Environmental and Recreational Water Use Analysis for the Wind – Bighorn River Basin, Wyoming

Wind – Bighorn River Basin Plan Update

Prepared for:

Wyoming Water Development Commission

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EXECUTIVE SUMMARY

In 2010, the Wyoming Water Development Commission (WWDC) requested a study to develop more robust and consistent methods for defining environmental and recreational (E&R) water uses for the River Basin Planning program. The study outlined that recreational and environmental uses needed to be identified and mapped, in a way that would assess their interactions with traditional water uses throughout the state of Wyoming.

Harvey Economics completed the study in 2012, with a report and handbook being produced to identify a consistent viewpoint and accounting process for E&R water demands and to help guide river basin planning efforts in moving forward. The methods developed in the handbook were implemented on the Wind-Bighorn River Basin (Basin), and the results of the Basin plan update are provided in this report. In addition to the handbook guidelines, Western Ecosystems Technology, Inc. coordinated with the WWDC to further the analysis through the development of three models: 1) protection, 2) environmental, and 3) recreation.

The Basin is located in central and northwestern Wyoming. Approximately 80% of Yellowstone National Park (YNP) is included in the Basin. Elevations in the Basin are variable as the Wind River and Bighorn Mountains funnel water from alpine areas to lower river corridors. Surface water usage and flow are regulated by the Yellowstone River Compact of 1950 and the General Adjudication of All Rights to Use Water in the Big Horn River System.

The Basin is comprised of 14,656,955 ac and 19 sub-basins. Land ownership in the Basin is well distributed among a variety of land owners/managers. The ownership layout follows a general pattern where the forested mountainous regions are administered by the US Forest Service (USFS) making up just over 20% of the Basin (3,036,732 ac); the open shrub/scrub and prairie habitat is a patchwork of state (609,456 ac; approximately 4%) and Bureau of Land Management (BLM) land (4,248,546 ac; approximately 29%); and the irrigated river bottoms are mostly private land (2,504,320 ac; approximately 17%). A few notable exceptions are YNP that is administered by the National Park Service (NPS; 1,622,482 ac; approximately 10%), and the Wind River Indian Reservation that is administered by the Bureau of Indian Affairs (1,996,585 ac; approximately 14%). Other smaller land owners include the Bureau of Reclamation, Wyoming Game and Fish Department (WGFD), and State Parks, which all own less than 3% of the total land in the basin. These lands are often associated with water through recreation or environmental uses.

Environmental uses are broken into state and federal environmental uses. Environmental water use in the Basin is demonstrated through permitted and protected resources and areas where environmental resources have been identified as important. State environmental uses include 51 instream flow filings, numerous WGFD Crucial Habitat Priority Areas, and designated crucial stream corridors. Other WGFD designated areas occurring across the Basin include Key Non-Game Wildlife Areas, enhancement areas, combined priority habitats, and wildlife management areas. Federal environmental uses include the wild and scenic Clarks Fork, seven designated

wilderness areas, US Fish and Wildlife Service listed species (three bird, three mammal, one fish, and four plant species), critical habitat for the Canada lynx, nearly 400,000 ac of National Wetlands Inventory polygons, and multiple BLM designated Areas of Critical Environmental Concern.

Recreation uses in the Basin include fishing, waterfowl hunting, boating, whitewater rafting, camping, hiking, general sightseeing (such as bird watching), and a variety of other passive and active recreation activities. Recreation activities associated with water use are fairly concentrated and often occur on land specifically identified for public access, such as USFS land, state parks, and YNP. Multiple reservoirs, including Boysen, Big Horn Lake (and associated Bighorn Canyon National Recreation Area), Buffalo Bill among others, provide recreation opportunities. Hot Springs and Sinks Canyon State Parks are also common recreation destination locations. Fisheries across the Basin are considered first class with miles of major river systems and mountain lakes providing access to the public.

A large area of protected E&R uses in the Basin exists in YNP. Strict regulations and subsequent protections are in place for the Park. Protected E&R water uses in the Basin exist along the permitted instream flow sections and areas immediately above the permitted segments. E&R uses are also protected in the wilderness areas present in the basin.

Competing recreational uses can be categorized around the large recreation reservoirs across the Basin. Due to the reliance of access (e.g., boat ramps, camp sites, etc.) to maintain specific recreation uses these items are competing. It is not uncommon for heavy early season runoff entering the reservoirs and low-level early season water release to flood the reservoirs, inhibiting recreation opportunities. This results in a competing situation. Similarly, depending on annual climate, late season conditions may draw reservoirs down to a level where recreation becomes difficult. Major reservoirs including Bighorn Lake, Boysen Reservoir, Buffalo Bill Reservoir, among other smaller reservoirs across the Basin fall into the competing categorization.

