5.0 CURRENT USE

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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

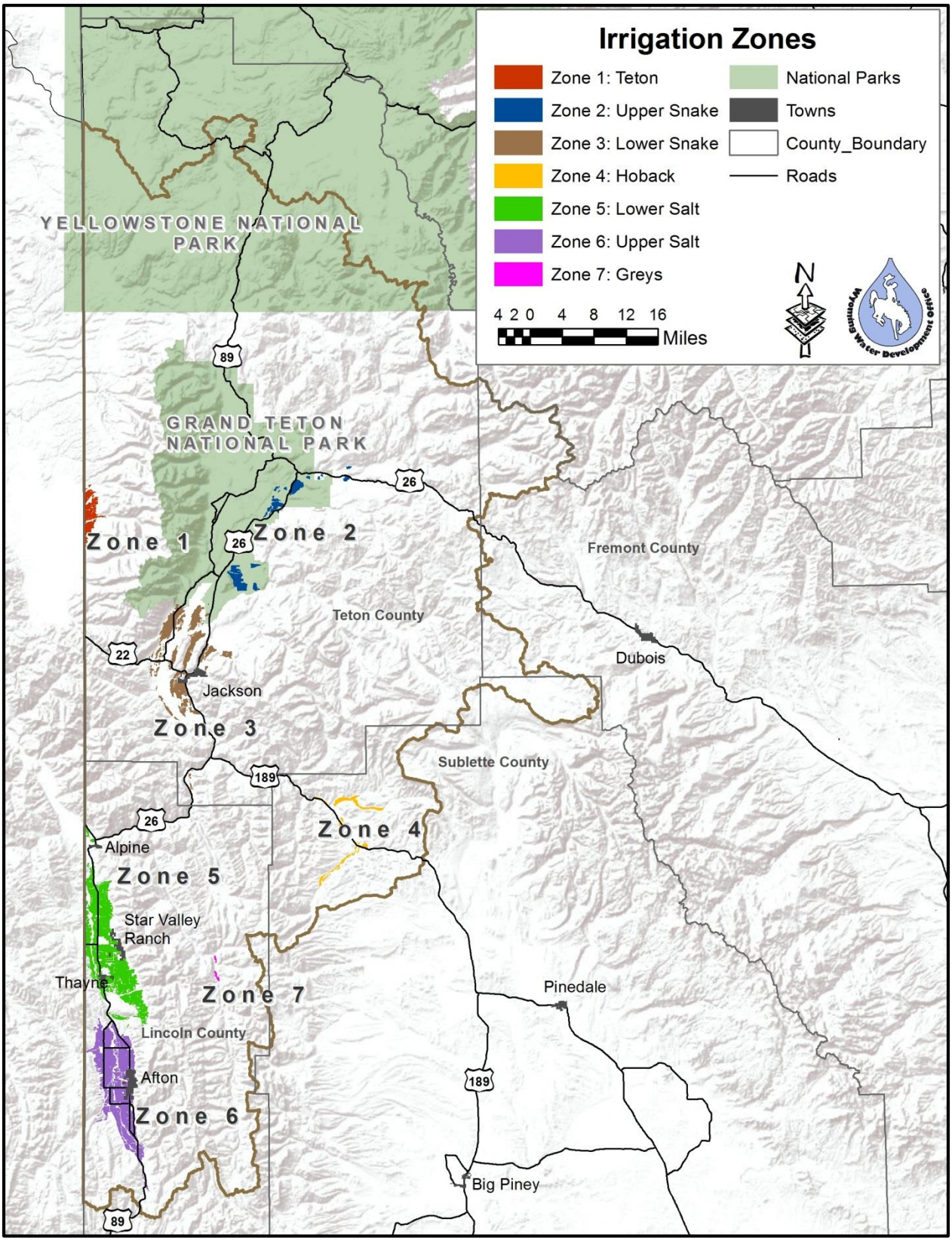


FIGURE 5-1: SNAKE/SALT RIVER BASIN IRRIGATION ZONES

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.

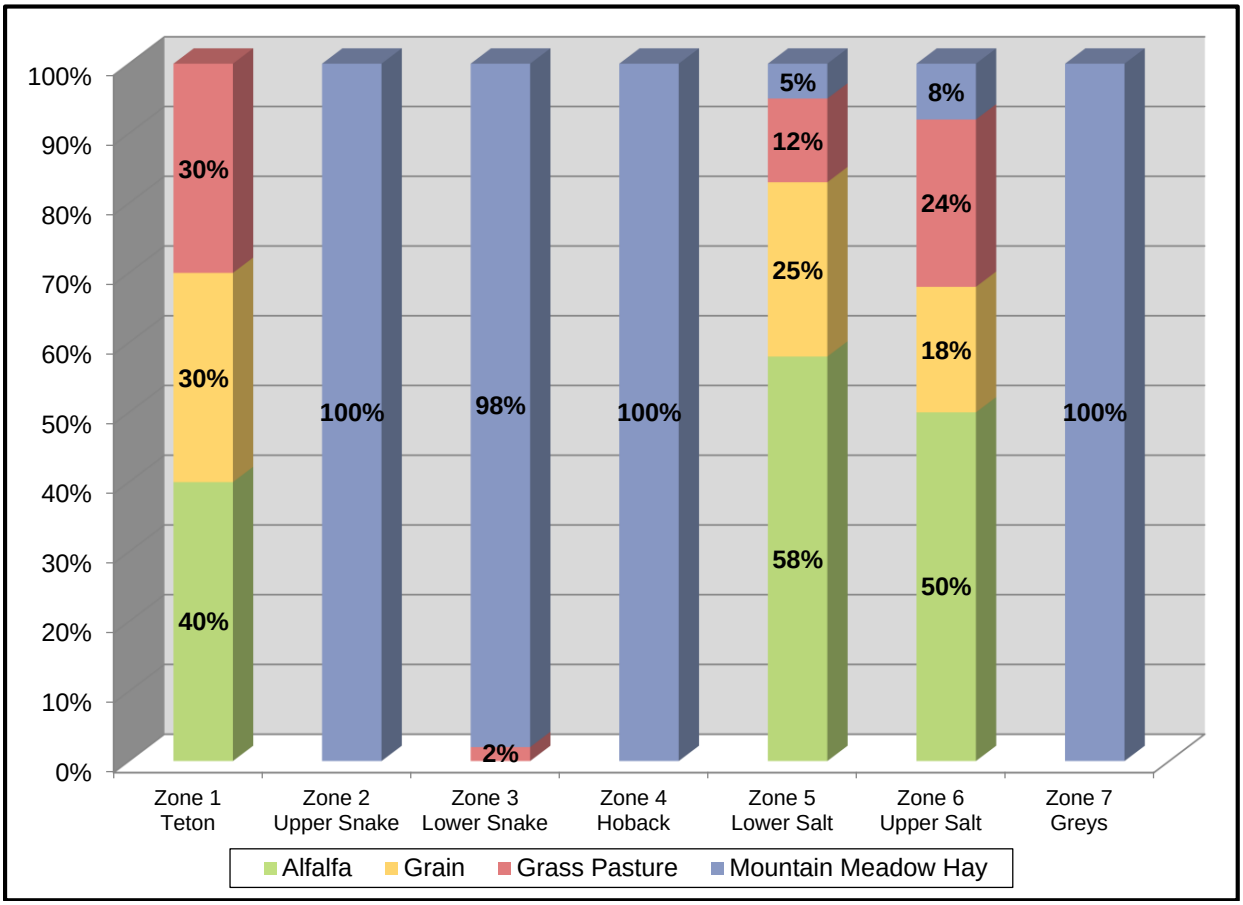


FIGURE 5-2: CROP DISTRIBUTION BY IRRIGATION ZONE

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.

