstream American Falls Reservoir right at the beginning of the runoff season. If and when American Falls successfully fills physically, the water in Palisades reverts to Palisades' right and ownership. The objective is to keep water as high in the basin as possible, thereby*

maximizing the ability to distribute the supply and minimizing the risk of spilling water from lower reservoirs when upper reservoirs are unable to fill. As another example, Jackson Lake under normal operations matches winter outflow to inflow in order to maintain flood control capacity in the reservoir as well as minimum fish flows in the river below the dam. When this happens, the "bypass" water is credited to Jackson Lake's storage right even though it is physically stored downstream in Palisades Reservoir. Thus the apparent bypass is actually a delivery of storage water.

Jackson Lake's operational year begins October 1st. Ideally the lake level is drawn down to 6760.95 feet, an elevation that provides 200,000 AF of winter flood control space. Under these circumstances, outflows are set to match inflows, which in an average year might be on the order of 400 or 500 cfs. Wyoming has the option, should inflows drop below the minimum fishery streamflow of 280 cfs, to add to the outflows by releasing from storage, provided there is a commensurate amount of water in Wyoming's pool in Palisades Reservoir. The exchange water is reallocated within Palisades Reservoir to Jackson Lake spaceholders. When spring runoff begins, typically in April, storage begins gradually in accordance with flood control criteria covering both Jackson Lake and Palisades. These criteria take into consideration forecasted inflow, downstream flow limitations, and a specified division of the total required space between Jackson Lake and Palisades Reservoir. Target levels are re-computed daily as the hydrograph rises. The objectives are to maintain adequate space in the reservoirs to control runoff while flow is increasing and complete filling during the receding limb of the hydrograph. Generally, filling is achieved by mid-June. For the remainder of the water year, the Bureau tries to maintain outflows as uniformly as possible to reach elevation 6760.95 by October 1st. In other words, over this period of an average or wet year, they are moving inflows plus 200,000 AF down the river. In a dry year, they will move more storage water and Jackson Lake will be below 6760.95 feet on October 1st. In an average or above average year, release rates are dictated by the need to evacuate for winter and spring flood control; in drier years, the rates may be more influenced by downstream demand.

To estimate the amount of water available to a new appropriator on the Snake River mainstem, certain assumptions were made regarding dry, average, and wet year operations of Jackson Lake. These assumptions were originated in the previous Basin Plan and were considered satisfactory to maintain for this study. The assumptions are extremely general, since in any given year, circumstances are unique. In particular, antecedent conditions bear greatly on annual operations, as a wet year following a dry or average year is operationally different from a wet year following a wet year. Furthermore, the generalizations are based on historic practice, which has neither required strict administration of the river nor forced resolution of potential conflicts in perspective between Wyoming and the USBR. With that in mind, in terms of a water year, the following scenarios were assumed for the operation of Jackson Lake for each modeled hydrologic condition:

DRY YEAR

- October – March: All winter outflows from Jackson Lake are assumed to be project flows that cannot be appropriated.

- April – May: Flows immediately below Jackson Lake are excesses that were not stored, and any amount is available to appropriators. If runoff ends early, the reservoir may or may not have achieved full capacity.
- June – September: Approximately 120,000 AF/month (477,000 AF/4 months) of flow below Jackson Lake are project deliveries and cannot be appropriated. Any remaining balance, however, is available to appropriators. The value 477,000 AF is the sum of 200,000 AF out of the flood control/irrigation pool, with an additional 277,000 AF out of storage. The latter value reflects the average annual change in storage for four dry years that occurred in 1973, 1977, 1992, and 1994.

AVERAGE YEAR

- October – March: All flows immediately below Jackson Lake are project deliveries being counted to Jackson Lake's decree and cannot be appropriated.
- April – June: Filling at both Jackson Lake and Palisades Reservoir occurs in accordance with flood control operations. Outflows from Jackson Lake are excesses that were not able to be stored, and any amount above the 280 cfs fishery requirement is available to appropriators.
- July – September: 66,666 AF/month (200,000 AF/3 months) of flow below Jackson Lake are project deliveries and cannot be appropriated. Any remaining balance, however, is available to appropriators.

WET YEAR

- October – December: All flows immediately below Jackson Lake are project deliveries and cannot be appropriated.
- January – March: As winter progresses, it becomes evident that spring flows will be high. Palisades Reservoir will no longer store water coming past Jackson Lake, and therefore, this flow may be appropriated.
- April – June: Outflows from Jackson Lake are excess that were not able to be stored, and any amount above the 280 cfs fishery requirement is available to appropriators.
- July – September: 66,666 AF/Month (200,000 AF/3 months) of flow below Jackson Lake are project deliveries and cannot be appropriated. Any remaining balance, however, is available to appropriators.

7.2.2.2 INSTREAM FLOW REQUIREMENTS

In addition to assumptions made to reflect operations of Jackson Lake, adjustments were made to account for the following instream flow rights:

- Assume approval of two pending instream flow right applications located on two reaches on Fish Creek, a tributary within the Snake River Basin. Both reaches covered by these permits fall within Reach 18 of the Snake River spreadsheet models and call for 150 cfs of flow throughout the year (or approximately 108,599 AFY).
- Assume approval of a pending instream flow right application on the Salt River. The reach covered by this permit falls within Reach 28 of the Salt River spreadsheet models and calls for 221 cfs throughout the year (or approximately 159,999 AFY).
- There is an approved instream flow right on Greys River. The reach covered by this permit falls within Reach 27 of the Salt River spreadsheet models and calls for 350

cfs in April through June and 204 cfs throughout the remainder of the year (or approximately 174,044 AFY).

These instream flows are non-consumptive. The adjustments consisted of subtracting the instream flow amounts from the physically available flows predicted by the spreadsheet models. The subtractions occurred on the reaches that contained the instream flow segment and this subsequently affected the available flow quantities within reaches located upstream from the segment. In other words, these waters are "spoken-for" only within reaches upstream of the segment. Because of the non-consumptive nature of instream flows, reaches downstream from the instream flow segments were not affected by this adjustment.

7.2.2.3 SUMMARY OF ADJUSTED PHYSICALLY AVAILABLE FLOW

The adjusted physically available flow determination was estimated in a spreadsheet separate from the models themselves. Table 7-5 shows the adjusted physically available flow for each hydrologic condition at the most downstream reach within each basin (or where flows enter Palisades Reservoir and leave Wyoming). These values take into account instream flow requirements and Jackson Lake operations as described above as well as downstream appropriations. Refer to *Technical Memorandum, Tab X: Available Surface Water Determination* for a complete series of tables that show the adjusted physically available flow for each reach in each basin and for each hydrologic condition.

TABLE 7-5: ADJUSTED PHYSICALLY AVAILABLE FLOWS AT MOST DOWNSTREAM REACH

Description	Dry Year (AFY)	Average Year (AFY)	Wet Year (AFY)
Snake River	1,775,752	2,717,548	4,049,867
Salt River	199,120	410,726	701,601
Greys River	117,292	278,374	488,441
Total	***2,092,165***	***3,406,648***	***5,239,909***

7.2.3 AVAILABLE FLOW PER COMPACT LIMITATIONS

When considering the Snake River Compact (Compact), the numbers presented above represent much more water than can actually be developed. This section describes the Compact and presents an estimate of the basin-wide future development permitted under the Compact.

The Snake River Compact of 1949 has been summarized in a separate memorandum completed for the previous Basin Plan: *Summary of Interstate Compacts and Court Decrees* (Fassett Consulting, LLC, 2002). Briefly stated, the Compact protects all Wyoming water rights that existed as of July 1, 1949. It further permits Wyoming to divert, for new development post-1949, four percent of the Wyoming-Idaho state line flow of the Snake River. Domestic and stock uses are exempt from the limitation, and out-of-basin exports are not permitted without Idaho's permission. Wyoming can develop the first half of the four percent without providing anything additional to Idaho. To develop the second half, however, Wyoming must provide replacement storage space for Idaho's use to the extent of one-third of the second half of the diversions allowed by the Compact. This provision is expected to be addressed by Wyoming's

33,000 AF pool in Palisades Reservoir at whatever time Wyoming's post-Compact use exceeds two percent of the stateline flows. To date, this has not happened.

Historically, Idaho has not required an accounting of Wyoming's post-1949 use, probably because Wyoming has not come close to encroaching on the "first half" limits of the Compact. River administration, from both an interstate and internal perspective, has generally not required strict accounting of diversions and precisely which rights are exercised.

For this study, as in the previous Basin Plan, an estimate was made of Compact limitations on future development under the three hydrologic conditions. The first step was to estimate the amount of water that was put to use after the 1949 Compact. It was assumed that the fraction of post-1949 adjudicated ***rights*** among all the adjudicated rights represents the amount of post-Compact ***use*** among all the uses. The adjudicated rights that existed prior to the 1949 Compact were compared to the rights that were adjudicated after the 1949 Compact. This "post-Compact fraction" was determined to be 4 percent in the Salt River Basin and 13 percent in the Snake River Basin. The actual basis of the computation was the adjudicated acres associated with each right.

Post-Compact depletions for each hydrologic condition were then calculated as the post-Compact fraction multiplied by the depletion estimated in each spreadsheet model. Post-Compact depletions on Greys River were assumed to be negligible as there has been no significant development in the sub-basin over the last five decades.

Stateline flow was next calculated for each hydrologic condition as specified in Article III of the Compact. The quantity of water crossing the state line was computed as the sum of annual flow for the following USGS gages:

- Snake River above Reservoir near Alpine (13022500)
- Salt River above Reservoir near Etna (13027500)
- Greys River above Reservoir near Alpine (13023000)

Annual change in reservoir storage serving Idaho (i.e. Jackson Lake) was assumed to be zero during average and wet years and -277,000 AF during dry years. This number represents the average of the historic annual change in storage for water years 1973, 1977, 1992, and 1994. The sum of gage flow, change in storage and post-Compact depletions constitutes the amount of water to which the four percent is applied in order to determine the Compact limitations.

Once the allowable diversions were calculated based on Compact limitations, current post-Compact diversions were subtracted to estimate the remaining diversion allowance. Based on Compact language a factor of 3.0 was used to convert depletions to diversions. Table 7-6 summarizes the results and computations. Results show the current remaining allowable surface water diversions from the basin are 95,023 AFY, 148,711 AFY, and 221,098 AFY in dry, average, and wet years, respectively. The table also shows the remaining allowance under the three growth scenarios (low, mid and high-growth). Refer to *Technical Memorandum, Tab X: Available Surface Water Determination* for the full calculations and a comparison of the results to those reported in the previous Basin Plan.