Other current E&R uses can be considered complementary due to their location in the Basins. All E&R uses above existing diversions can be considered protected in the present, but are subject to future water diversion or management activities, making them complementary. Waters and E&R uses above the diversion cover a large portion of the Basin, as nearly all of the upper watersheds in the Basin are USFS managed land. All other E&R water uses across the Basin are assumed to be complementary. This is based on the assumption that current water conditions will continue in a similar regime to historic and present water use. A number of large permitted diversions with senior water rights exist throughout the Basin and require water to be maintained in the stream, thereby support E&R uses, specifically wetlands, potential US Fish and Wildlife Service listed species habitats, WGFD priority and crucial areas. Similarly, while small in magnitude, the hundreds of other diversions that exist along the waterways, cumulatively support E&R uses throughout the Basin as water will remain in the system to complement the E&R activities. These small and large diversions due have the ability to effect E&R uses at a localized scale if modifications were to occur.

The divertible recreation uses include golf courses and ski resorts. Information gathered for this report verified six golf courses that are included under either municipal water rights or permitted diversions. These uses are protected. Information was not available on the remaining course. Two ski resorts were identified in the Basin; however, information on water use permits could not be obtained; therefore, these uses are not categorized.

The protection model demonstrated a range of protections across the Basin. In most cases, greater protection was assigned to areas higher in the watershed. These areas are typically provide institutional protection associated with national forests and wilderness areas and may include critical habitats or instream flow filings. Most of the upper reaches of the watershed are above existing diversions; therefore, changes in water use are less likely to result from diversion changes and more likely to be effected by water storage projects. Less protection was evident along many of the higher-order streams. These areas typically have more private land ownership and less institutional regulations. Additionally, these areas more support agriculture (and other water uses); therefore, are more subject to impacts. This is supported by the diversion locations and irrigation water consumption identified in the Basin.

The environmental model followed a similar pattern to the protection model, with more environmental uses identified higher in the Basin's watershed. This not surprising, given many of the environmental factors are provided some level of institutional protection based on land ownership. At a finer scale, more variability was demonstrated in the environmental model. This was often due to USFWS species habitat and BLM and WGFD priority areas. These agency-designated habitats are present throughout the Basin in upper and lower sections of the watershed, specifically along many of the major lower-order streams (e.g., Bighorn or Shoshone Rivers). In general, higher environmental scores were apparent in the western Basin. Many environmental uses were mapped in this region and subsequently resulted in higher environmental model scores. Additionally, many of the major waterbodies, such as the Bighorn River and Shoshone River received higher scores due to due to designation as critical stream corridors under multiple datasets.

Higher recreation scores were demonstrated in the upper watersheds, specifically on USFS and NPS managed land. This makes sense, given the recreation opportunities and purposeful management of USFS and NPS to provide the public with open space. In general, the Basin provides a range of recreation uses, with the western sub-basins (e.g., Clarks Fork, North Fork, Popo Agie) assigned higher scores relative to other areas across the Basin. These areas are known for the fisheries, rafting, and general outdoor recreation. Many of the larger waterbodies in the Basin also scored high including the various forks of the Shoshone, Popo Agie, among others. It is important to recognize that fewer factors were used to inform the recreation model. This results in land ownership having a greater impact on the overall score and less recreation uses being captures. Additionally, the recreation model was not set up to capture the higher recreation use commonly associated with the Basin's reservoirs. The reservoirs are common destination locations for recreation, but not fully captured in the recreation model.

YNP is a significant feature in the Basin. This area is known for both E&R uses. Because YNP is an independent feature, it is not managed in the same manner as the remainder of the Basin (or state), and many of the datasets that identified the E&R uses do not include YNP area. Therefore, the model scores may not accurately represent the levels of protections afforded to YNP or the E&R uses that exist. In nearly all cases, it should be assumed that YNP provided high E&R uses and is afforded high levels of protection.

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1 INTRODUCTION

In 2016, the Wyoming Water Development Commission (WWDC) contracted Western EcoSystems Technology, Inc. (WEST) to identify, categorize, and evaluate environmental and recreational (E&R) water uses within the Wind-Bighorn River Basin (Basin) in Wyoming. Environmental water demand is the amount of water required to support a given water-dependent ecosystem or ecosystem function, and recreational water demand is the amount of water needed to support water-based recreational activities. In most instances, these demands are non-consumptive, but do require that water be in place for the use to be sustained or for the activity to occur. To help identify areas with high environmental or recreation water use, WEST developed two use models: environmental and recreation. While these models do not quantify specific water demand requirements, they do provide a relative scale of E&R use throughout the Basin. WEST also developed a third model to identify levels of protection for water uses across the Basin. This report provides results of the E&R use analysis, including water use identification, mapping, categorization, and assimilation.

