7.0 WATER AVAILABILITY

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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.

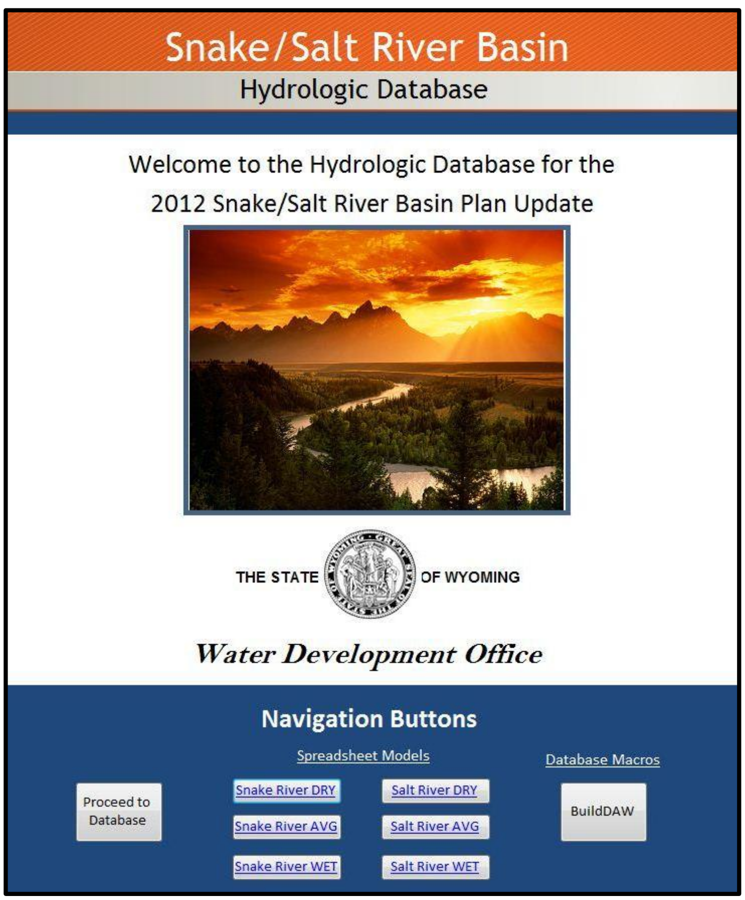
<u>Snake River Basin Models</u>
- Dry Year
- Average Year
- Wet Year

<u>Salt River Basin Models</u>
- 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.