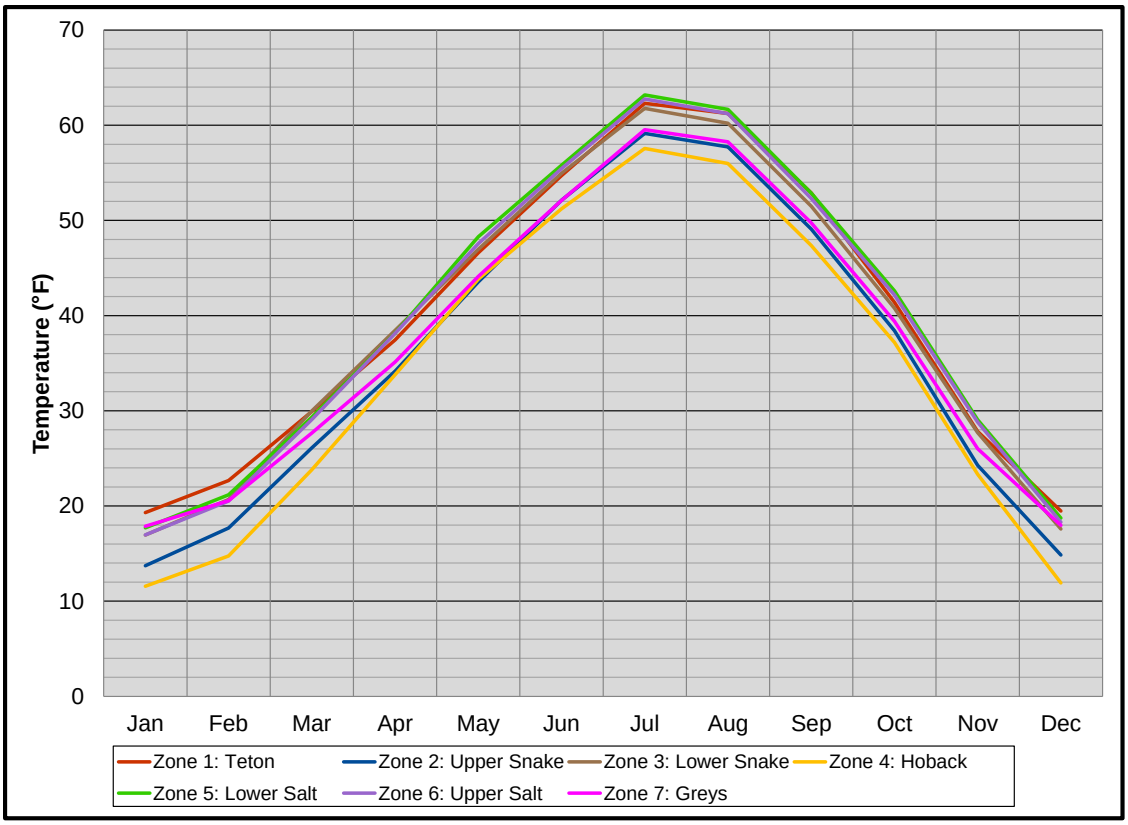


FIGURE 5-3: AVERAGE MONTHLY TEMPERATURES BY IRRIGATION ZONE

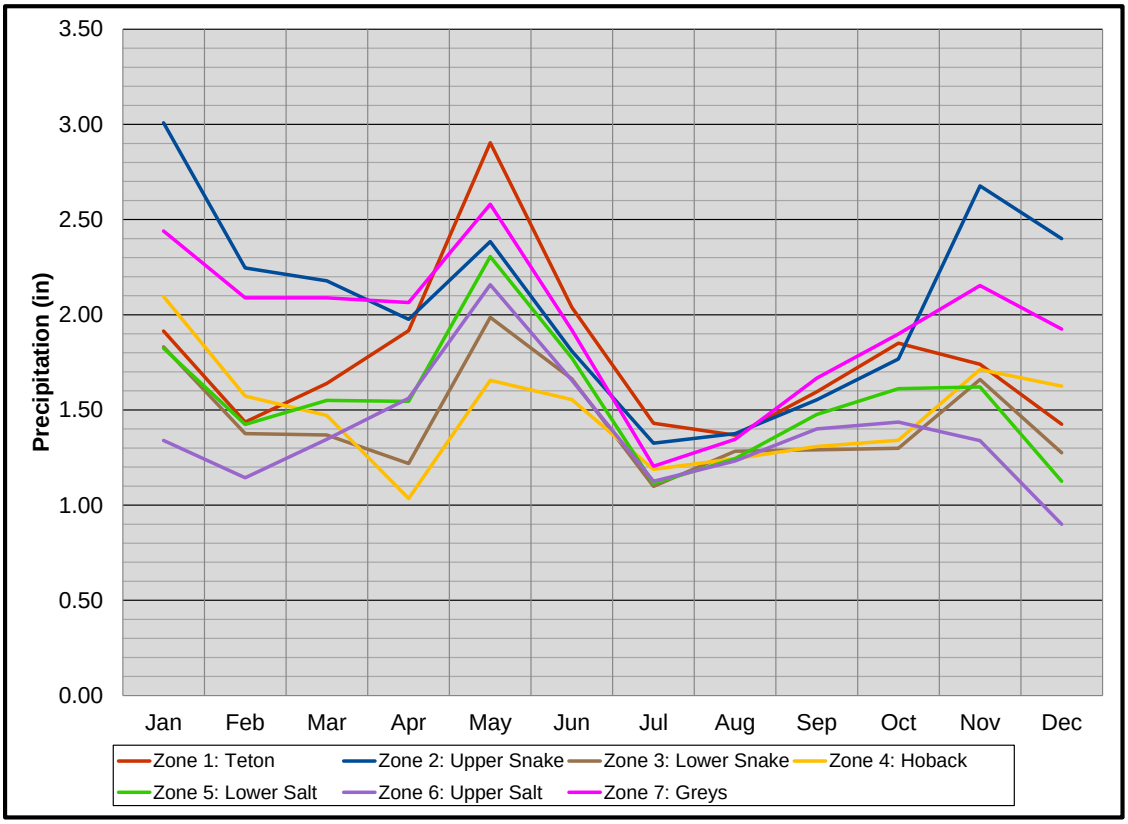


FIGURE 5-4: AVERAGE MONTHLY PRECIPITATION BY IRRIGATION ZONE

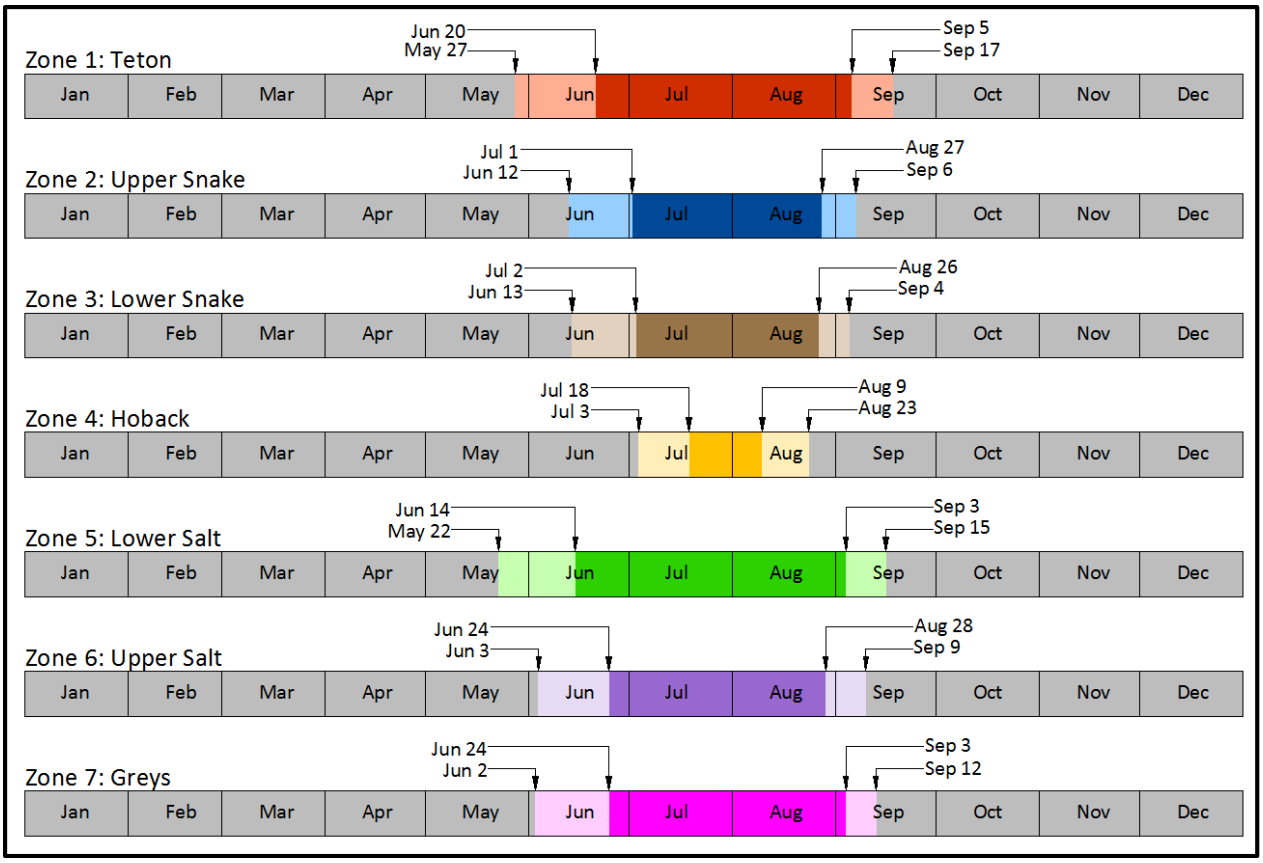