In the late 1990's the WWDC began implementing its current basin planning framework which seeks to identify and describe existing water demands and supplies within each river basin, as well as potential future water development opportunities. Under this framework a river basin plan has been developed for each of Wyoming's seven basins. The most recent *Wind-Bighorn River Basin Plan* was the 2010 update (MWH Americas et al. 2010). The original plan was published in 2003 (BRS 2003). A Technical Memorandum addressing E&R uses was also developed (MWH Americas 2010b). The goal of each basin plan is to estimate current water demand and project future water demands by type of use. The WWDC recognizes five unique categories of use:

1. Agricultural
2. Municipal and Rural Domestic
3. Industrial
4. Environmental
5. Recreational

Of the five water use categories, E&R water uses are the only categories that are almost exclusively non-consumptive in nature, so traditional methods for quantifying them do not apply. Thus, many of the E&R water uses identified in each basin plan are discussed solely in qualitative terms, which have resulted in inconsistencies in how E&R water uses are addressed across basin plans. Originally, E&R uses were mostly described without regard for how they interact with traditional uses instead each use was summarized in terms of their overall impact on the water resources of the Basin.

To develop a more consistent approach that provides a more detailed assessment of the interaction between traditional and non-consumptive uses, the WWDC obtained funding from the 2010 Legislature for an *Environmental and Recreation Water Use Study* to develop a

procedure that could be applied in all the basins. Harvey Economics (HE) was contracted to complete the study, and in 2012, HE published a new set of procedures to address E&R water uses in *The Environmental and Recreational Use Handbook* (Handbook; Harvey Economics 2012). This analysis adheres to the procedures outlined in the Handbook, which are described in the methods sections, and furthers the evaluation through the development of use and protection models.

2 STUDY AREA – WIND – BIGHORN RIVER BASIN

The follow study area description is taken from the 2010 Wind-Bighorn River Basin Plan Update. The Basin covers approximately 22,000 square miles of central and northwestern Wyoming and includes all of Bighorn, Park, and Hot Springs Counties, approximately 95% of Washakie County, approximately 85% of Fremont County, roughly 10% of Teton County, and the entire Wind River Indian Reservation (Figures 2-1 and 2-2). Also included are small, relatively undeveloped portions of northwestern Natrona and western Johnson Counties. Approximately 80% of Yellowstone National Park (YNP) is included in the Basin. Elevations in the Basin are variable because the Wind River and Bighorn Basins are bordered by high alpine mountain ranges. Elevations range from roughly 3,500 feet above sea level, where the Bighorn River crosses the state line into Montana in Big Horn County, to 13,804 feet at the summit of Gannett Peak in Fremont County.

2.1 Unique Characteristics

Within the Basin, surface water usage and flow is regulated by the Yellowstone River Compact of 1950 and the General Adjudication of All Rights to Use Water in the Big Horn River System. The Wind River Indian Reservation is a 2,000,000-acre Native American reservation that is located in Fremont and Hot Springs Counties, within the Basin. The Wind River and many of its tributaries originate on or run through the reservation, making it an important factor for water management in the Basin. The natural resources on the reservation are jointly owned by two tribes, the Shoshone and Arapaho, although some tribal members hold water rights individually. Tribal surface water rights date to 1868, the oldest water rights in the Basin, and legal proceedings between the state of Wyoming and the Shoshone and Arapaho Tribes awarded the right to 500,000 acre feet of water from the Wind River system to the tribes.

The remainder of land in the Basin is federal, state, and privately owned land. Approximately 30% (not counting the Wind River Indian Reservation) of the land within the Basin is privately owned. Unique water-related environmental features of the Basin include the glaciers of the Wind River mountain range, a section of the Clarks Fork designated as a federal “Wild and Scenic” river, Sink’s Canyon, the Thermopolis Hot Springs, and the numerous natural wonders of YNP. There are several reservoirs located within the Basin. Capacity of the reservoirs, range from small one-acre ponds to the larger reservoirs such as Boysen and Buffalo Bill. These storage facilities play a large role in water utilization within the planning area, as well as being important to down-stream water users.