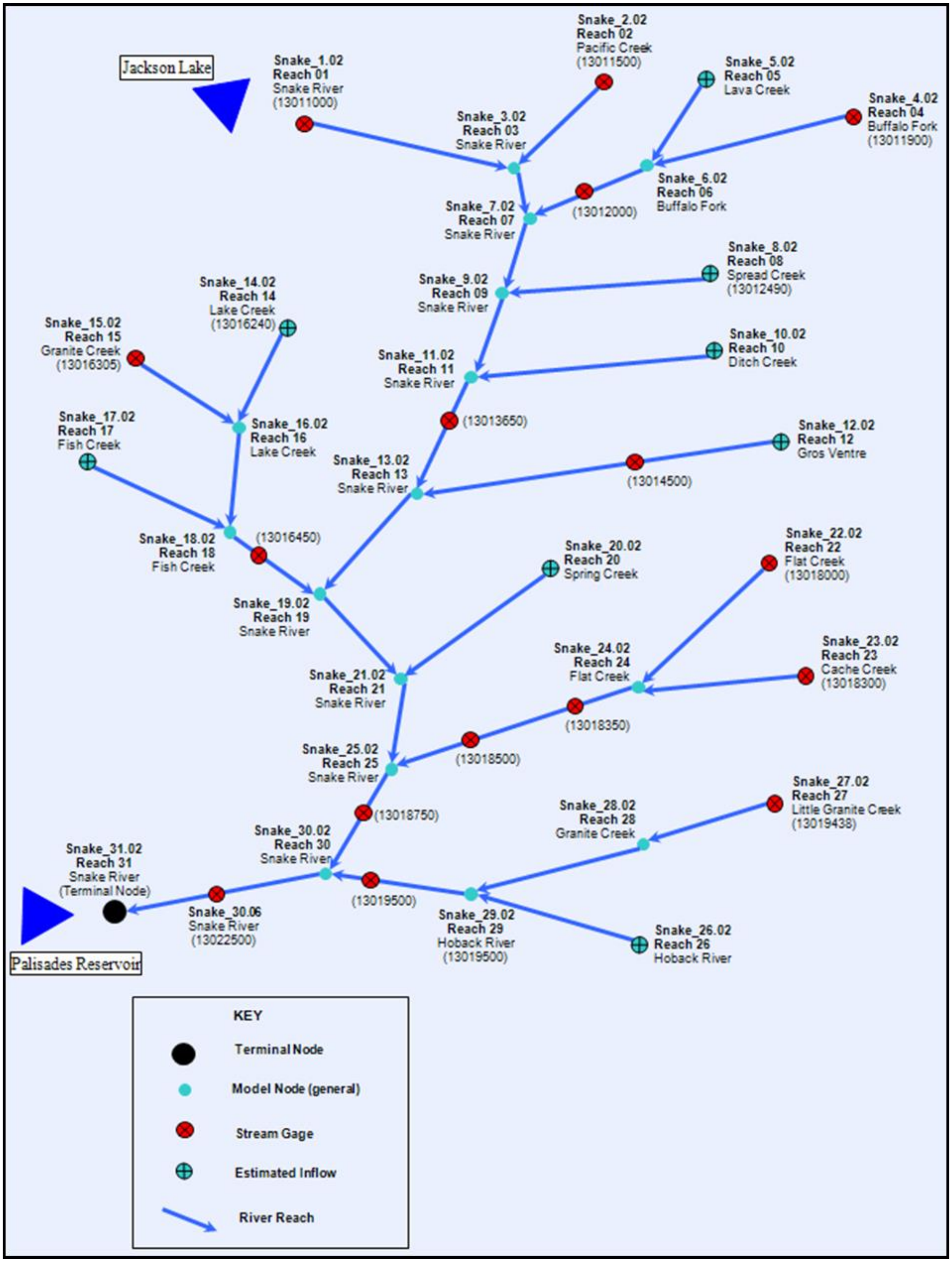


FIGURE 7-1: SNAKE RIVER BASIN MODEL NETWORK

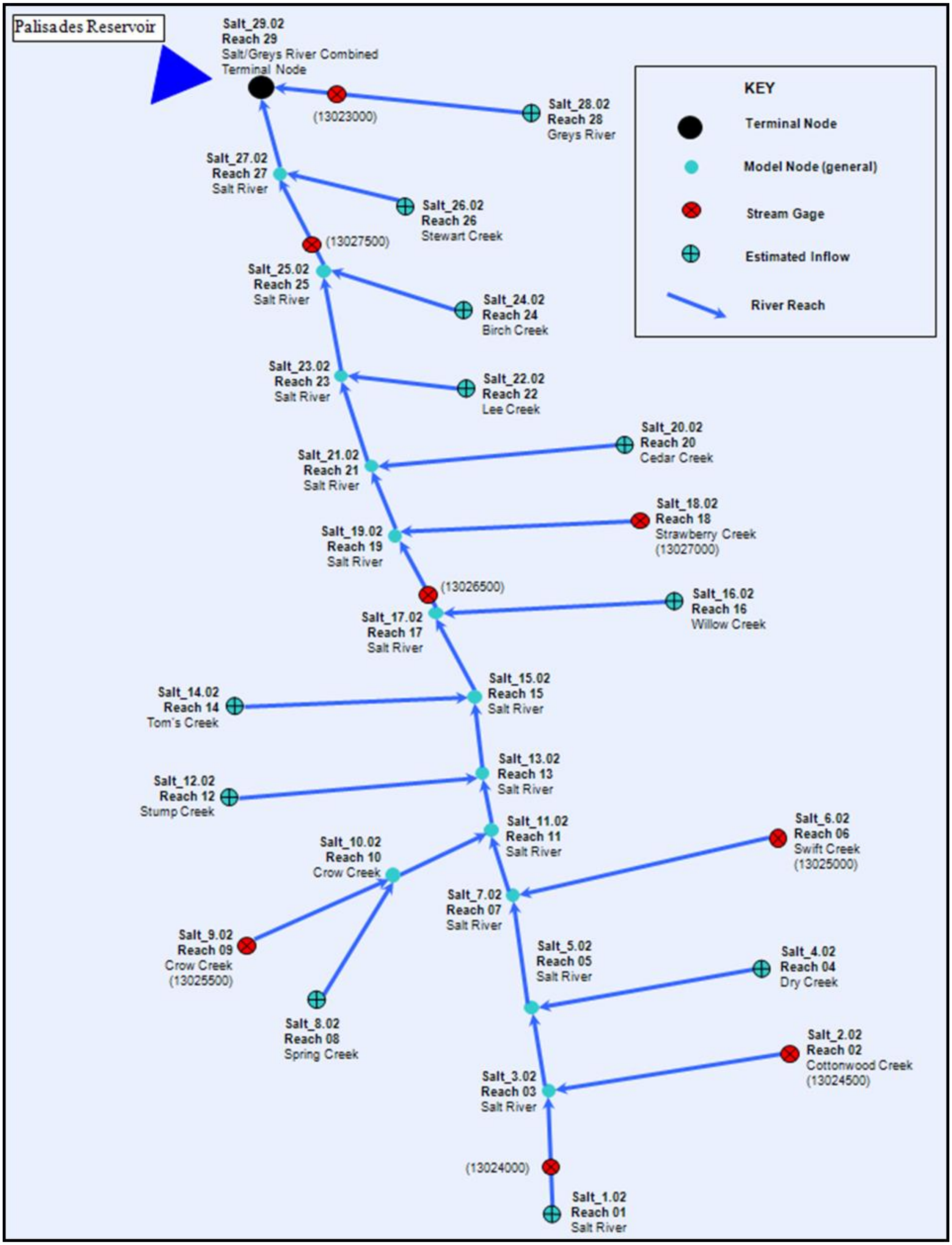


FIGURE 7-2: SALT RIVER BASIN MODEL NETWORK