FIGURE 5-5: AVERAGE HISTORIC 28 AND 32 DEGREE F. FROST DATES BY IRRIGATION ZONE

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.*

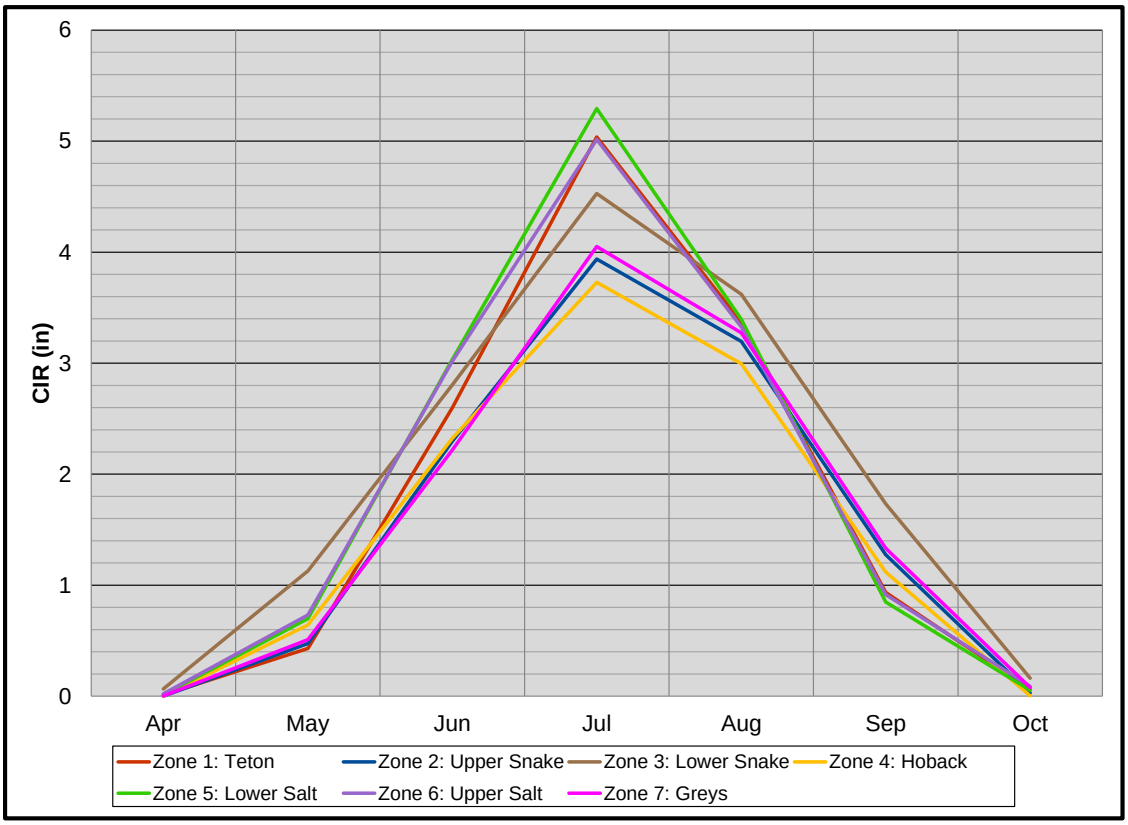


FIGURE 5-6: MONTHLY CROP IRRIGATION REQUIREMENTS BY IRRIGATION ZONE

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.