TABLE 7-6: SNAKE/SALT RIVER BASIN REMAINING ALLOWABLE SURFACE WATER DIVERSIONS UNDER COMPACT

Hydrologic Condition	Current (AFY)	Growth Scenario		
		Low-Growth (AFY)	Mid-Growth (AFY)	High-Growth (AFY)
Dry Year	95,023	98,424	96,321	94,477
Average Year	148,711	152,153	150,094	148,205
Wet Year	221,098	224,542	222,438	220,594

7.2.4 AVAILABLE FLOW SUMMARY

Surface water availability in the Snake and Salt River Basins is a matter of physically available supply and basin-wide Compact limits. In both the Snake and Salt River Basins, a new appropriation in a tributary basin will be limited by local supply and may be severely limited in some months without water storage. On the other hand, overall water supply in the basin greatly exceeds current use. On the mainstem of both rivers and in the larger tributaries of the Snake River, the Compact is more limiting than physical supply. There are locations and months in which the entire annual Compact allowance could be diverted within one month. Thus the supply available to any given proposed use varies greatly across the basin and could be impacted by concurrent development of the Compact allowance elsewhere in the basin.

Figures 7-3 and 7-4 summarize the results of this analysis by location and for each hydrologic condition, showing the annual adjusted physically available flows, adjusted for Jackson Lake operations and instream flow demands for the Snake and Salt River Basins. Figure 7-5 illustrates and enumerates the remaining annual allowable surface water diversions by individual sub-basin and hydrologic conditions with respect to the Snake River Compact limitations. For additional results pertaining to surface water availability, refer to *Technical Memorandum, Tab X: Available Surface Water Determination.*

GREYS RIVER NEAR ALPINE

SWIFT CREEK DIVERSION DAM

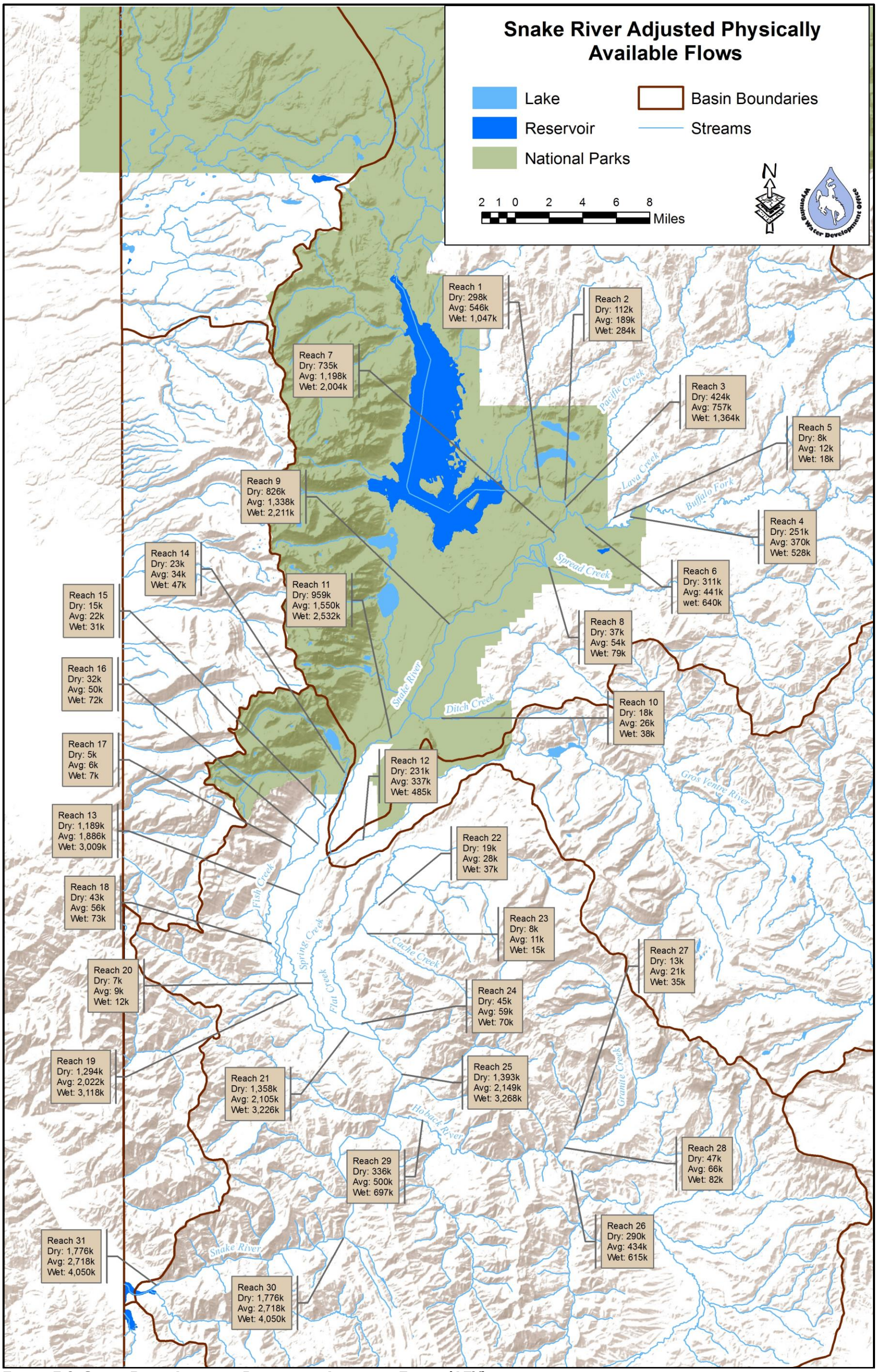


FIGURE 7-3: SNAKE RIVER ADJUSTED PHYSICALLY AVAILABLE FLOWS (AFY)

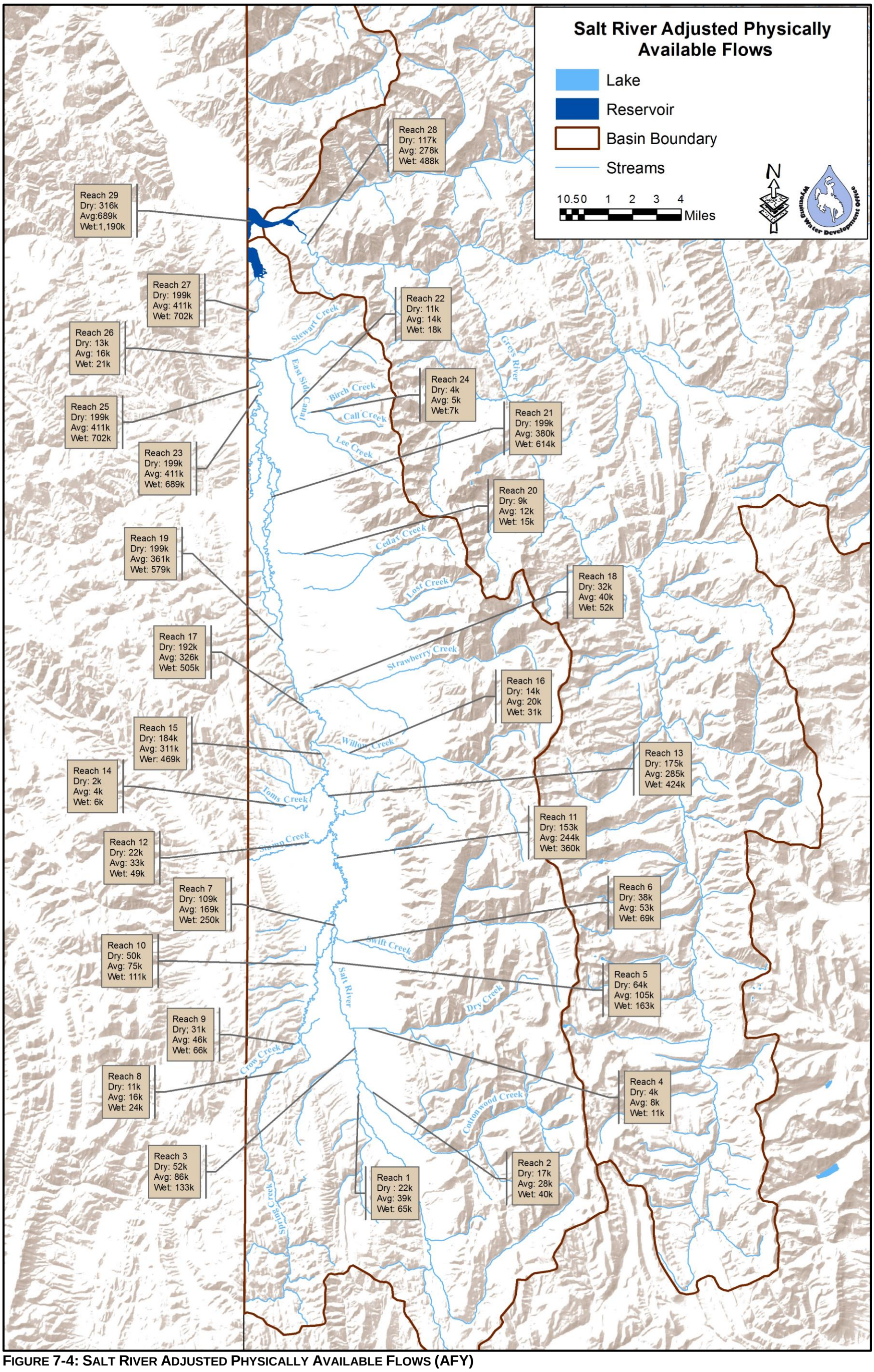
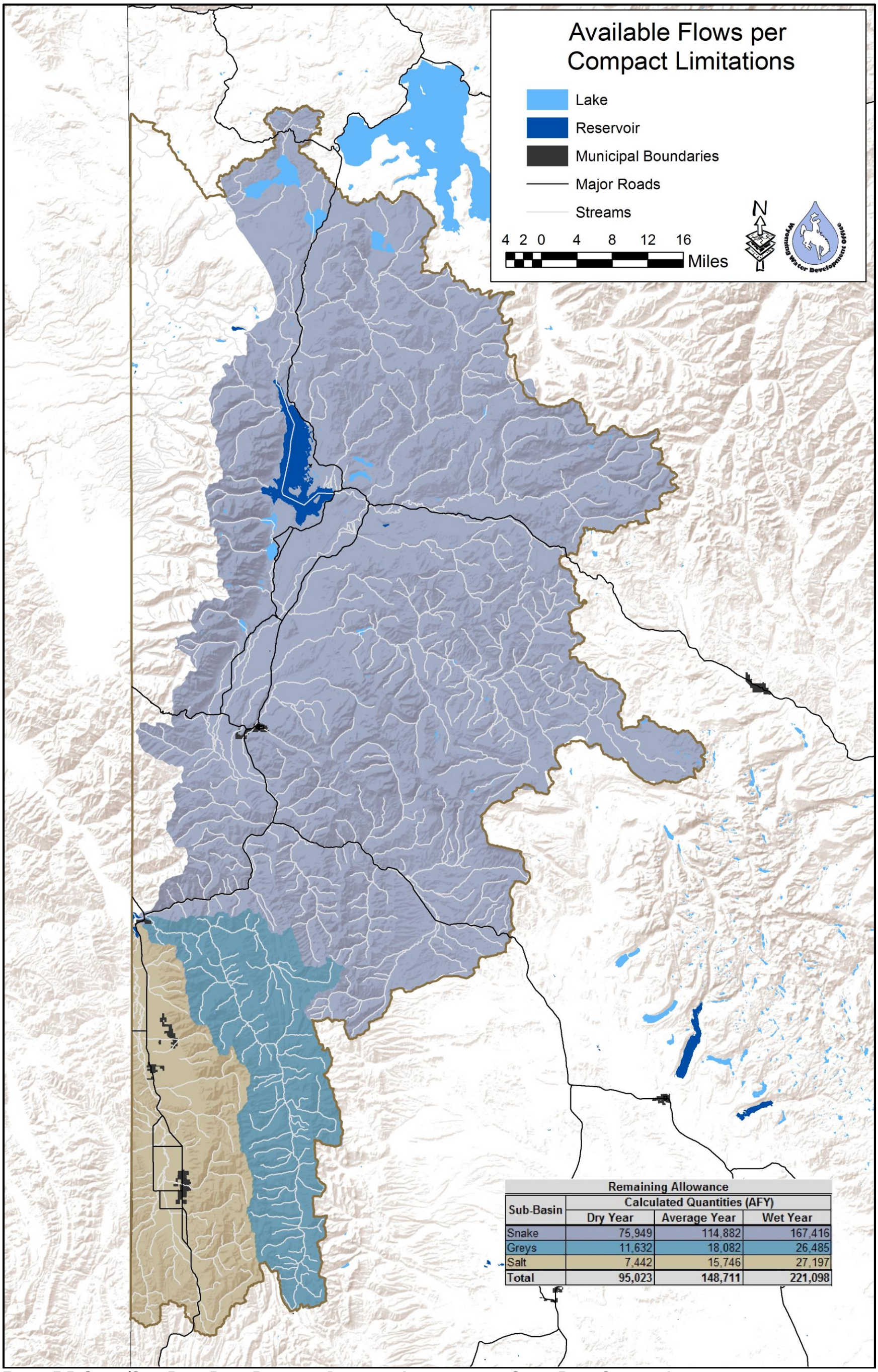