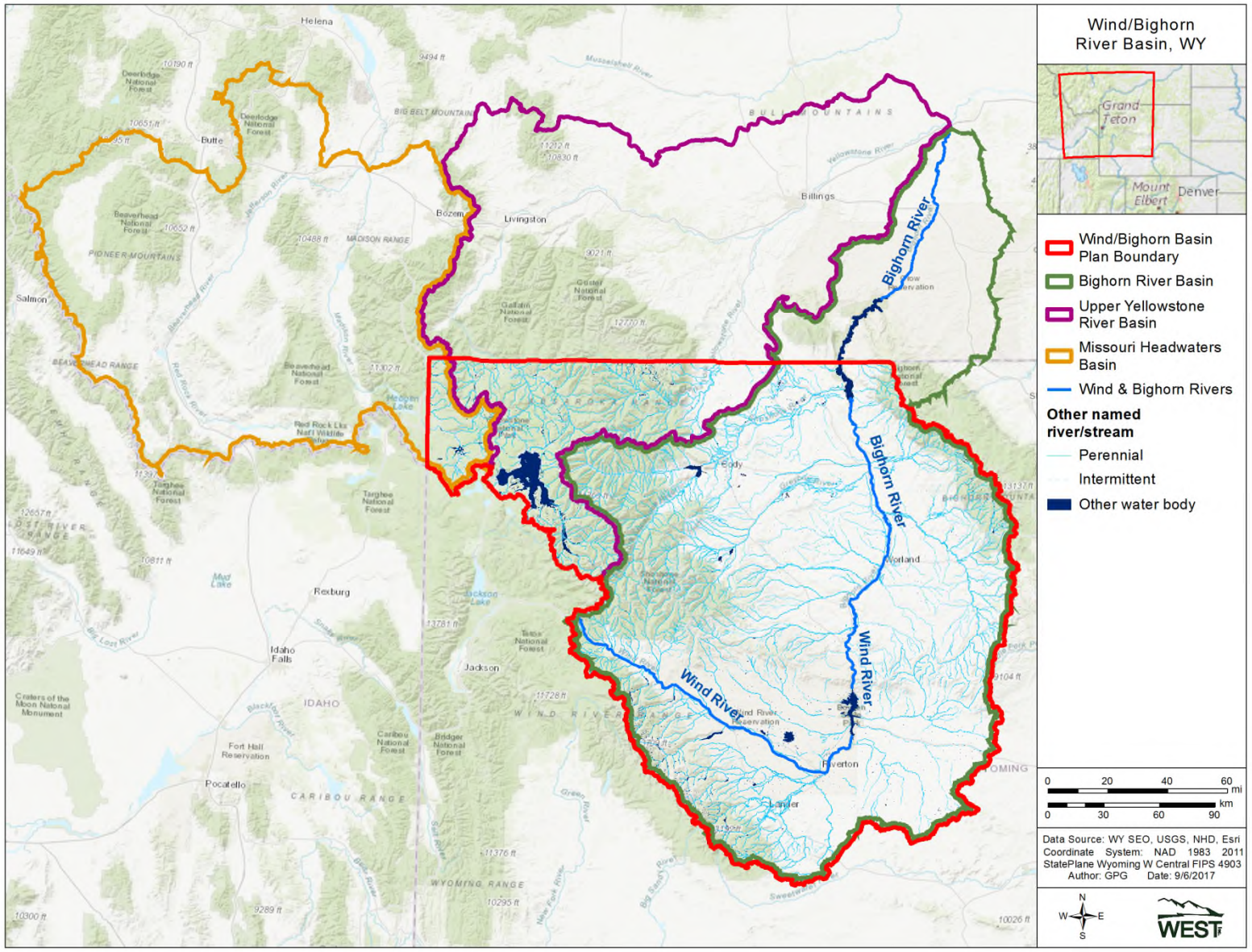


Figure 2-1. Overview of the entire Wind – Bighorn River Basins in Wyoming and Montana.