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

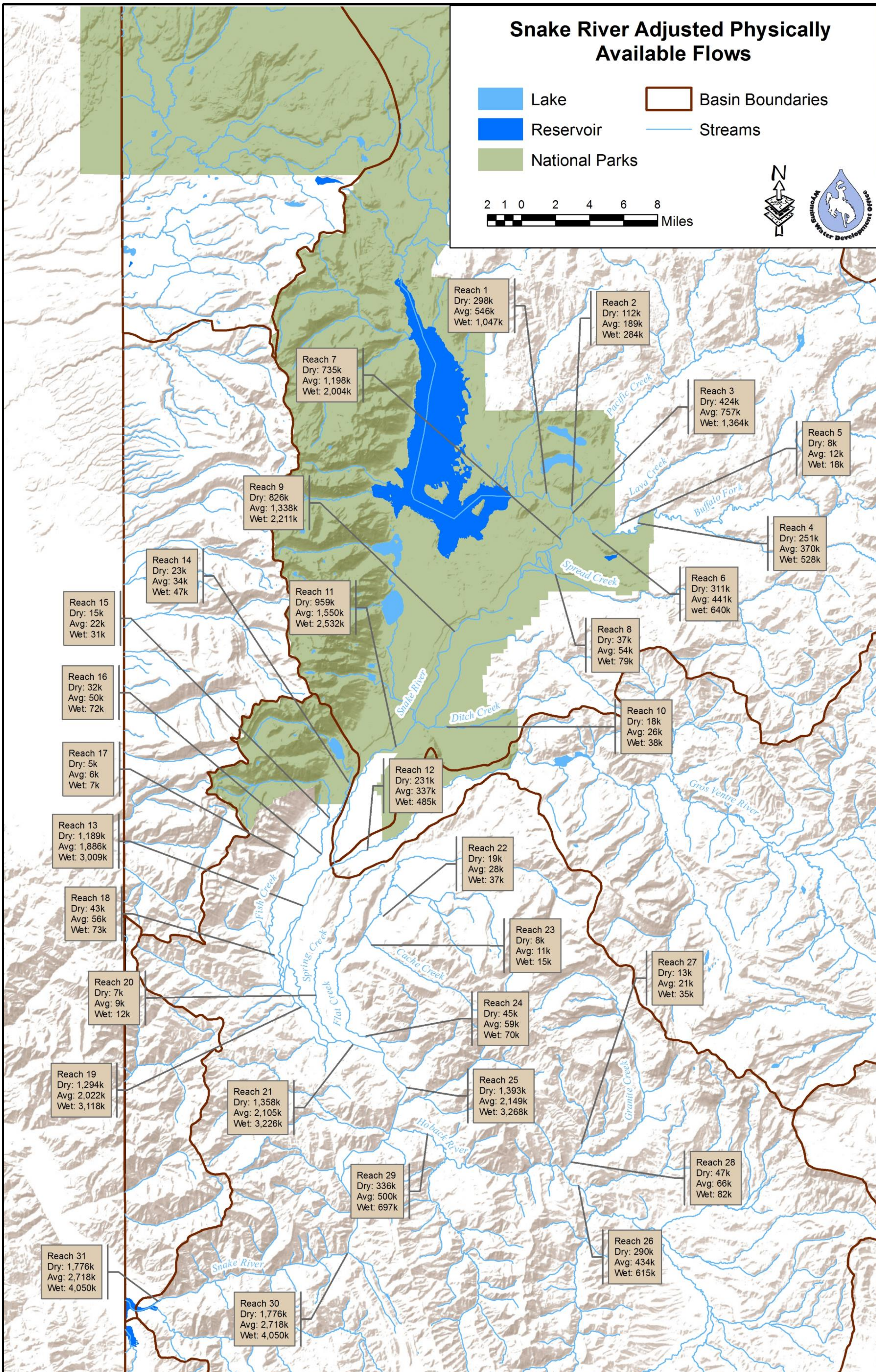


FIGURE 7-3: SNAKE RIVER ADJUSTED PHYSICALLY AVAILABLE FLOWS (AFY)