FIGURE 7-4: SALT RIVER ADJUSTED PHYSICALLY AVAILABLE FLOWS (AFY)



Remaining Allowance			
Sub-Basin	Calculated Quantities (AFY)		
	Dry Year	Average Year	Wet Year
Snake	75,949	114,882	167,416
Greys	11,632	18,082	26,485
Salt	7,442	15,746	27,197
Total	**95,023**	**148,711**	**221,098**

FIGURE 7-5: SNAKE/SALT RIVER BASIN REMAINING DIVERSION ALLOWANCE PER SNAKE RIVER COMPACT LIMITATIONS

7.3 GROUNDWATER AVAILABILITY

The quantity of groundwater resources available in the Snake/Salt River Basin is dependent on the three-dimensional physical extent, water saturation and permeability of the various geologic units. 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 quality of the groundwater is variable, but is generally of favorable quality in most areas of the basin.

The most heavily used aquifers in the basin are the Quaternary unconsolidated deposits and associated deposits located in the valley areas of the basin, followed by the relatively flat-lying Tertiary bedrock formations. The Volcanic and Intrusive Formations are heavily used in the vicinity of Alta, Wyoming. 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, in excess of 32.5 million acre-feet of groundwater are available in the Wyoming portion of the Snake/Salt River Basin. There is estimated to be 10 million acre-feet of groundwater available in the alluvial aquifer (Hinckley Consulting, 2003) and 22.5 million acre-feet of groundwater available in the Mesozoic and Paleozoic aquifer groups.

It was estimated in the previous Basin Plan that groundwater recharge in the entire basin ranged from 1 million to 1.5 million acre-feet annually (Hinckley Consulting, 2003). Although this recharge estimate may be conservative, it demonstrates that the annual sustained yield of groundwater would be much less than the storage capacity, which is more than 32.5 million acre-feet.

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.

As of 2002, Hinckley estimated that total groundwater consumption in the basin was approximately 7,540 acre-feet per year. Hinckley further stated that the actual groundwater withdrawal (pumpage) in the basin may be one or more times the listed consumptive use of groundwater (Hinckley Consulting, 2003).

In 2007, the Wyoming Framework Water Plan estimated total municipal and domestic groundwater depletions (consumptive use) in the Snake/Salt River Basin to be 9,100 acre-feet per year (WWC Engineering, Inc, 2007). Adding approximately another 1,000 acre-feet per year for all other groundwater uses in the basin brings the total groundwater depletion to a total of approximately 10,100 acre-feet per year in 2007. Current (2013) total groundwater consumptive use (depletions) in the basin is estimated to be approximately 9,751 acre-feet per year.

WWC Engineering estimated that total groundwater use in the Snake/Salt River Basin was approximately 6,800 acre-feet per year in 2007. As this quantity is less than the 9,100 acre-feet per year reported for total depletions for municipal and domestic uses in the same report (WWC Engineering, Inc, 2007), this 6,800 acre-feet per year quantity is considered to be too low and

probably an error. This number probably should have been approximately 10,100 acre-feet per year in 2007 as discussed above.

This study predicts future population growth from 2012 to 2032 using projections developed by DAIEAD. Current (2012) municipal and domestic groundwater use is estimated to be 8,865 acre-feet annually. There is estimated to be an additional 886 acre-feet of groundwater consumed annually for miscellaneous uses in the basin, with total basin groundwater uses equaling 9,751 acre-feet per year. Municipal and domestic groundwater use is estimated to increase under the high, mid and low-growth scenarios to 13,072, 10,832 and 9,364 acre-feet per year respectively. Using the current ratio of municipal and domestic water use to miscellaneous use, total groundwater use in 2032 would equal 16,171, 13,413 and 11,619 acre-feet per year under the three growth scenarios.

In summary, the abundance of available groundwater resources in the Snake/Salt River Basin ensures future groundwater development as the population grows and sufficient groundwater supply will remain available in the basin for the foreseeable future.

7.4 WATER CONSERVATION

Irrigated agriculture is the largest water use sector in the Snake/Salt River Basin and would benefit most from water conservation. Improvements in diversions and delivery efficiencies could provide more water to fields, and improvements in irrigation methods would better meet crop water requirements. The greatest potential savings would come through the change from flood irrigation to sprinkler irrigation.

The previous Basin Plan estimated the amount of water conserved from conversion of flood to sprinkler irrigation. For this Update, the following formulas were developed and applied to determine the quantity of water potentially saved by this conversion. The updated crop irrigation requirements (CIR) were used along with an estimate of acres currently under flood irrigation.

1. $\text{Flood Water Used (in)} = \text{Crop Irrigation Requirements} * 2$
2. $\text{Sprinkler Water Used (in)} = \text{Flood Water Used (in)} * 0.6667$
3. $\text{Water Conserved (in)} = \text{Flood Water Used (in)} - \text{Sprinkler Water Used (in)}$
4. $\text{Sprinkler Water Conserved (AF)} = \frac{\text{Water Conserved (in)}}{12} * \text{Acres Flood Irrigated}$

There were 26,063 acres under flood irrigation in the previous Basin Plan. For the 2012 Update, the acreage under flood irrigation has been reduced to 24,279 acres. If these lands were converted from flood to sprinkler irrigation, 18,047 acre-feet of water could be saved. Table 7-7 summarizes the potential water savings from the conversion.

TABLE 7-7: WATER CONSERVED BY CONVERTING FROM FLOOD TO SPRINKLER IRRIGATION ANNUALLY

Sub-Basin	Acres Flood Irrigated	2012 CIR (Inches)	Water Used (Inches)		Water Conserved	
			Flood	Sprinkler	(Inches)	(AFY)
Upper Salt River	5,987	13.11	26.22	17.48	8.74	4,360
Lower Salt River	3,016	13.33	26.66	17.77	8.89	2,233
Upper Snake River	2,927	11.21	22.42	14.95	7.47	1,823
Lower Snake River	12,349	14.04	28.08	18.72	9.36	9,631
Teton River	0	12.44	24.88	16.59	8.29	0
Total	***24,279***	**--**	**--**	**--**	**--**	***18,047***

Although a significant amount of water could be conserved by changing from flood to sprinkler irrigation, changing or improving irrigation practices can change the timing and amount of return flows that affect downstream water use and potentially the entire water system. This is especially important in the Snake/Salt River Basin since many environmental and recreational water uses in the basin depend on return flows from irrigation.

Water for municipal and domestic use in the Snake/Salt River Basin is entirely from groundwater. Strict water conservation efforts are generally not practiced in the basin except in times of water shortage. Metering and charging for the amount of water used are the most common methods of encouraging water conservation. Many of the municipalities and water districts within the basin meter water use and have tiered water rates that increase the cost of water as use increases. Restricting lawn and landscape watering is another method of decreasing water use since lawn and landscape watering is a major water use.