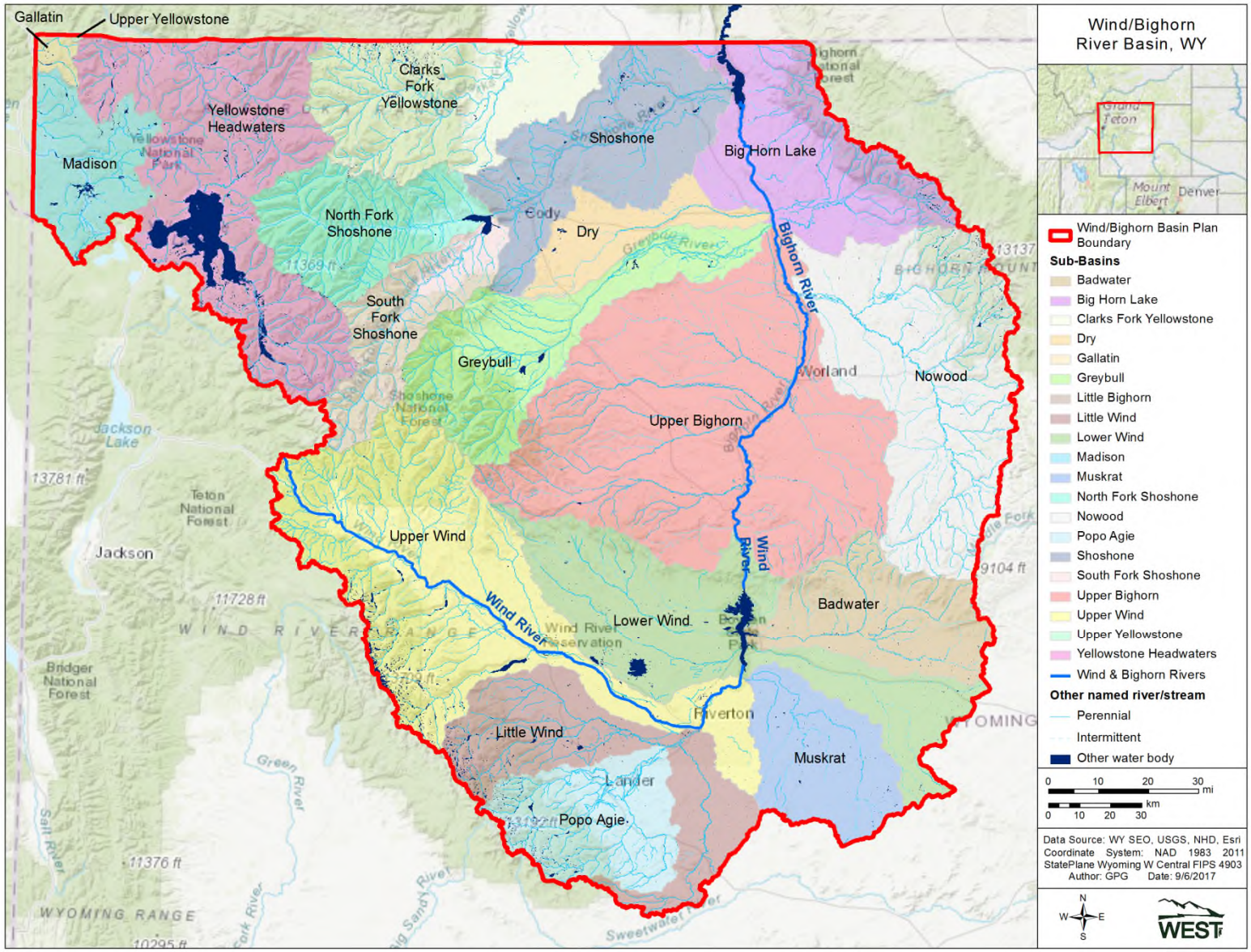


Figure 2-2. Overview of the Wind – Bighorn River Basins in Wyoming.

3 METHODS

The Handbook describes the following five steps to address E&R water uses in the Basin:

1) **Identify E&R water uses in the Basin** WEST gathered the Geographic Information System (GIS) data recommended in the Handbook and additional data to support the E&R use descriptions, as well as data for other E&R water uses included in the original Basin Plan and the 2010 update (Table 3-1).

2) **Map E&R water uses in the Basin:** WEST used the GIS data identified in the previous step to create maps depicting the land ownership, environmental water uses, and recreation water uses across the Basin. These maps were used to identify where specific E&R uses were occurring within the Basin.

3) **Locate divertible non-E&R water uses in the Basin:** WEST mapped existing non-E&R consumptive water uses in the Basin by diversion location and magnitude using GIS data obtained from the WWDC and previous basin plans.

4) **Categorize non-consumptive E&R water uses in the Basin:** WEST used the land ownership, E&R water use, and non-E&R water diversion maps to categorize each E&R water use as "protected", "complementary", or "competing" based on their proximity downstream to non-E&R water diversions and their location in the watershed. These categories are defined in the Handbook and are described below.

5) **Assimilate the results of the E&R water use analysis into Basin Plan:** WEST evaluated all of the information collected and developed to three models. This information was used to discuss and inform future water planning relative to the Basin's E&R uses.

Table 3-1. Geographic information system (GIS) data sources for environmental and recreational mapping in the Wind-Bighorn River Basin.

Name	Source
Basin Borders	WWDC
Hydrologic Unit Codes	USGS
Waters and Reservoirs – National Hydrology Dataset	USGS
Land Ownership	USGS
Instream Flows	WWDO, SEO, WGF
Crucial Habitat Priority Areas - Aquatic	WGFD
Crucial Habitat Priority Areas - Combined	WGFD
Enhancement Habitat Priority Areas	WGFD
Crucial Streams Corridors	WGFD
Wildlife Habitat Management Areas	WGFD
Key Nongame Wildlife Areas	WGFD
Wild and Scenic Rivers	WyGISC

Table 3-1. Geographic information system (GIS) data sources for environmental and recreational mapping in the Wind-Bighorn River Basin.