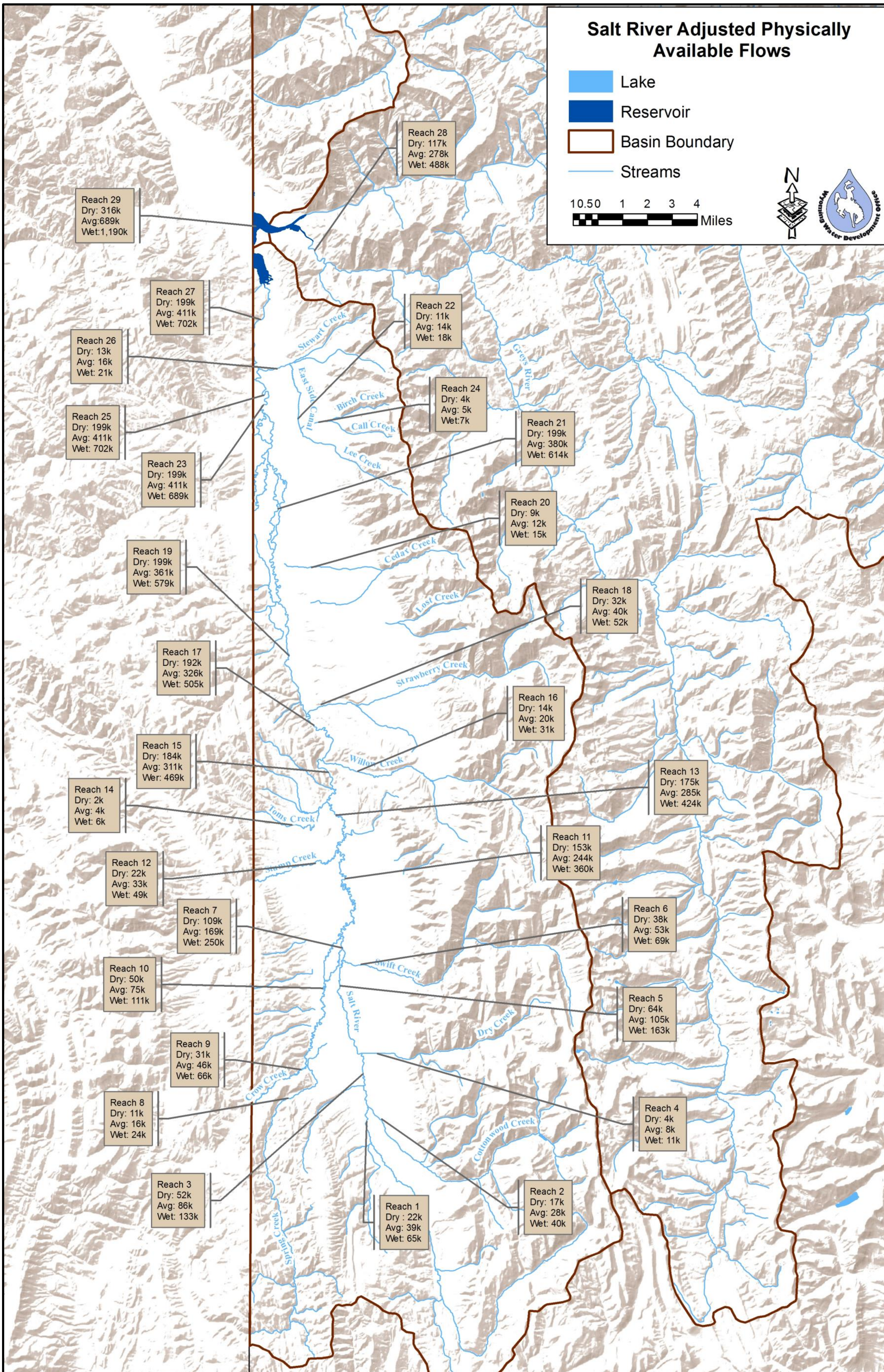