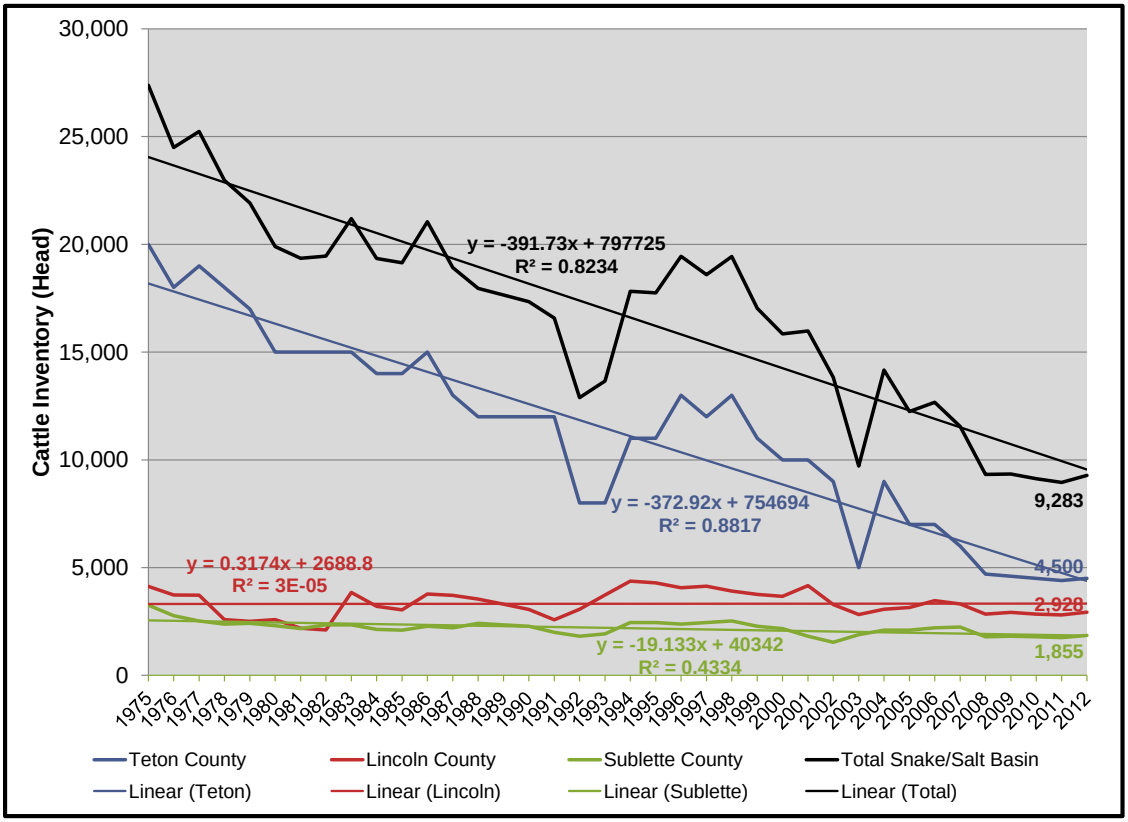


FIGURE 5-7: CATTLE INVENTORY AND HISTORIC TRENDS BY COUNTY WITHIN THE SNAKE/SALT RIVER BASIN

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.

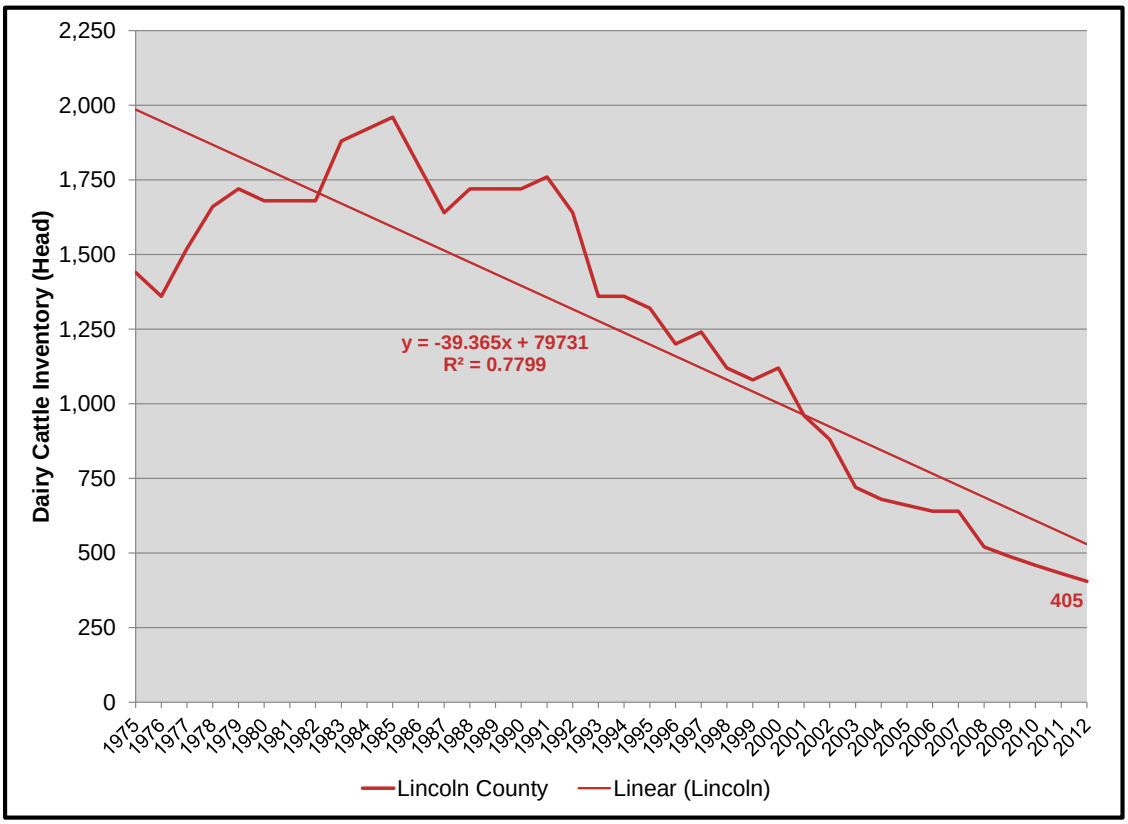


FIGURE 5-8: DAIRY CATTLE INVENTORY AND HISTORIC TRENDS IN LINCOLN COUNTY WITHIN THE SNAKE/SALT RIVER BASIN

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.

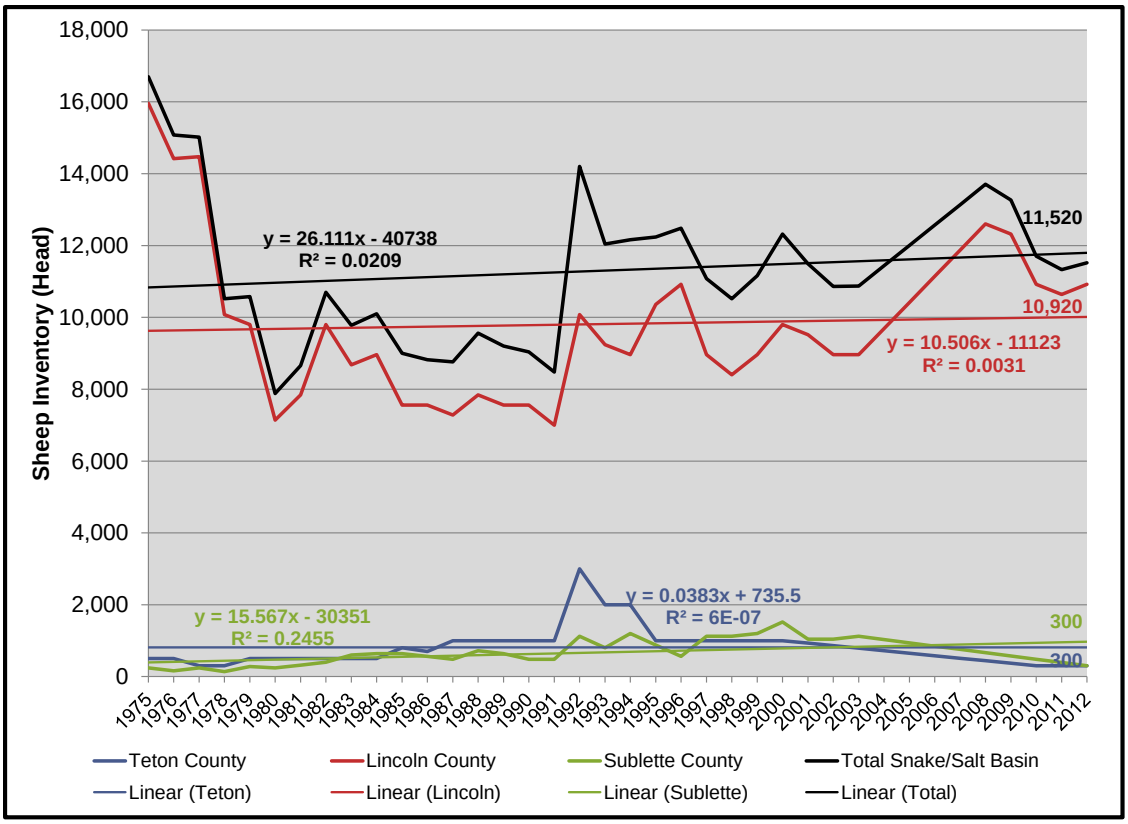


FIGURE 5-9: SHEEP INVENTORY AND HISTORIC TRENDS BY COUNTY WITHIN THE SNAKE/SALT RIVER BASIN

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.