Name	Source
Wilderness Areas	WyGISC
Threatened, Endangered, Candidate, and Sensitive Species	USFWS – Information for Planning and Conservation database
USFWS Critical Habitat	USFWS
National Wetlands Inventory	USFWS
BLM Areas of Critical Environmental Concern	BLM
WGFD Stream Classifications	WGFD
National Parks	USGS
US Forest Service	USGS
State Parks[1]	WYO Parks
National Recreation Areas	USGS
Fishing Spots	WyGISC
Model Demand Nodes	WWDO (2003 Basin Plan- GIS products)
National Wildlife Refuges	USFWS
Whitewater Rafting Stream Segments	American Whitewater
Golf Course Locations	WyGISC
Ski Resort Locations	WyGISC
Lakes	WSGS
Partners for Fish and Wildlife Program[2]	USFWS
Reservoir Storage	SEO

[1]WYO Parks 2017
[2]Partners for Fish & Wildlife 2017
BLM=Bureau of Land Management; SEO=Wyoming State Engineer's Office; USFWS=US Fish and Wildlife Service; USGS=US Geological Survey; WDEQ=Wyoming Department of Environmental Quality; WGFD=Wyoming Game and Fish Department; WSGS=Wyoming State Geological Survey; WWDO=Wyoming Water Development Office; WyGISC=Wyoming Geographic Information Science Center

3.1 Identification of E&R Water Uses

WEST searched a variety of publically available resources for data identifying specific recreational and environmental uses in the Basin. Initially, WEST used the Handbook and previous Basin plan to identify specific primary and secondary sources. Beyond previously identified and reported sources, WEST concentrated on publicly available datasets from state and federal agencies (primarily web-based). Where possible, the datasets previously developed by the Wyoming Water Development Office (http://waterplan.state.wy.us/) were used. An emphasis was put on state and federal resources, as these are typically referenced when evaluating potential project impacts. WEST contacted agency staff as appropriate to gather and interpret additional datasets.

3.2 Mapping of E&R Water Uses

WEST used ArcGIS to plot the identified E&R across the Basin and sub-basins. Prior to plotting information, the data were sorted between E&R uses and state and federal environmental uses. Additionally, any dataset that was not linked to water resources was removed or specifically identified. Datasets that were difficult to represent or not visible at reasonable scales were not plotted. These data were stored in GIS and in some cases used in the model development. In addition to plotting data for visual representation, GIS data were sorted and stored in an ArcGIS geodatabase for ease of use and sharing on future projects.

3.3 Separating Consumptive Uses

The next step in estimating non-consumptive E&R water demands was to separate consumptive E&R water demands from non-consumptive uses. In other words, if a diversion exists for a golf course, those uses were identified in specific terms and aggregated as sub-elements of other uses. For example, golf course diversions may be classified as agricultural, municipal or recreational water by the Wyoming State Engineers Office (SEO), and should be included in the divertible demands for the appropriate category. Divertible water uses with specific beneficial purposes that have received a water right in the state of Wyoming were treated in the same way as traditional water uses. Existing uses, as well as projected future uses for these diversions were identified and estimated in the basin planning process. Due to the non-consumptive nature of E&R uses, this task was fairly brief.

3.4 Non-Consumptive E&R Water Use Categories

The Handbook recommended that non-consumptive E&R water uses be categorized so that they can be more easily compared to traditional uses. The majority of E&R water uses are non-consumptive, because they usually occur in the stream channel and therefore, benefit from water being left in the channel; whereas, traditional uses divert water from the channel for consumption. WEST used the existing Basin Plan update and supporting technical memorandums to identify diversion locations and magnitudes. The location and magnitude of diversions were used to support the categorization of E&R uses. The Handbook proposed that E&R water uses be classified as "protected" from traditional water uses that dewater the channel, "complementary" with consumptive water uses without explicit protection, or "competing" with consumptive water uses. The Handbook provides the following descriptions for each of these categories:

Protected – Protected E&R water uses are both recognized and protected in some way from incursions by traditional water uses. The 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 diverter in a location which ensures the continuation of that non-divertible use.

Example: If the most senior water right downstream is larger than or equal to the recreational or environmental water use immediately above that senior water diversion in the stream system, that recreational water use is protected and should be recognized as such in the Basin planning process.

Complementary – Complementary E&R water uses exist without explicit protection, but exist and will continue to exist typically by their location or linkage with a traditional water use. For instance, environmental water uses are often located at the highest reaches within a watershed, and intervening uses are very unlikely to occur. Environmental water uses which occur at high elevations or in a forest high in the watershed are unlikely to be disturbed by 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 example or sub-category of complementary water use stems from the incidental linkage of certain environmental or recreation 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 – Competing E&R water uses are located in areas where other traditional water use diversions may constrain or eliminate the environmental or recreational use at any point in time. These water uses are incidental and subject to elimination. These uses should also be recognized in the Basin planning process, but with the explicit understanding that such water uses can and will disappear when future appropriators step forward.