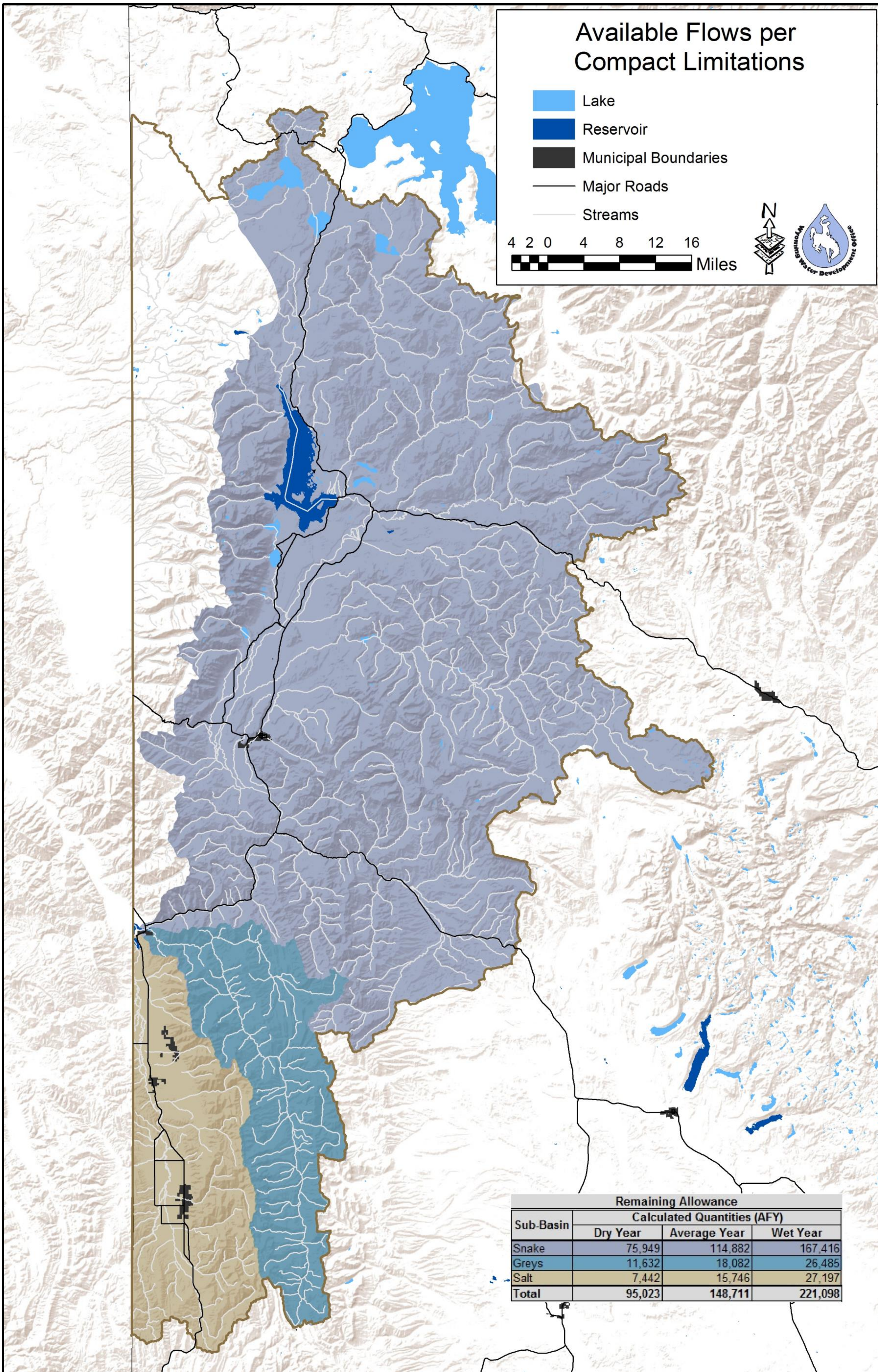