Other potential water conservation measures include the following:

- Sub-metering: a method to meter water use in units such as apartments, condominiums, and trailer homes to indicate water use by those individual units; the entire complex of units is metered by the main supplier.
- Leak Detection
- Water Main Rehabilitation
- Water Reuse: the use of wastewater or reclaimed water from one application for another application
- Tiered Pricing: increasing per-unit charges for water as the amount used increases.
- Time-of-Day Pricing: water rates increase during peak use periods.
- Water Surcharges: imposes a higher rate on excessive water use by establishing a threshold level for excess consumption based on average daily per capita or per-household consumption.

7.5 SUMMARY OF WATER AVAILABILITY

Information presented in Chapters 4, 5, 6, and this chapter provides an estimate of the current remaining water allowance under the Snake River Compact (Table 7-8). The table includes values calculated using the natural flow and irrigated acreage estimates from Chapter 4; the livestock watering, municipal, domestic, industrial, and reservoir evaporation estimates from Chapter 5; and the Compact depletion calculations from Table 7-6 in this Chapter. Projected surface water availability values were also calculated for high, mid and low-growth scenarios and these totals are shown in Tables 7-9, 7-10, and 7-11.

Information included in the tables does not include the irrigated lands in the Teton Sub-basin. These lands are governed by the Roxana Decree and are therefore not included in the Snake River Post Compact Availability numbers presented in the tables. Figure 7-6 shows the available flow information and the Wyoming boundaries of the Snake River Compact and Roxana Decree.

As described in Section 7.2.3 depletions are calculated differently than diversions by definition in the Snake River Compact. Tables 7-8 through 7-11 present the calculated depletions. Table 7-12 presents the diversions calculated for the modeled period of record and for the projected uses.

LOWER CLIFF CREEK NEAR HOBACK RIVER CONFLUENCE

TABLE 7-8: SURFACE WATER AVAILABILITY WITH CURRENT CONSUMPTIVE USES (AFY)

Description	Natural Flow	Agricultural Irrigation[1]	Livestock Watering	Municipal[2]	Domestic[2]	Industrial	Reservoir Evaporation	Total Use	Depleted Flow	Remaining Allowance with Current Depletions
Data Source	Table 4-1	Table 4-3	Table 5-8	Section 5.2	Section 5.2	Section 5.3	Table 5-14	Calculated	Calculated	Table 7-6
Wet	5,654,715	80,763	369	0	0	0	72,175	153,307	5,501,408	221,098
Average	3,821,438	80,747	369	0	0	0	72,175	153,291	3,668,147	148,711
Dry	2,506,613	80,404	369	0	0	0	72,175	152,948	2,353,665	95,023

1. Agricultural Irrigation water use totals do not include the Teton River Basin.
2. Municipal and Domestic Water Use information is described in Section 5.2 of the Report. All Municipal and Domestic uses throughout the Basin are from Groundwater Sources and are therefore not included in the surface water numbers in this table.

TABLE 7-9: SURFACE WATER AVAILABILITY, HIGH-GROWTH SCENARIO, 2032 (AFY)

Description	Natural Flow	Agricultural Irrigation[1]	Livestock Watering	Municipal[2]	Domestic[2]	Industrial[2]	Reservoir Evaporation	Total Use	Depleted Flow	Remaining Allowance with 2012 Depletions
Data Source	Table 4-1	Table 6-3	Table 6-4	Section 6.3	Section 6.3	Section 6.4	Table 5-14	Calculated	Calculated	Table 7-6
Wet	5,654,715	84,560	445	0	0	0	72,175	157,180	5,497,535	221,098
Average	3,821,438	84,560	445	0	0	0	72,175	157,180	3,664,258	148,711
Dry	2,506,613	84,560	445	0	0	0	72,175	157,180	2,349,433	95,023

1. Agricultural Irrigation water use totals do not include the Teton River Basin.
2. Municipal, Domestic and Industrial Water Use information is described in Section 6.3 and 6.4 of the Report. All projected Municipal, Domestic, and Industrial uses throughout the Basin are from Groundwater Sources and are therefore not included in the surface water numbers in this table.

TABLE 7-10: SURFACE WATER AVAILABILITY, MID-GROWTH SCENARIO, 2032 (AFY)

Description	Natural Flow	Agricultural Irrigation[1]	Livestock Watering	Municipal[2]	Domestic[2]	Industrial[2]	Reservoir Evaporation	Total Use	Depleted Flow	Remaining Allowance with 2012 Depletions
Data Source	Table 4-1	Table 6-3	Table 6-4	Section 6.3	Section 6.3	Section 6.4	Table 5-14	Calculated	Calculated	Table 7-6
Wet	5,654,715	77,279	376	0	0	0	72,175	149,830	5,504,885	221,098
Average	3,821,438	77,279	376	0	0	0	72,175	149,830	3,671,608	148,711
Dry	2,506,613	77,279	376	0	0	0	72,175	149,830	2,356,783	95,023

1. Agricultural Irrigation water use totals do not include the Teton River Basin.
2. Municipal, Domestic and Industrial Water Use information is described in Section 6.3 and 6.4 of the Report. All projected Municipal, Domestic, and Industrial uses throughout the Basin are from Groundwater Sources and are therefore not included in the surface water numbers in this table.

TABLE 7-11: SURFACE WATER AVAILABILITY, LOW-GROWTH SCENARIO, 2032 (AFY)

Description	Natural Flow	Agricultural Irrigation[1]	Livestock Watering	Municipal[2]	Domestic[2]	Industrial[2]	Reservoir Evaporation	Total Use	Depleted Flow	Remaining Allowance with Current Depletions
Data Source	Table 4-1	Table 6-3	Table 6-4	Section 6.3	Section 6.3	Section 6.4	Table 5-14	Calculated	Calculated	Table 7-6
Wet	5,654,715	68,041	315	0	0	0	72,175	140,531	5,514,184	221,098
Average	3,821,438	68,041	315	0	0	0	72,175	140,531	3,680,907	148,711
Dry	2,506,613	68,041	315	0	0	0	72,175	140,531	2,366,082	95,023

1. Agricultural Irrigation water use totals do not include the Teton River Basin
2. Municipal, Domestic and Industrial Water Use information is described in Section 6.3 and 6.4 of the Report. All projected Municipal, Domestic, and Industrial uses throughout the Basin are from Groundwater Sources and are therefore not included in the surface water numbers in this table.

TABLE 7-12: CURRENT AND PROJECTED DIVERSIONS

Description	Full Supply Depletion 2012	Post Compact Fraction	Post Compact Depletions 1949 - 2012 (AFY)	Post Compact Diversions 1949 - 2012 (AFY)[2]	New Full Supply Depletions 2032[3]	New Post Compact Diversions 2032	Post Compact Depletions 2032 Total	Post Compact Diversion Total (AFY)
Data Source	Table 6-9	Table 7-6	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated
Snake (Hoback)[1]	3,060	0.13	398	1,193	202	606	600	1,799
Salt	54,294	0.04	2,172	6,515	3,583	10,749	5,755	17,264
Greys	185	0.04	7	22	12	36	19	58
Total	***57,539***		***2,577***	***7,731***	***3,797***	***11,391***	***6,374***	***19,122***

1. Acreages in the Upper and Lower Snake are not projected to increase.
2. Diversions are calculated by multiplying depletions by 3. See section 7.2.3 for more information
3. The new full supply depletion where calculated by subtracting current full supply demands from the projected high scenario demands in Table 6-3.

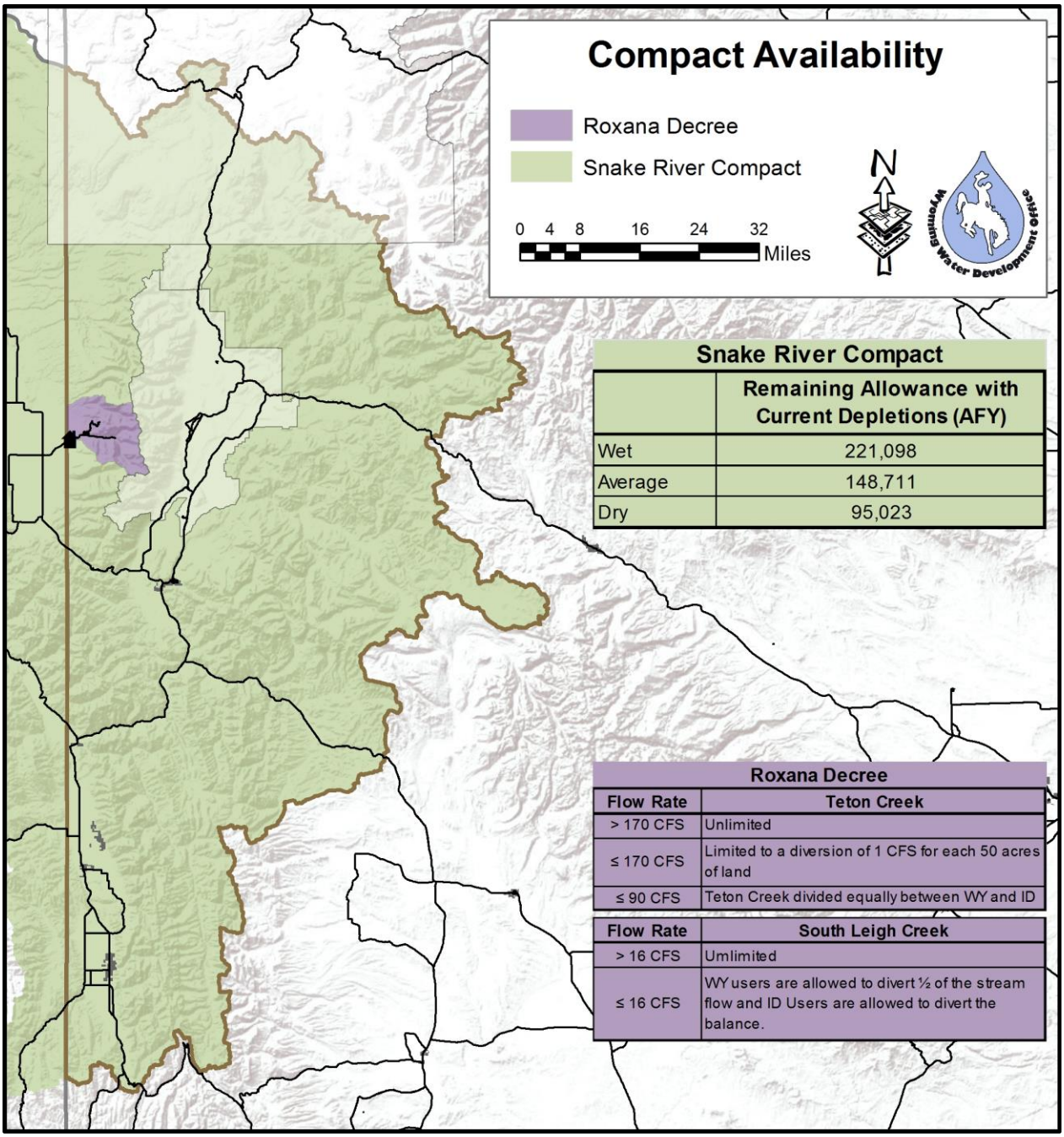


FIGURE 7-6: SNAKE RIVER COMPACT AND ROXANA DECREE AVAILABILITY

The depletions and diversions listed in Table 7-12 were calculated for irrigation, livestock, municipal, domestic, industrial, and reservoir evaporation. The tables do not include any projected growth of nonconsumptive environmental and recreational uses. These uses play a central part in the economy of the basin with tourism being the basin's largest economic sector. Yellowstone and Grand Teton National Park's visitation totals show an upward trend. Similarly, Leisure and Hospitality Sales Tax Revenue has increased for the last ten years.