WEST concluded that the three non-consumptive E&R water use categories represent different points on a spectrum of stream protection. For example, blue ribbon stream segments that occur high up in a watershed in a designated wilderness area (WA) are afforded nearly the same level of protection as a stream segment with a permitted instream flow water right located on a higher order stream lower down in the watershed. However, using the E&R water use categories defined by the Handbook, the former stream segment would be classified as "complementary", while the latter stream segment would be classified as "protected". Furthermore, non-consumptive water uses in direct competition with traditional consumptive water uses could be considered to have little or no protection. Due to the potential difficulties categorizing individual E&R uses, WEST applied a general approach to categorize uses across large segments of the Basin, but looked to further the evaluation by assigning relative scales of protection. Building on this notion and work completed for the *Snake and Salt River Plan* (Pavlica 2013), WEST developed models to identify and categorize areas with varying degrees of environmental or recreational value within the Basin, as well as areas with varying degrees of protection for non-consumptive E&R water uses.

3.5 Model Development

The evaluation areas for the models followed the methods identified in the *Snake and Salt River Plan* where National Hydrography Dataset data were used to identify stream corridors and these corridors were buffered by 0.25 miles. After the evaluation areas were identified, the E&R water use models were created by combining a series of GIS data layers into a single map, where objects in each of the data layers were assigned different values based on their environmental or recreational significance. For example, the Wyoming Game and Fish Department (WGFD) stream classification GIS data layer includes different classes of spatial data for blue ribbon streams, red ribbon streams, yellow ribbon streams, and so on. Because blue ribbon streams are the most productive streams, they are considered to have the highest recreational value and were accordingly assigned a higher numerical value than red ribbon streams, yellow ribbon streams, and so on. Similar values were assigned to other recreational features such as designated whitewater stream segments, state parks, public access areas, etc. All of these GIS

data layers were then combined into a single raster map. Where two or more GIS data layers overlapped, the assigned numerical values for recreational features in each layer were added together for that raster point. The result was a raster map populated with a range of spatially distributed numerical values. These values were then classified as high, moderate-high, moderate-low, or low value using a defined range of values for each class, and then overlaid on a map of the Basin.

A third model was developed to identify areas that were afforded varying degrees of protection using the same method described above. The protection model evaluated the institutional protection afforded to waters throughout the Basin based on land management, land ownership, and other regulatory protections.

3.6 Assimilation of E&R Water Use Data into Basin Plans

The last step recommended by the Handbook is interpreting the E&R uses in an overall basin plan. To complete this task, the E&R models in combination with the E&R use maps were compared to the protection models to identify areas of high value that may not be afforded the appropriate level of protection. These results were summarized in this report to inform WWDC where these "at risk" areas occur, so they can be taken into account in future water development planning. Additionally, WEST reviewed the updated Basin Plan to identify if water shortages or excesses exist in the Basin or are assumed to occur in the future, and then evaluate how this situation may affect E&R uses.

4 SECTION ORGANIZATION AND MAPS

The Basin was divided into three regions (north, west, and south) and 17 sub-basins to help convey information in a more meaningful manner (see list below). Sub-basins were delineated according to the US Geological Survey Hydrologic Unit Code 4 classification (Figure 2-2). Descriptions and information presented in this report were broken down by region and/or sub-basin where appropriate. The main report body includes figures by region and is used to display E&R uses across larger areas of the Basin. Figures broken down by sub-basin are included in the Appendices and are used to demonstrate more detailed information for the model results.

1. Madison & Gallatin
2. Yellowstone Headwaters & Upper Yellowstone
3. Clarks Fork-Yellowstone
4. Shoshone
5. Big Horn Lake
6. North Fork Shoshone
7. South Fork Shoshone
8. Dry
9. Greybull
10. Upper Bighorn
11. Nowood
12. Upper Wind

13. Lower Wind
14. Badwater
15. Little Wind
16. Popo Agie
17. Muskrat

To maintain a consistent terminology throughout this report, the following terms are used when referring to the areas or resources of study:

- Study Area or Basin: Refers to the all the sub-basins together, including the complete Wind-Bighorn River Basin within Wyoming.

- Sub-basin: Will be used to describe any of the smaller contributing drainages or partial basins that make up the Wind-Bighorn River Basin (Figure 4-1).

- Waters: Is used in reference to individual streams or reservoirs. In some instances, it may refer to all stream or reservoir features in the Basin or sub-basin.

A map was created for each of the regions that displays all gathered data for: 1) land ownership, 2) state – environmental uses, 3) federal – environmental uses, 4) recreational uses, and 5) diversions. These maps provide a landscape-level view of the specific use categories and demonstrate the wide-range of uses across the Basin. Additionally, more targeted sub-basin maps were created to depict the three model results and are included in the Appendices. These maps were determined to be important for depicting water uses related to E&R in the study area. Each of these maps is discussed in more detail in the model section 8.3. In most cases, the E&R information was available for the entire Basin (or state) and was therefore presented for the entire river basin. Exceptions are specifically noted.

5 RESULTS

These sections discuss the land ownership, environmental water use, and recreational water use identified throughout the Basin. Each of the sections is outlined in a manner generally consistent with the Handbook. The goal of this section is to identify the use factors that are supported by water across the Basin. This foundation supports subsequent categorization and model development.