FIGURE 7-4: SALT RIVER ADJUSTED PHYSICALLY AVAILABLE FLOWS (AFY)



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. $\text{Sprinkler Water Conserved (AF)} = \dfrac{\text{Water Conserved (in)}}{12} * \text{Acres Flood Irrigated}$

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)

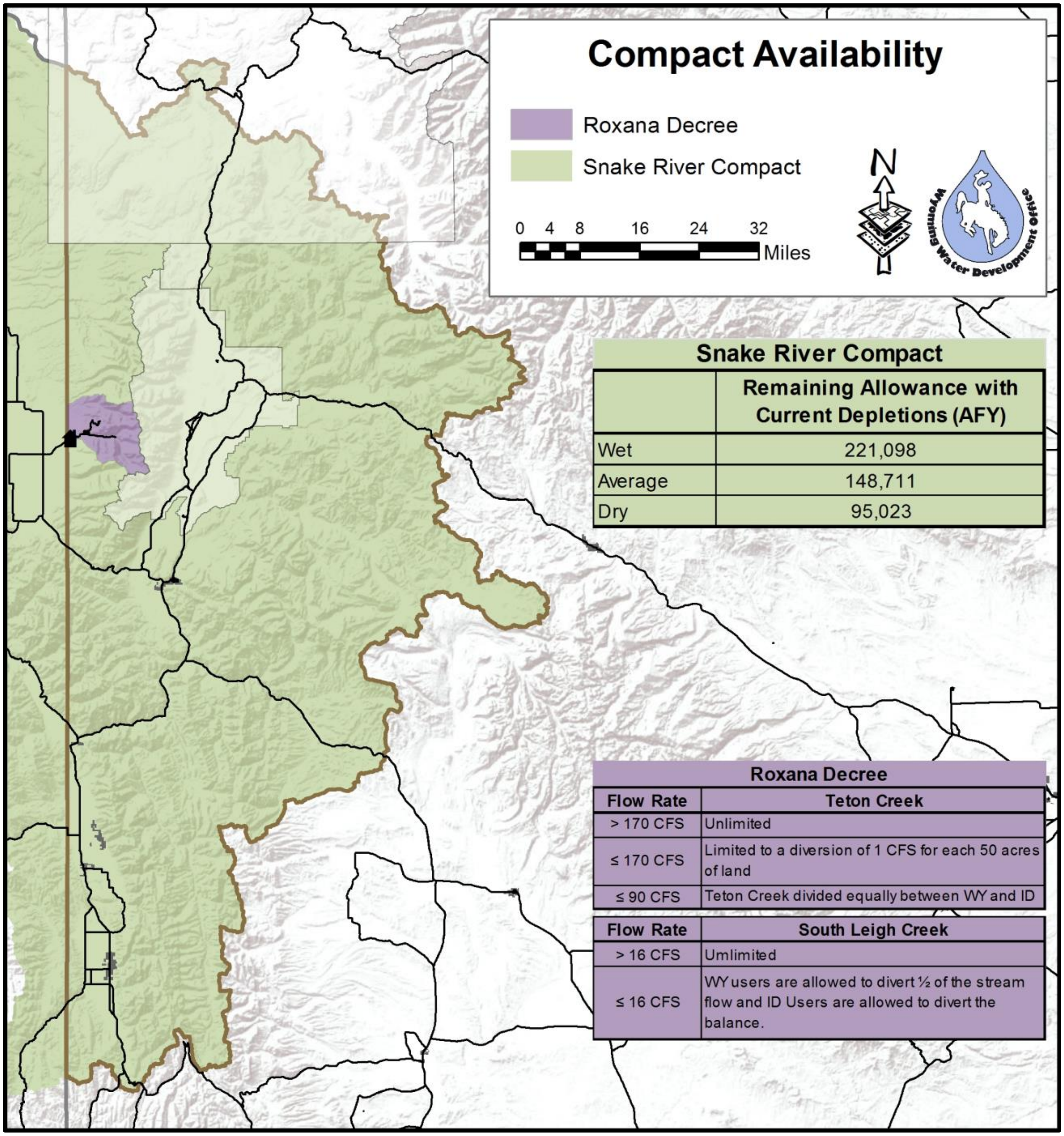
Description	Natural Flow	Agricultural Irrigation[1]	Livestock Watering	Municipal[2]	Domestic[2]	Industrial[2]	Reservoir Evaporation	Total Use	Depleted Flow	Remaining Allowance with Current Depletions
Data Source	Table 4-1	Table 6-3	Table 6-4	Section 6.3	Section 6.3	Section 6.4	Table 5-14	Calculated	Calculated	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.