The large percentage of federal lands within the basin makes it safe to assume environmental and recreational opportunities available today will continue to be available throughout the planning horizon. If these demands grow, there may be additional competition between environmental and recreational uses and traditional water uses.

Millions of acre-feet of groundwater are potentially available for future development within the basin. Population growth will likely increase the demand for groundwater development. An increase in population densities could cause locally declining groundwater levels in small geographic areas. Additionally, a concentration of septic systems in highly developed areas could cause local groundwater contamination and a decline in groundwater quality.

Water conservation in the Snake/Salt River Basin is not a major issue at this time and may not be an issue well into the future due to the extensive water resources available to the basin. However, if uses come into conflict such as agricultural uses interfering with environmental and recreational uses, conservation may be a method to reduce these conflicts. Water conservation may be necessary in drought conditions, or where groundwater development is extensive causing local aquifer draw down and interference between wells.

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8.0 BASIN ISSUES, STRATEGIES AND WATER USE OPPORTUNITIES

8.0 BASIN ISSUES, STRATEGIES, AND WATER USE OPPORTUNITIES

TABLE OF CONTENTS

8.1 Introduction 155
8.2 Future Water Use Opportunities 157
8.2.1 Reservoir Storage Opportunities 158
8.2.2 Groundwater Use Opportunities 160
8.3 Water Conservation and Efficiencies 160
References 161

8.0 BASIN ISSUES, STRATEGIES, AND WATER USE OPPORTUNITIES

8.1 INTRODUCTION

As part of River Basin Planning, Basin Advisory Groups (BAGs) were formed to provide a local perspective to the planning process. They assist the Wyoming Water Development Office (WWDO) and the planning teams in identifying water related issues and water use opportunities within their specific basins. In the Snake/Salt River Basin, the first BAG meeting was held May 15, 2001 in Jackson, Wyoming. There were 30 members from a variety of interests such as agriculture, industry, environment, government, and recreation (Sunrise Engineering, Inc., 2003).

A list of water use opportunities was developed for the 2003 Plan. A long list of opportunities was developed first through discussions with the Snake/Salt River BAG. This long list was then evaluated using criteria established by the planning team and the BAG and a short list was created consisting of opportunities that scored well for the Snake and Salt Sub-basins. The short list scoring criteria included water availability, financial feasibility, public and political acceptability, available users/sponsors, legal and environmental constraints, and multiple use feasibility. Both the long list and short list were presented in a technical memorandum completed for the previous Basin Plan: *Future Water Use Opportunities* (Sunrise Engineering, Inc., 2002) and the 2003 Plan final report (Sunrise Engineering, Inc., 2003). Table 8-1 presents the short list of water use opportunities for the Snake River Sub-basin and Table 8-2 presents the short list of opportunities for the Salt River Sub-basin.

TABLE 8-1: SHORT LIST OF WATER USE OPPORTUNITIES FOR THE SNAKE RIVER SUB-BASIN BY WATER USE SECTOR

Water Use Sector	Water Use Opportunities
Agricultural	▪ Convert Spring Gulch Irrigation System to sprinkler ▪ Convert South Park Irrigation System to sprinkler ▪ Construct Cottonwood Creek Reservoir (Gros Ventre)
Municipal/Domestic	▪ Develop additional community water sources ▪ Fire protection wells in outlying areas ▪ Improve winter flood control in Jackson ▪ Meter unmonitored community water systems
Environmental	▪ Improve water quality of surface run-off from developed areas ▪ Re-establish riparian river banks (habitat) ▪ Create additional wetlands (location dependent) ▪ Transfer GTNP water rights to instream flow ▪ Increase flows in west bank spring creeks ▪ Re-establish meandering patterns in rivers
Recreational	▪ Increase snowmaking operations ▪ Make aesthetic ponds a beneficial use by SEO ▪ Initiate Cloud Seeding Operations
Industrial	▪ Promote additional water bottling opportunities

Note: This table was adapted from the previous Basin Plan final report (Sunrise Engineering, Inc., 2003).

TABLE 8-2: SHORT LIST OF WATER USE OPPORTUNITIES FOR THE SALT RIVER SUB-BASIN BY WATER USE SECTOR

Water Use Sector	Water Use Opportunities
Agricultural	▪ Re-construct Cottonwood Lake Dam (Enlarge Reservoir) ▪ Enlarge Strawberry Reservoir ▪ Dredge & enlarge Swift Creek Reservoir ▪ Route runoff for Groundwater Augmentation ▪ Construct Dry Creek Reservoir ▪ Construct reservoir at Headwaters of Salt River ▪ Construct Willow Creek Reservoir ▪ Construct Crow Creek Reservoir ▪ Construct Green Canyon Reservoir ▪ Construct Stump Creek Reservoir ▪ Construct Cedar Creek Reservoir ▪ Construct Stewart Creek Reservoir
Municipal/Domestic	▪ Develop additional community water sources ▪ Meter unmonitored community water systems
Environmental	▪ Create Alpine wetland (Greys River Area) ▪ Re-establish riparian river banks ▪ Create additional wetlands ▪ Re-establish meandering patterns in rivers
Recreational	▪ Construct new dam on Salt River above narrows ▪ Initiate cloud seeding operations
Industrial	▪ Promote additional water bottling opportunities ▪ Construct hydro facilities on existing irrigation systems ▪ Construct low head/open channel hydro projects

Note: This table was adapted from the previous Basin Plan final report (Sunrise Engineering, Inc., 2003)

During development of the Wyoming Framework Water Plan, 2007, water related issues important to the BAG were discussed and listed (WWC Engineering, Inc, 2007). These issues were included as part of Volume II of the Framework Water Plan. As the planning process has continued, the issues developed for the Framework Water Plan were refined and new issues added. Through continued planning with the BAG and the planning team, strategies have been developed to address the issues. A combination of the initial BAG issues, the Framework Water Plan issues, and the strategies is shown in Appendix C.

As part of this planning process, issues, strategies and water use opportunities were combined to form a matrix showing potential strategies and opportunities to address the issues. Table 8-3 displays a summary of the integration and synthesis of all the issues, strategies and water use opportunities by water use sector. A comparison of the short list of opportunities from 2003 and the strategies and opportunities developed as part of the current planning process shows these lists are very similar. Although the 2003 list is more detailed than the list from the current effort, they address the same basic issues for the water use sectors.

TABLE 8-3: SNAKE/SALT RIVER BASIN ISSUES AND WATER USE STRATEGIES AND OPPORTUNITIES BY WATER USE SECTOR

Water Use Sector	Issues	Strategies and Opportunities
Agricultural	Improve water use efficiency	▪ Evaluate and modernize irrigation systems ▪ Encourage water conservation to aid agricultural operations
	Increase irrigation water supply	▪ Reconstruct the dam at Cottonwood Lake ▪ Examine other potentials for reservoir storage
Municipal/Domestic	Economic and population growth – Is there water available?	▪ Plan orderly growth ▪ Evaluate and describe groundwater resources in the basin ▪ Project future water needs to better allocate water resources ▪ Develop additional water supplies
	Municipal and rural domestic water supplies	▪ Maintain and improve existing water supply systems to meet demands ▪ Encourage water conservation and meter water systems
	Wastewater	▪ Evaluate wastewater systems for impacts to water quality ▪ Reuse wastewater. Implement appropriate systems in the basin
	Flooding	▪ Improve winter flood control in Jackson
Environmental	Aesthetics of streams and rivers	▪ Conduct watershed studies to evaluate and define water needed to maintain healthy environments
	Protect riparian areas	▪ Conduct riparian area rehabilitation projects
	Protect and develop wetlands	▪ Conduct wetland rehabilitation projects
	Channel maintenance	▪ Conduct river morphology rehabilitation projects
	Water quality	▪ Maintain surface water quality monitoring programs ▪ Monitor groundwater quality to insure no degradation ▪ Promote proper land management and use to protect water quality
Recreational	Maintain adequate water for recreational use.	▪ Evaluate the amount of water needed for recreational uses including fishing and whitewater rafting
	Consider the aesthetics of water features	▪ Make aesthetic ponds a beneficial water use
	Consider fishing and fisheries	▪ Maintain water quality and fish habitat
	Consider snowmaking operations	▪ Continue snowmaking operations for winter sports areas
Industrial	Economic development	▪ Promote water bottling opportunities

8.2 FUTURE WATER USE OPPORTUNITIES

This section discusses opportunities to develop water storage in the basin as well as developing groundwater sources. Water conservation is also discussed as a method to more efficiently use water and decrease the demand for water resources.