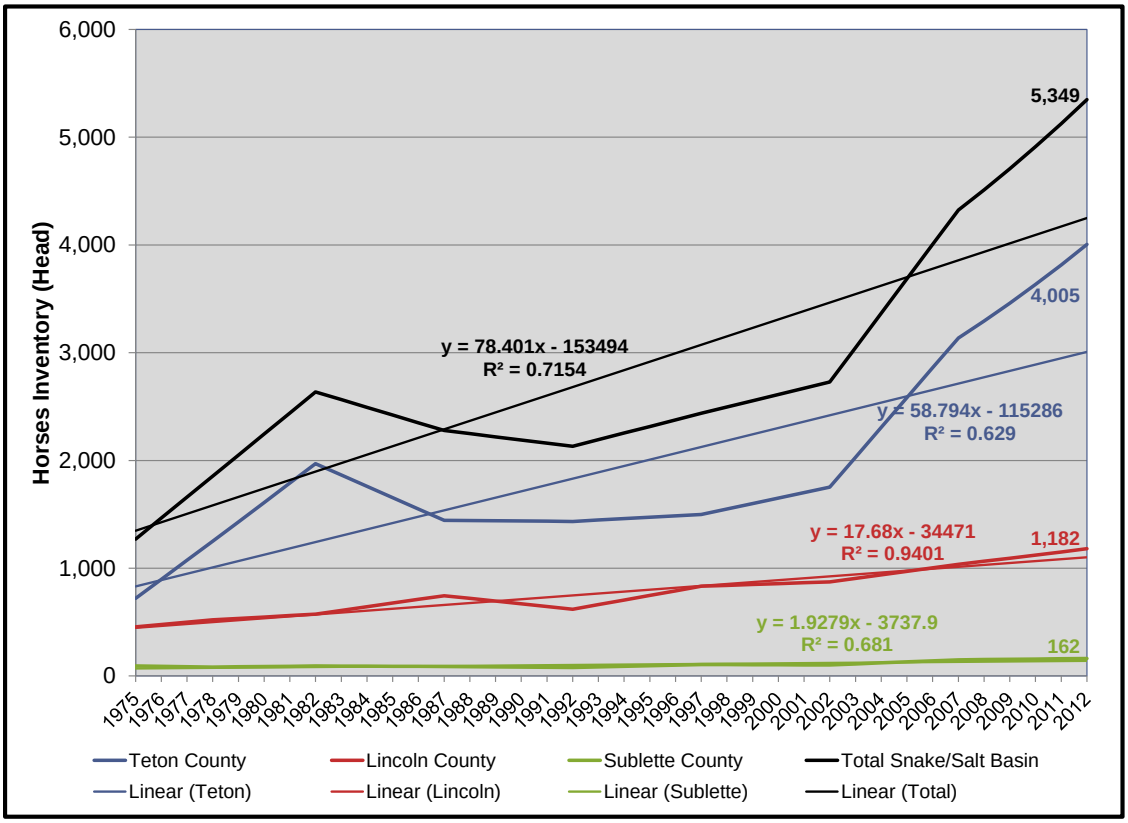


FIGURE 5-10: HORSE INVENTORY AND HISTORIC TRENDS BY COUNTY WITHIN THE SNAKE/SALT RIVER BASIN

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

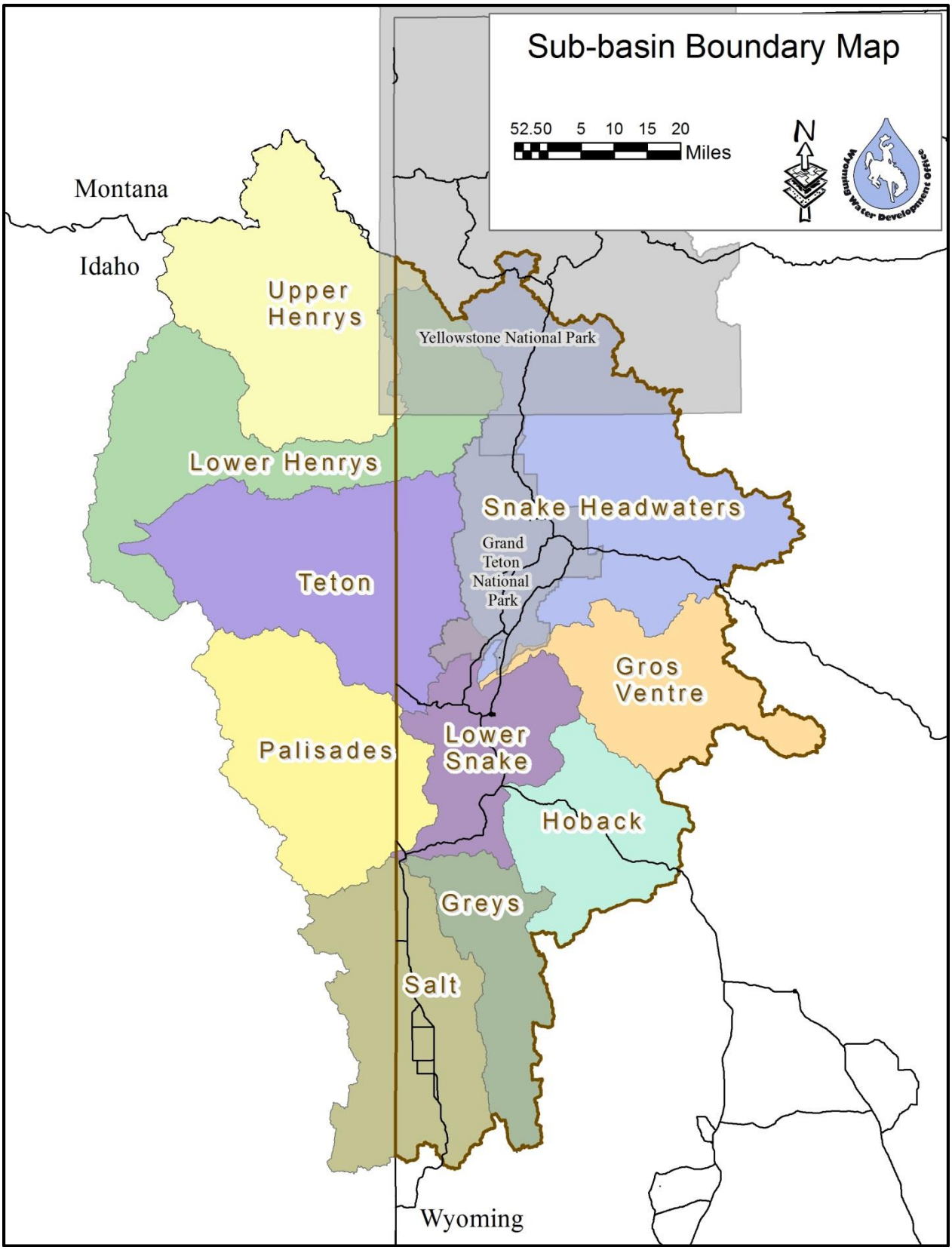


FIGURE 5-11: SUB-BASINS DEFINED FOR THE ENVIRONMENTAL AND RECREATIONAL ANALYSIS