Snake River Compact	
	Remaining Allowance with Current Depletions (AFY)
Wet	221,098
Average	148,711
Dry	95,023

Roxana Decree	
Flow Rate	Teton Creek
> 170 CFS	Unlimited
≤ 170 CFS	Limited to a diversion of 1 CFS for each 50 acres of land
≤ 90 CFS	Teton Creek divided equally between WY and ID
Flow Rate	**South Leigh Creek**
> 16 CFS	Umlimited
≤ 16 CFS	WY users are allowed to divert ½ of the stream flow and ID Users are allowed to divert the balance.

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.

REFERENCES

Alley, W., & Burns, A. (1981). *Mixed Station Extension of Monthly Streamflow Records.* Reston, Virginia: U.S. Geological Survey.

Boyle Engineering. (2003, February 6). Snake/Salt River Basin Plan. *Technical Memorandum Task 3D - Available Surface Water Determination*. Frantz, Meg; Williams, Linda. Retrieved from http://waterplan.state.wy.us/plan/snake/techmemos/surdet.pdf

Fassett Consulting, LLC. (2002, May 3). Snake/Salt River Basin Plan. *Technical Memorandum - Summary of Interstate Compacts and Court Decrees*. Fassett, Gordon W. Retrieved from http://waterplan.state.wy.us/plan/snake/techmemos/compacts.pdf

Frick, D., & Wellborn, M. (1999, November). *Technical Memorandum, Task Memo, Subtask 11.10 Fill Missing Baseflow Data*. Colorado Decision Support Systems.

Hinckley Consulting. (2003, September 10). Snake/Salt River Basin Plan. *Technical Memorandum, Available Groundwater Determination*. Retrieved from http://waterplan.state.wy.us/plan/snake/techmemos/gndet.pdf

Lowham, H. (1988). *Streamflows in Wyoming.* U.S. Geological Survey Water Resources Investigations Report, 88-4045.

State of Colorado. (2011). Retrieved from Colorado Decision Support System: http://cdss.state.co.us

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