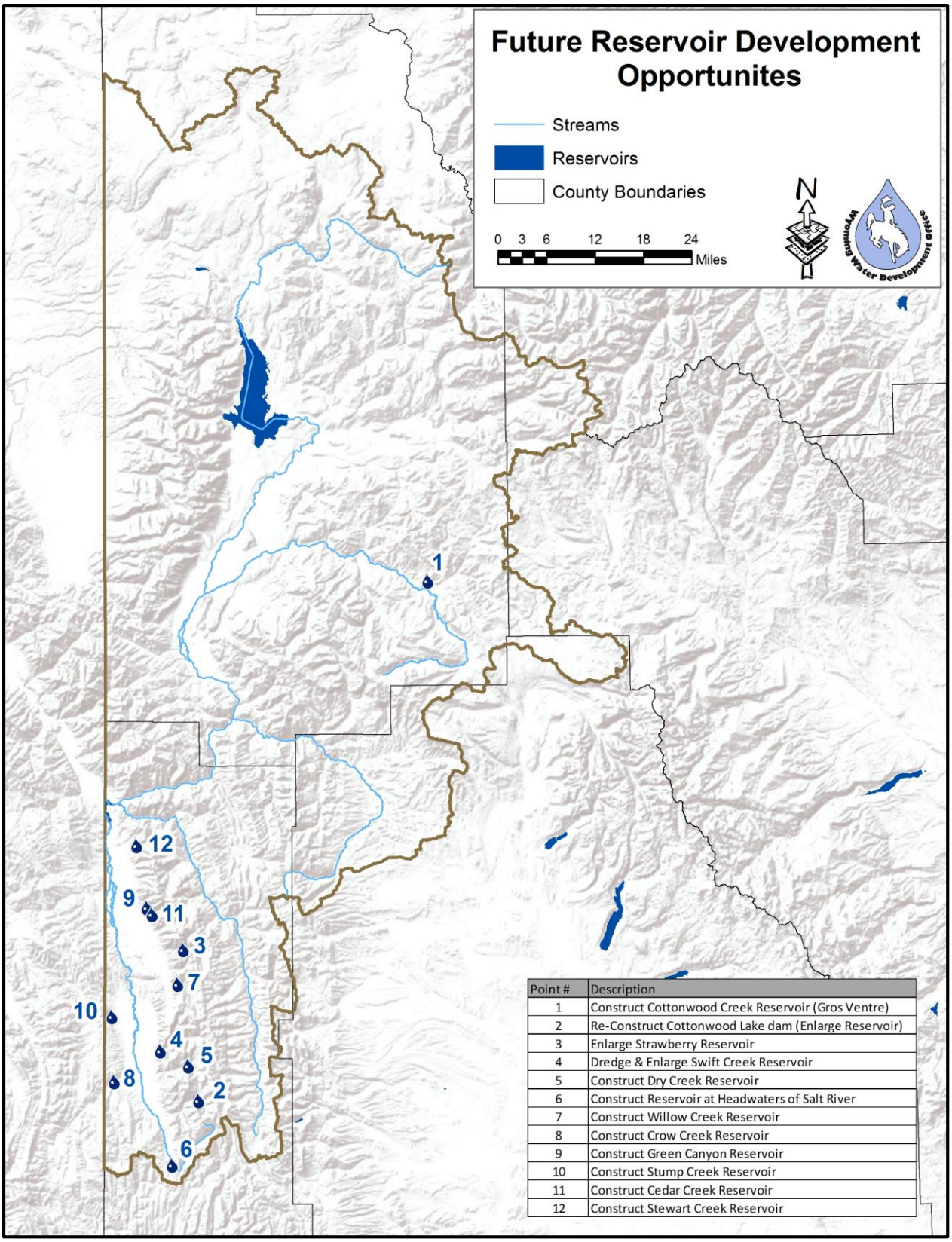
8.2.1 RESERVOIR STORAGE OPPORTUNITIES

There were 12 potential reservoir projects presented in the 2003 Plan short list. One potential reservoir was in the Snake River Sub-basin, and the other 11 were in the Salt River Sub-basin. These projects are listed in Tables 8-1 and 8-2 along with other water resource projects. Figure 8-1 shows the approximate location of the potential reservoirs. The size of the reservoirs and the lands where the water would be used are not provided.

Additionally, the WDO, Dam and Reservoir Section has developed a listing of potential reservoir sites in the Snake/Salt River Basin from past studies. There are a large number of potential sites listed in Teton, Lincoln, and Sublette Counties from the various studies. All of the potential projects presented in the 2003 Plan and in the WDO list, except the Cottonwood Lake reconstruction and enlargement, would require initial reconnaissance studies before they are considered further. The Cottonwood Lake reconstruction and enlargement has undergone several studies and has been funded for Level III permitting and construction through the Water Development Program.

Reservoir water storage benefits irrigated agriculture by providing a predictable water supply and by extending the irrigation season. There may be both benefits and impacts to environmental and recreational water uses from water storage. Minimum reservoir pools and regulated fall and winter releases may benefit environmental and recreational water uses. Loss of stream habitat and continuity as well as changes in stream hydrology may negatively impact these same uses. Cost and potential benefits and/or impacts to the various water uses must be considered on each reservoir project before proceeding.

JACKSON LAKE DAM OUTLET WORKS



Point #	Description
1	Construct Cottonwood Creek Reservoir (Gros Ventre)
2	Re-Construct Cottonwood Lake dam (Enlarge Reservoir)
3	Enlarge Strawberry Reservoir
4	Dredge & Enlarge Swift Creek Reservoir
5	Construct Dry Creek Reservoir
6	Construct Reservoir at Headwaters of Salt River
7	Construct Willow Creek Reservoir
8	Construct Crow Creek Reservoir
9	Construct Green Canyon Reservoir
10	Construct Stump Creek Reservoir
11	Construct Cedar Creek Reservoir
12	Construct Stewart Creek Reservoir

FIGURE 8-1: FUTURE RESERVOIR DEVELOPMENT OPPORTUNITIES

8.2.2 GROUNDWATER USE OPPORTUNITIES

The multiple aquifers in the Snake/Salt River Basin are generally favorable for future groundwater development and use opportunities in most areas of the basin. Currently used aquifers of the basin will continue to be available for additional development and use opportunities. The heavily used Cenozoic aquifers, including the unconsolidated alluvial deposits and Tertiary bedrock formations, have abundant groundwater available for future use.

Older bedrock formations in the Snake/Salt River Basin are generally situated in groundwater compartments formed by the geologic structures of the Overthrust Belt and on the flanks of Precambrian basement-cored uplifts. The use of the older (Paleozoic and Mesozoic aquifers) and deeper aquifers may require site-specific hydrogeologic investigations to help identify favorable well sites, depending on the desired use (municipal, industrial, etc.) for the basin's groundwater resources. Refer to *Technical Memorandum, Available Groundwater Determination – Tab XI [2013]*

8.3 WATER CONSERVATION AND EFFICIENCIES

In the Snake/Salt River Basin, agricultural, environmental, and recreational water uses depend on surface water while municipal, industrial, and domestic water uses depend on groundwater. Irrigated agriculture is the largest water use in the basin, and conservation within this water use sector could produce the greatest water savings. See discussions in Chapter 7 and refer to *Technical Memorandum, Water Conservation- Tab XV [2012]*.

Although there are several methods to conserve water in irrigated agriculture, the greatest savings can be realized by moving from flood irrigation to sprinkler irrigation. Sprinkler irrigation conserves water, improves efficiency and often increases productivity. Using irrigation water more efficiently may make more water available for instream environmental and recreational uses. However, there are also losses to the environment when changing from flood irrigation to sprinkler. Peak stream discharges may be greater, causing flooding and erosion, and reduction in soil and water table recharge from deep percolation may mean reduced return flows to streams in fall and winter.

The most effective tools for conservation in municipal water use are metering and tiered water rates, where rates increase with increased water use. All of the municipalities within the basin depend on groundwater and conservation is important to prevent overdrawing or mining aquifers.

There are no specific conservation methods for rural domestic water use. Rural domestic water use almost always depends on groundwater and the cost of pumping and aquifer draw-down are the controlling factors for this use. As pumping costs increase and water levels drop, water conservation becomes important if not mandatory.

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9.0 PROGRAM STRATEGIES AND RECOMMENDATIONS

9.0 PROGRAM STRATEGIES AND RECOMMENDATIONS

TABLE OF CONTENTS

9.1 Program Strategies 162
9.1.1 Program Strategies.....162
9.1.2 Data Acquisition.....162
9.1.3 Water Resources Modeling.....163
9.2 Recommendations 163
9.2.1 Agriculture 163
9.2.2 Industry 164
9.2.3 Municipal and Domestic.....164
9.2.4 Environmental 164
9.2.5 Recreation.....164

9.0 PROGRAM STRATEGIES AND RECOMMENDATIONS

This chapter provides program strategies and recommendations for future planning in the Snake/Salt 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 Snake/Salt River Basin, which include outreach and agency coordination, data acquisition, and water resource modeling. Strategies for improving these elements are presented in the following discussion.

9.1.1 PROGRAM STRATEGIES

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 regular 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, the field staff, and the planning team. Regular meetings should be scheduled with the Cheyenne SEO, the WDO planning team 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. It is important to work with SEO division superintendents and the field staff to obtain diversion and water use data. Additionally, working with the SEO to obtain and improve current water rights information and irrigated lands mapping is important. The SEO should continue to update their irrigated lands and points of diversion GIS products for future modeling efforts and have diversion records digitized in order that they may be more readily used as model inputs.

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 projections and the future water availability.

Recreational and environmental water uses are nonconsumptive uses, but may impact other water use and development opportunities. The WWDC commissioned the Basin Planning, Environmental and Recreation, Level I Study, and the planning team applied the data collection and analysis methods developed in this study to better understand the impacts of these nonconsumptive uses. Datasets developed for this study allowed better evaluation of where environmental and recreational 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 these data required coordination with federal, state, and local agencies as well as private groups and organizations. These efforts should continue as part of the planning process to keep datasets up to date and accurate.

9.1.3 WATER RESOURCES 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 Snake/Salt River Basin 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, depletions, and water remaining for development, datasets (such as the diversions dataset) should be improved to make the spreadsheet models more accurate. More complete datasets will allow more accurate estimations of water available for future use and development.