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

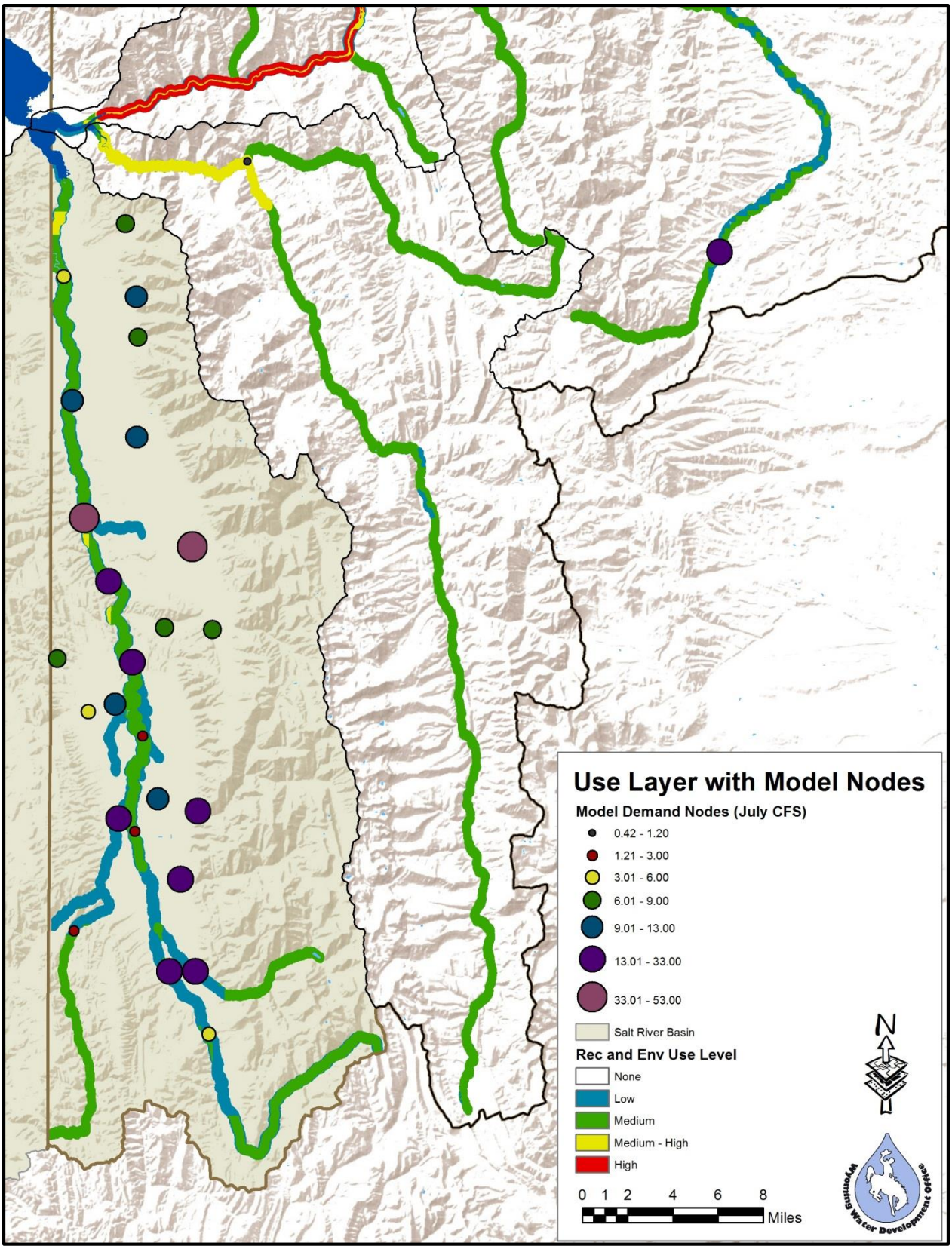


FIGURE 5-12: SALT RIVER BASIN USE LAYER MAP

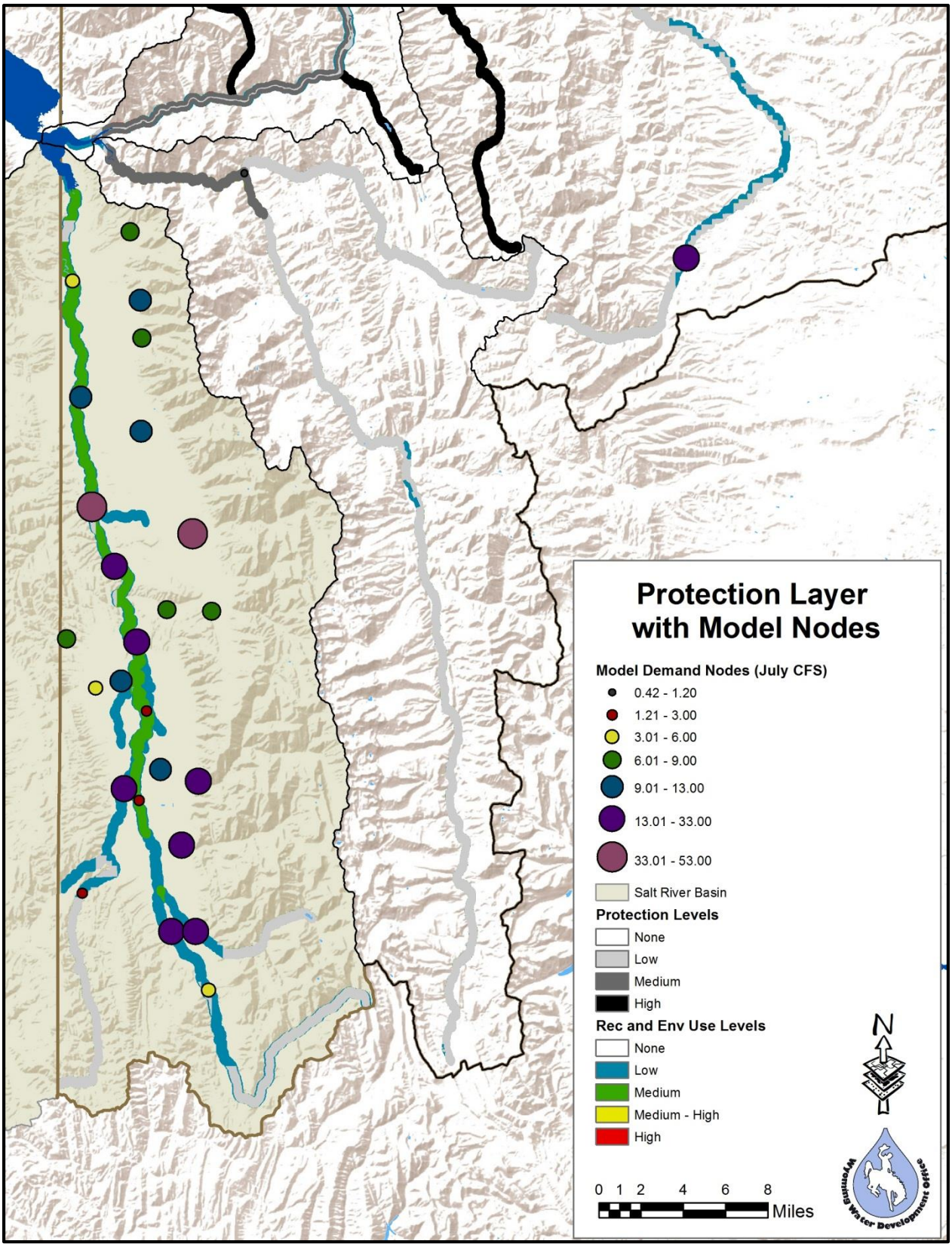


FIGURE 5-13: SALT RIVER BASIN PROTECTION LAYER MAP

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.

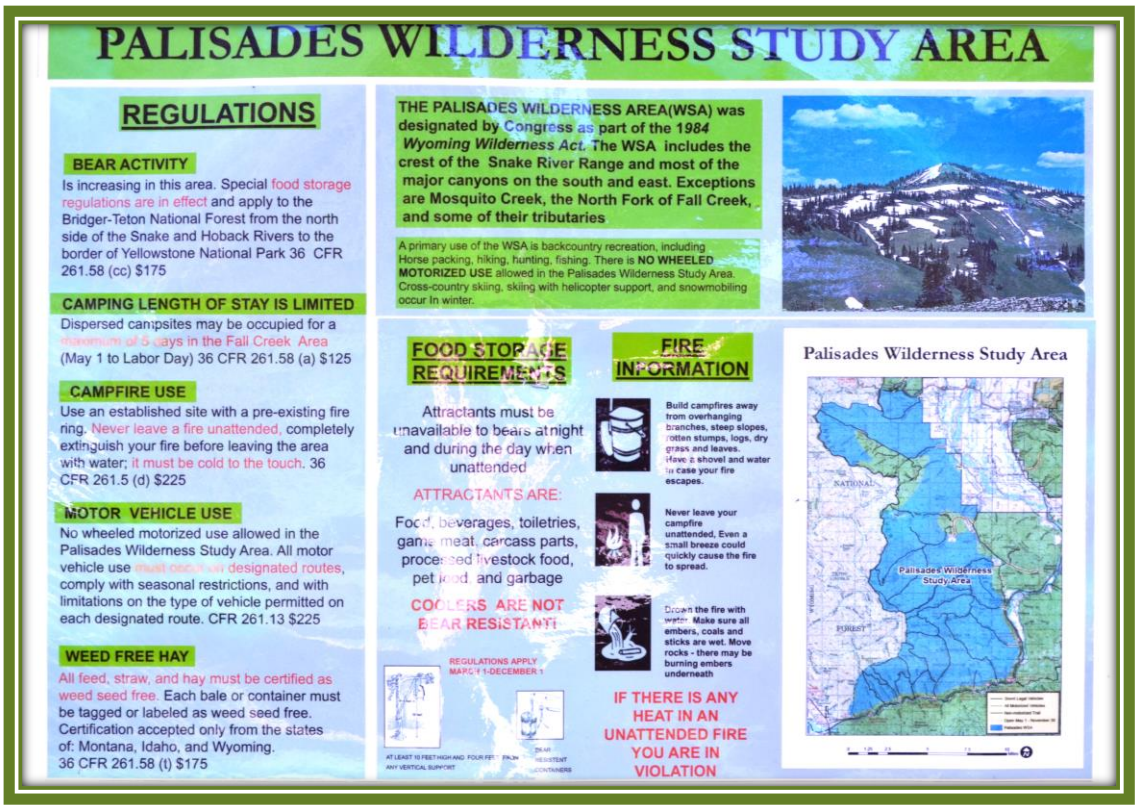
Utilizing the Recreational Sites Maps, the next step in the analysis was to inventory the recreational uses. Table 5-12 includes the number of recreational sites included in the study area for each sub-basin. Each of the sites included in the table can be found on maps included in the technical memorandum.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