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 (see Table 8-3). 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 AGRICULTURE

The two major issues in agricultural water use are improving irrigation efficiency and increasing late season water supply. Improving water use efficiency may be addressed by upgrading and improving irrigation infrastructure, such as diversions and canals, and by converting flood irrigation methods to sprinklers. Increasing late season water supplies would best be addressed by construction of storage reservoirs or by using groundwater for late season supplemental water. Currently agricultural irrigation water in the basin is supplied almost totally by surface water. There is sufficient water available under compact to increase agricultural production. With the quantity of water available and implementing conservation practices, the increase in production would most likely not compete with environmental and recreational water uses.

9.2.2 INDUSTRY

Industrial water use has varied over the years and has been concentrated in the Salt River Sub-basin. Industries have relied on groundwater sources supplied from municipal systems. The availability of groundwater presents an opportunity for development industries in the basin and particularly water bottling operations. However, a water bottling plant that was operating in the Salt River Sub-basin (Star Valley) has closed. Dairy related industries have also closed primarily due to economics of the industry rather than a lack of water.

9.2.3 MUNICIPAL AND DOMESTIC

Maintaining adequate clean water supplies for municipal and domestic uses is an essential issue for growth and development in the basin. Planning for future population growth and development is important in meeting the commitment for adequate water supplies. Municipalities and rural domestic water supplies rely on groundwater in the basin and many studies and projects evaluating groundwater resources have been and are being conducted. Community water systems can be and are being developed to meet the current and future water demands of the basin residents. Planning efforts on population growth and water supplies should continue to be sure water is available to meet the projected growth

Concerns about handling of waste water and the potential for pollution are being addressed through permitting and through development of better waste water treatment designs. Flooding issues in Jackson are also being mitigated by specific projects. These efforts should be continued.

9.2.4 ENVIRONMENTAL

Environmental issues discussed in this planning effort focus on water and streams. Protecting and improving riparian corridors and stream channels are important to maintaining a healthy environment and water quality. Additionally, maintaining wetlands and constructing new wetlands protects water quality and provides other environmental benefits. Projects are underway to improve and maintain stream channels, riparian corridors and wetlands. These projects should be continued and environmental water uses should be part of planning efforts.

There are aesthetic components to maintaining and improving riparian corridors, stream channels and wetlands, which are important for tourism and quality of life. Also, allowing streams to have flood plains and riparian corridors is important in flood control and mitigation of impacts to streams.

9.2.5 RECREATION

Maintaining clean water, stream habitats and riparian areas are important components to water related outdoor recreation. Considering aesthetic ponds as a beneficial water use is important for recreational water use. Snowmaking at ski resorts and perhaps cloud seeding may be important in maintaining winter sports activities in the basin. Assuring water supplies to golf courses within the basin is also important for summer recreation. Recreational waster uses should be considered in planning efforts and projects.

APPENDIX A
FRAMEWORK TABLES

APPENDIX A: FRAMEWORK TABLES

Appendix A presents the updated Framework Tables. Data developed as part of this Plan Update is indicated with a 2014 date. 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 II
Table 5-1: Irrigated Acreage II
Table 5-2: 1973 Versus Current Active Crop Distribution II
Table 5-3: Estimated Average Annual Irrigation Surface Water Diversions II
Table 5-4: Estimated Average Annual Irrigation Water Requirement (IWR) III
Table 5-5: Estimated Average Annual Irrigation Water Supply-Limited Consumptive Use (Depletions) III
Table 5-6: Municipal and Domestic Use III
Table 5-7: Municipal and Domestic Water Depletions III
Table 5-8: Annual Industrial Water Use III
Table 6-1: Presently Irrigated Acreage and Projected Irrigation Development IV
Table 6-2: Current and Projected Irrigation Diversion IV
Table 6-3: Current and Projected Consumptive Irrigation Use IV
Table 6-6: Livestock Consumptive Use IV
Table 6-7: Actual and Projected Populations IV
Table 6-9: Projected Annual Electrical Generation Water Needs V
Table 6-10: Total Industrial Water Demand Projections V
Table 6-14: Projected Annual Total Consumptive Water Demands by Use V
Table 6-15: Summary of Current and Projected Future Water Uses V
Table 7-1: Average Annual Streamflow and Uses – Normal Conditions VI
Table 7-2: Available Flows VI
Table 7-3: Average Annual Streamflow and Uses – Mid-Level Development – Dry Conditions VI

TABLE 4-1: TOTAL ANNUAL FLOW

Basin Plan	River Basin	Area (Acres)[1]	Ratio Based on Normal Conditions (AF per Acre)	Yield (AFY)		
				Wet	Normal	Dry
2003	Snake/Salt[2]	3,264,000	1.08	5,047,000	3,540,000	2,179,000
2014	Snake/Salt[2]	3,273,932	1.17	5,654,715	3,821,438	2,506,613

1. Changes in the calculated area are likely the result of changes made to the Geographic Projection used within the GIS.
2. Excludes the flows for the Henrys Fork and Teton Rivers.

TABLE 5-1: IRRIGATED ACREAGE

Basin Plan	River Basin	1973 Total (Acres)	Total (Acres)[2]	Current Irrigated Lands (Acres)[1]	
				Surface Water	Groundwater
2003	Snake/Salt	94,000	99,000	---	---
2014	Snake/Salt	94,000	99,029	99,029	---

1. Current irrigated acreage listed for primary source of supply.
2. This total included the Greys and Teton Sub-basins.

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)
2003	Snake/Salt	99,000	46,000	37,000	---	---	---	16,000
2014	Snake/Salt	99,029	46,376	37,159	---	---	---	15,495

1. Grass/Pasture category includes any kind of grass or hay (wild, native, tame, other; excluding alfalfa), mountain meadow, and pasture.
2. Small Grains category contains winter wheat, spring wheat, barley, and oats.
3. Above crops aggregated for comparisons; all current basin plans did not distinguish based on identical crop types.

TABLE 5-3: ESTIMATED AVERAGE ANNUAL IRRIGATION SURFACE WATER DIVERSIONS

Basin Plan	River Basin	Historical Diversions						Theoretical Diversions	
		Wet (AFY)	Normal (AFY)	Dry (AFY)	Overall Average (AFY)[1]	Surface Irrigated (Acres)	Overall Unit Average (AF per Acre)	Maximum Diversions (AFY)	Maximum Diversions (AF per Acre)
2003	Snake/Salt[2]	---	---	---	363,000	99,000	3.67	448,000	4.52
2014	Snake/Salt	---	---	---	261,033	99,029	2.64	293,549	2.96

1. Overall average in the long-term average for the period of record, and is not the average of the Wet, Normal, and Dry columns.
2. The Bear, Green, Platte, and Snake/Salt River Basin Plans did not provide normal, dry, and wet year scenarios for diversions.

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
2003	Snake/Salt	126,000	99,000	1.27	122,000	126,000	132,000	1.23	1.27	1.33
2014	Snake/Salt[1]	84,671	99,029	0.855	84,671	84,671	84,671	0.855	0.855	0.855

1. Please refer to Section 5.1.6 Crop Irritation Requirements for more information on this analysis.

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
1973	Snake/Salt	84,000	---	---	---	---	---	---
2003	Snake/Salt	---	102,000	99,000	1.03	105,000	102,000	94,000
2014	Snake/Salt	---	80,747	99,029	0.815	80,763	80,747	80,404

TABLE 5-6: MUNICIPAL AND DOMESTIC USE

Basin Plan	River Basin	Demand Factor[1] (gpcpd)	Surface Water (gpd)		Groundwater (gpd)	
			Municipal	Domestic	Municipal	Domestic
2003	Snake/Salt	223	≈ 0	≈ 0	5,875,140	2,241,000
2014	Snake/Salt[2]	230	0	0	6,954,528	959,409

1. Demand factors are based on average use in the basin, which are reported as gallons per capita per day (gpcpd). Use is calculated in gallons per day (gpd).
2. The Demand factor was calculated from the total population and total Average Use as reported in the Municipal and Domestic Water Use Technical Memorandum

TABLE 5-7: MUNICIPAL AND DOMESTIC WATER DEPLETIONS

Basin Plan	River Basin	Depletions (AFY)		
		Surface Water	Groundwater	Total
2003	Snake/Salt	0	9,100	9,100
2014	Snake/Salt	0	8,865	8,865

TABLE 5-8: ANNUAL INDUSTRIAL WATER USE

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
Surface Water Use (AFY)											
2003	Snake/Salt	0	---	0	0	0	---	---	---	---	
2014	Snake/Salt	0	0	0	0	0	0	0	---	---	0
Groundwater Use (AFY)											
2003	Snake/Salt	0	0	0	0	0	140	---	---	---	140
2014	Snake/Salt	0	0	0	0	0	0	0	---	---	0

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
2003	Snake/Salt	99,000	103,000	87,000	76,000
2014	Snake/Salt[1]	99,029	103,609	94,584	83,200

Note: Projections were completed to 2032, a 20 year projection rather than a 30 year projection.

TABLE 6-2: CURRENT AND PROJECTED IRRIGATION DIVERSION

Basin Plan	River Basin	Current (AFY)	30-Year Projections (AFY)		
			High Scenario	Mid Scenario	Low Scenario
2003	Snake/Salt	363,000	382,000	319,000	285,000
2014	Snake/Salt[1]	261,033	273,528	249,702	219,648

Note: Projections were completed to 2032, a 20 year projection rather than a 30 year projection.

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
2003	Snake/Salt	122,000	128,000	107,000	95,000
2014	Snake/Salt[1]	84,671	88,468	80,601	70,777

Note: Projections were completed to 2032, a 20 year projection rather than a 30 year projection.

TABLE 6-6: LIVESTOCK CONSUMPTIVE USE

Basin Plan	River Basin	Current (AFY)	30-Year Projections (AFY)		
			High Scenario	Mid Scenario	Low Scenario
2003	Snake/Salt	470	410	340	210
2014	Snake/Salt[1]	369	445	376	315

Note: Projections were completed to 2032, a 20 year projection rather than a 30 year projection.

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
2003	Snake/Salt	27,480	75,100	46,700	29,300
2014	Snake/Salt[1]	34,473	50,679	42,033	36,413

Note: Projections were completed to 2032, a 20 year projection rather than a 30 year projection.

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)			Cooling Water Total Use Surface Water (AFY)			Cooling Water Total Use Groundwater (AFY)		
				High Scenario	Mid Scenario	Low Scenario	High Scenario	Mid Scenario	Low Scenario	High Scenario	Mid Scenario	Low Scenario
2003	Snake/Salt	None	0	0	0	0	0	0	0	0	0	0
2014	Snake/Salt[1]	None	0	0	0	0	0	0	0	0	0	0

Note: Projections were completed to 2032, a 20 year projection rather than a 30 year projection.