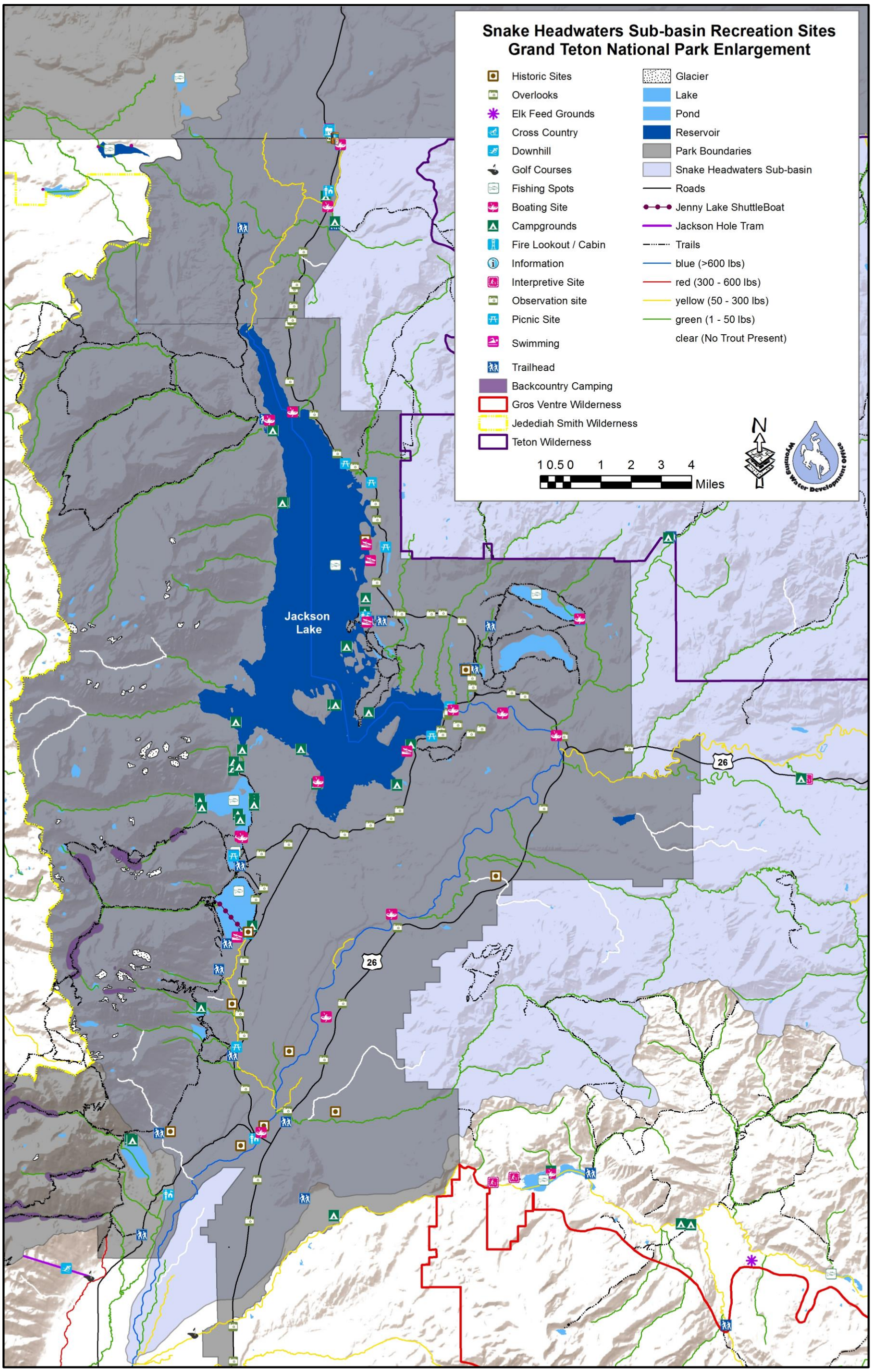


FIGURE 5-14: SNAKE HEADWATERS SUB-BASIN RECREATIONAL SITES MAP, GRAND TETON NATIONAL PARK ENLARGEMENT

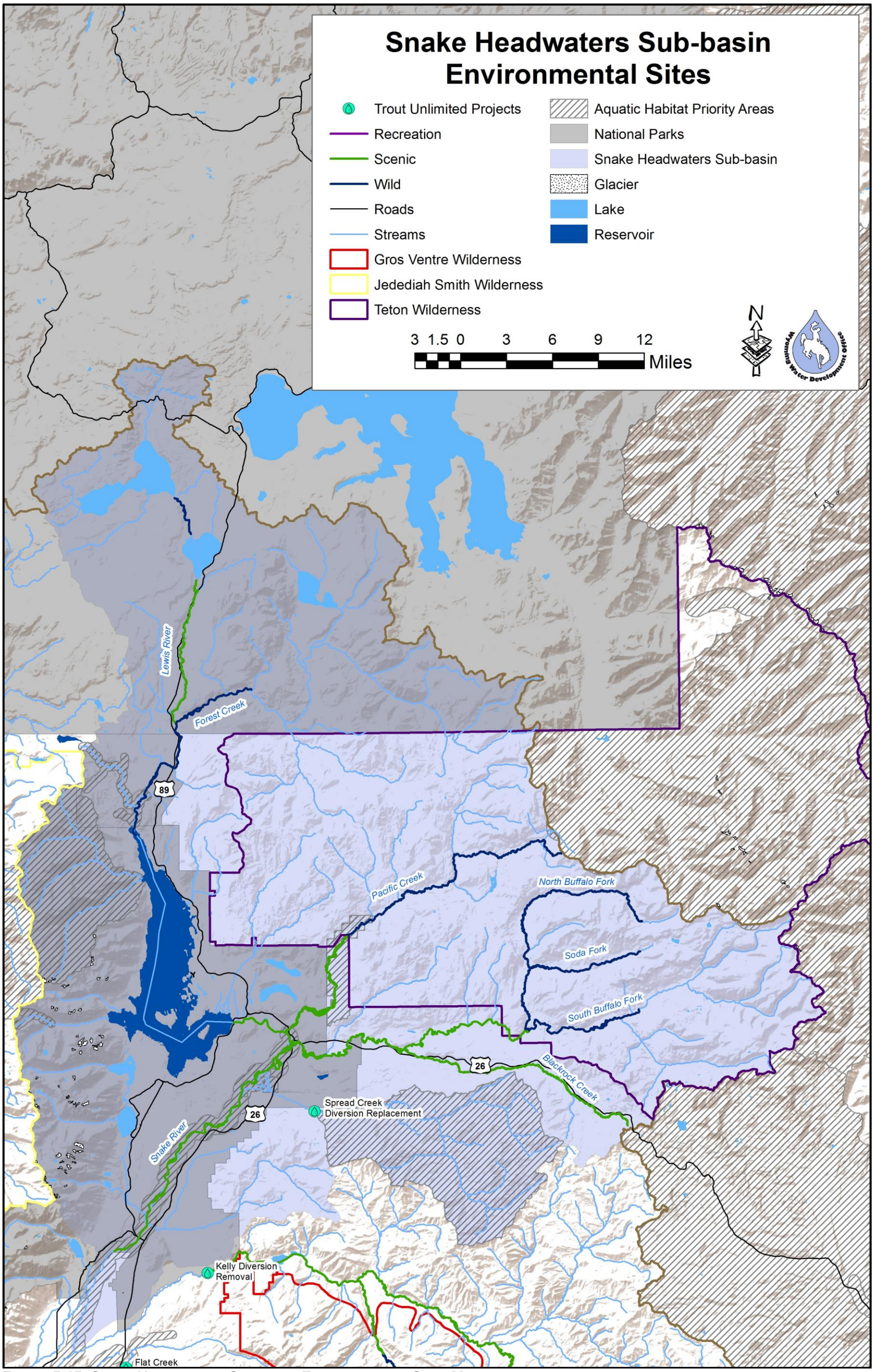


FIGURE 5-15: SNAKE HEADWATERS SUB-BASIN ENVIRONMENTAL SITES MAP

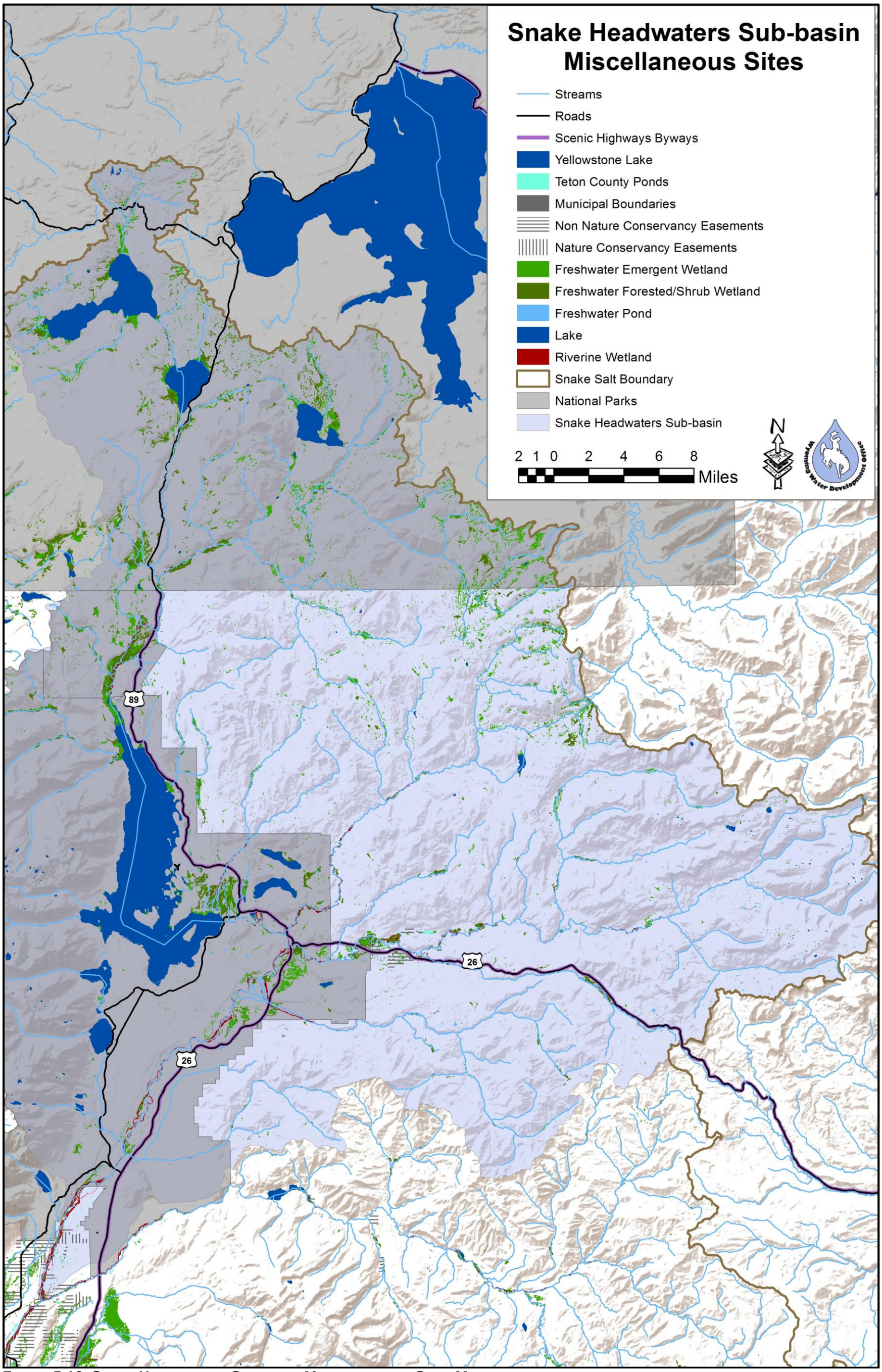


FIGURE 5-16: SNAKE HEADWATERS SUB-BASIN MISCELLANEOUS SITES MAP

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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