TABLE 6-10: TOTAL INDUSTRIAL WATER DEMAND PROJECTIONS

Basin Plan	River Basin	30-Year Projections (AFY)		
		High Scenario	Mid Scenario	Low Scenario
2003	Snake/Salt	50	48	24
2014	Snake/Salt[1]	40	24	0

Note: Projections were completed to 2032, a 20 year projection rather than a 30 year projection.

TABLE 6-14: PROJECTED ANNUAL TOTAL CONSUMPTIVE WATER DEMANDS BY USE

Basin Plan	River Basin	Type of Use											
		Agriculture			Municipal & Domestic			Industrial			Recreational[1]		
		30-Year Projections (AFY)			30-Year Projections (AFY)			30-Year Projections (AFY)			30-Year Projections (AFY)		
		High Scenario	Mid Scenario	Low Scenario	High Scenario	Mid Scenario	Low Scenario	High Scenario	Mid Scenario	Low Scenario	High Scenario	Mid Scenario	Low Scenario
2003	Snake/Salt	128,100	107,100	94,900	18,600	11,500	7,200	50	50	20	1,600	1,300	950
2014	Snake/Salt	88,913	80,977	71,092	13,032	10,808	9,364	40	24	0	-	-	-

Note: Projections were completed to 2032, a 20 year projection rather than a 30 year projection.
1. The Recreational Analysis for the 2014 Snake Salt Update was completed differently than for the 2003 Update. As a result no projections are available for this scenario.

TABLE 6-15: SUMMARY OF CURRENT AND PROJECTED FUTURE WATER USES

Basin Plan	River Basin	Current (AFY)[1]	30-Year Projections (AFY)		
			High Scenario	Mid Scenario	Low Scenario
Surface Water					
2003	Snake/Salt	194,200	202,200	179,300	168,100
2014	Snake/Salt	157,215	161,088	153,152	143,267
Groundwater					
2003	Snake/Salt	6,800	18,700	11,700	7,400
2014	Snake/Salt	8,865	13,072	10,832	9,364

Note: Projections were completed to 2032, a 20 year projection rather than a 30 year projection.
1. Includes reservoir evaporation as a use.

TABLE 7-1: AVERAGE ANNUAL STREAMFLOW AND USES – NORMAL CONDITIONS

Basin Plan	River Basin	State Line Outflow-Natural Conditions (AFY)[1]	Depletions of Streamflows to Wyoming (AFY)[2]					Depleted Streamflow Leaving Wyoming (AFY)[3]	Wyoming's Remaining Share Under Compact (AFY)[7]
			Irrigation	Municipal, Domestic, and Stock	Industrial	Reservoir Evaporation	Total		
2003	Snake/Salt River[8]	3,540,000	122,000	0	0	72,200	194,200	3,345,800	155,000
2014	Snake/Salt River[4,5,6]	3,821,438	84,671	369	0	72,175	157,215	3,664,223	148,711

1. Estimates are based on outflow plus depletions from the current river basin plan.
2. Depletion estimates are from the current river basin plan.
3. Depleted flows are based on outflow estimates from the current river basin plan.
4. Excludes the flows for the Henrys Fork and Teton Rivers.
5. Includes the flow of Greys River.
6. Total Depletions not Post Compact Depletion.
7. Refer to Table 7-6 in the 2012 Snake/Salt River Basin Plan for Specifics.

TABLE 7-2: AVAILABLE FLOWS

Basin Plan	Sub-Basin	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)
2003	Salt River	694,000	31,000	458,000	22,000	216,000	12,000
	Snake River	4,159,000	165,000	2,888,000	116,000	1,769,000	69,000
2014	Snake River	4,438,246	4,049,867	3,124,912	2,717,548	2,428,571	1,775,752
	Salt River	861,600	701,601	570,725	410,726	359,119	199,120
	Greys River	488,441	221,098	278,374	148,711	117,292	95,023

TABLE 7-3: AVERAGE ANNUAL STREAMFLOW AND USES – MID-LEVEL DEVELOPMENT – DRY CONDITIONS

Basin Plan	River Basin	State Line Outflow-Natural Conditions (AFY)[1]	Depletions of Streamflows to Wyoming (AFY)[2]					Depleted Streamflow Leaving Wyoming (AFY)[3]	Wyoming's Remaining Share Under Compact (AFY)[7]
			Irrigation	Municipal, Domestic, and Stock	Industrial	Reservoir Evaporation	Total		
2003	Snake/Salt River[4]	2,164,300	107,100	0	0	72,200	179,300	1,985,000	90,000
2014[8]	Snake/Salt River[4,5,6]	2,506,613	80,601	376	0	72,175	153,152	2,353,461	96,321

1. Estimates are based on outflow plus depletions from the current river basin plans.
2. Depletion estimates are from the current river basin plans.
3. Depleted flows are based on outflow estimates from the current river basin plans.
4. Excludes the flows for the Henrys Fork and Teton Rivers.
5. Includes the flow of the Greys River.
6. Total Depletions, not Post Compact Depletion.
7. See Appendix C to the Report for more information.
8. The 2014 Report provided 20 Year Projections, rather than 30 year.

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 please 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.

APPENDIX C
SNAKE/SALT RIVER BASIN ADVISORY GROUP ISSUES AND STRATEGIES

APPENDIX C: SNAKE/SALT RIVER BASIN ADVISORY GROUP ISSUES AND STRATEGIES

During development of the Wyoming Framework Water Plan, 2007, water related issues important to the Snake Salt River Basin Advisory Group were discussed and listed. These issues were included as part of Volume II of the Framework Water Plan. As the planning process has continued, the issues developed for the Framework Water Plan were refined and new issues added. Through continued planning with the BAG and the planning team, strategies have been developed to address the issues. A combination of the initial BAG issues, the Framework Water Plan issues, and the strategies is presented in Table C1.

Table C1: Issues and Strategies Identified from Basin Advisory Groups and the Framework Water Plan

Categories	2001/2003 Issues	2005/2007 Issues	2008 Strategies
Water Quality	Monitor Water Quality	Flat Creek Watershed Enhancement Project	Maintain surface water quality monitoring programs.
	Pollution of Water Sources	Fish Creek Groundwater Study	Monitor groundwater quality to ensure no degradation.
	Protect Stream From Pollution	Monitoring Program - Teton Co. Conservation District	Promote proper land management and use to protect water quality.
	Water Quality, Is it Getting Better or Worse, And Why	DEQ Subdivision reviews	
	Domestic & Culinary Use	NPS long term water quality monitoring program (start in Spring of 2007)	
		Teton Co. and/or Teton Co. Conservation Dist. Watershed plan	
		BTNF water quality projects	
Environmental Concerns	Aesthetics & Character of Streams and Rivers	Alpine Wetlands Project	Conduct Watershed studies to evaluate and define the water needed to maintain a healthy environment.
	Wetlands	Snake River Resource Management Plan - BLM	
	Wildlife, Eagles, Ducks, etc.	Jackson Lake Dam operations	
	Protection of Riparian Areas from Development	Upper Snake River Restoration Project	
		Instream flows - channel maintenance and other environmental issues	
Recreation	Enough Water for White Water Rafting	Snake River Fund	Evaluate the water resources within the basin.
	Active & Passive Recreation	Wild and Scenic Campaign	Consider recreation in the water resources evaluation
	Visitor Use vs. Local Use	Jackson Lake Dam operations	
	Fishing	Water as a visual resource	
	Water as a Visual Resource - The Importance of Water in a Dry Climate	Fishing and other water recreation (uses and impacts)	
	Consider Economic Impacts of Fishing and Other Water Recreation	White water rafting	
Agriculture	Maintain Existing Irrigation Water Rights	Canal Modernization/North Canal Project	Continue to support irrigated agriculture within the basins.
	Improve Irrigation Efficiency	Incentives for more efficient irrigation systems (conservation)	Work to promote water conservation within the basins.
	Agricultural Use	Traditional uses of agricultural land moving to untraditional uses	Evaluate irrigation infrastructure.
	Saving the Livelihood of Farmers in Star Valley		Improve and modernize irrigation to aid agriculture.
Other Uses/Consumptive	Bottled & Trucked Out Water	Jackson Lake Hydroelectric Project	Work to promote water conservation within the basin.
		Alpine Master Plan	

Categories	2001/2003 Issues	2005/2007 Issues	2008 Strategies
Water Law/ Compacts	How Can We Advise the Planning Team to Acquire a Say in the Storage, Release and Use or the Water Released From Jackson Lake		Continue to work within the terms of the compact to allow future development while maintaining river systems.
Growth	Continued Population Increases (Water Adjudication)	Growth in Teton County, Idaho	Evaluate and describe groundwater resources within the basins.
	Plan for Orderly Growth	Growth impacts in basin	Project future water needs to ensure sufficient water is available to meet anticipated demands for growth and economic development.
	How Much Water Do We need in the Basin and Do We Still Have It?	Economic Development in the Basin	Maintain and improve existing water supply infrastructure to allow local water systems to meet the demands of population growth.
	Population in the Basin - Growth and the resulting Demand for Water.		
	Training Administrators		
	Training Operators for Water and Wastewater		Consider wastewater systems in development plans
Fisheries	Maintain Water Quality for Fish Habitat	Protect instream flows	Evaluate the amount of water needed for recreation and recreational activities.
	Protect Instream Flows	Fisheries Management of the Snake and Salt River Basins	
		Studies of Snake River Cutthroat Trout in the Salt River	
		Species & Habitat Inventory from Palisades Dam to headwaters of Snake	
		Temporary change in use to instream flow	
		Illegal fish introductions	
		Petition for listing of the Yellowstone cutthroat trout	
Wastewater	Wastewater Treatment	Wastewater treatment and reuse	Evaluate wastewater systems for impact to water quality.
	Wastewater Reuse		Evaluate and implement appropriate wastewater systems within the basins.
Other		Snake River Operations	
		Drought and related issues	
		Water 2025	
		WYDOT issues in the basin	
		Weather Modification Feasibility Study	
		Overlapping authorities, jurisdictions and permitting authorities on Snake River	Work toward coordinated management of water resources in the basin.