5.1 Land Ownership

The Basin is comprised of 14,656,955 ac and 19 sub-basins (Table 5-1, Figures 5-1 through 5-3). Land ownership in the Basin is well-distributed among a variety of land owners/managers. The ownership layout follows a general pattern where the forested mountainous regions are administered by the US Forest Service (USFS) making up just over 20% of the Basin (3,036,732 ac); the open shrub/scrub and prairie habitat is a patchwork of state (609,456 ac; approximately 4%) and Bureau of Land Management (BLM) land (4,248,546 ac; approximately 29%); and the irrigated river bottoms are mostly private land (2,504,320 ac; approximately 17%; Figures 5-1 through 5-3). A few notable exceptions are YNP that is administered by the National Park Service (NPS; 1,622,482 ac; approximately 10%; Figure 5-3), and the Wind River Indian Reservation that is administered by the Bureau of Indian Affairs (1,996,585; approximately 14% Figure 5-2). Other smaller land owners include the Bureau of Reclamation (BOR), WGFD, and State Parks, all with ownership under 3% of the total land in the Basin. These lands are often associated with water use through recreation or environmental use.

Land ownership is often a driving factor for water use and distribution. As described in more detail below, E&R activities occur more frequently on public lands that provide a greater level of protection for environmental factors and allow more access to recreation opportunities. This is evident in the environmental and recreation models (see Sections 8.3.2 and 8.3.3). Additionally, traditional water uses such as agriculture are more likely to be consolidated on private land. Potential water development projects may occur on either public or private land; however, the development and evaluation process is commonly more rigorous when public land is involved. The protection model demonstrates the difference between private and public land and is discussed in Section 8.3.1.

Table 5-1. Land ownership in the Wind – Bighorn River Basin.

Basins & Sub-Basins	Bureau of Land Management		Private Land owner		Forest Service		Bureau of Indian Affairs		National Park Service	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Wind – Bighorn River Basin	**4,248,546**	**29.0**	**2,504,321**	**17.1**	**3,036,733**	**20.7**	**1,996,586**	**13.6**	**1,622,483**	**11.1**
Badwater	308,307	56.3	177,306	32.4	0	0	672	0.1	0	0
Big Horn Lake	421,823	52.1	120,353	14.9	200,565	24.8	0	0	27,060	3.3
Clarks Fork Yellowstone	116,275	14.4	151,224	18.7	492,707	61.0	0	0	1	0
Dry	105,450	37.8	53,594	19.2	0	0	0	0	0	0
Gallatin	0	0	0	0	0	0	0	0	40,978	100
Greybull	150,001	20.4	223,052	30.3	272,922	37.1	0	0	0	0
Little Wind	176,244	24.7	46,432	6.5	23,445	3.3	444,176	62.2	0	0
Lower Wind	195,743	17.9	135,420	12.4	0	0	508,760	46.6	0	0
Madison	0	0	0	0	0	0	0	0	398,585	100
Muskrat	386,117	82.0	48,837	10.4	0	0	1,813	0.4	0	0
North Fork Shoshone	24,327	4.5	31,686	5.8	460,332	84.2	0	0	20,701	3.8
Nowood	607,662	47.2	347,580	27.0	208,997	16.2	0	0	0	0
Popo Agie	126,893	24.6	101,213	19.6	195,072	37.8	43,207	8.4	0	0
Shoshone	280,332	35.7	354,553	45.2	881	0.1	0	0	1,817	0.2
South Fork Shoshone	11,356	2.7	83,507	20.1	308,779	74.2	0	0	0	0
Upper Bighorn	1,273,285	57.3	551,627	24.8	35,404	1.6	221,182	10.0	0	0
Upper Wind	64,733	4	77,790	4.8	616,795	37.8	776,776	47.6	0	0
Upper Yellowstone	0	0	0	0	0	0	0	0	2,057	100
Yellowstone Headwaters	0	0	146	0	220,833	16.3	0	0	1,131,284	83.4

Table 5-1 *(continued)*. Land ownership in the Wind – Bighorn River Basin

Basins &	State Land Board		Bureau of Reclamation		State Fish and Wildlife		State Park & Recreation		The Nature Conservancy		Total
Sub-Basins	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres***
Wind – Bighorn River Basin	**609,457**	**4.2**	**430,855**	**2.9**	**139,839**	**1**	**31,216**	**0.2**	**26,713**	**0.2**	**14,656,956**
Badwater	57,188	10.4	0	0	0	0	4,483	0.8	0	0	547,955
Big Horn Lake	26,671	3.3	0	0	12,585	1.6	0	0	1	0	809,447
Clarks Fork Yellowstone	24,959	3.1	20,626	2.6	1,412	0.2	0	0	493	0.1	807,730
Dry	14,910	5.4	104,982	37.6	0	0	0	0	0	0	278,935
Gallatin		0		0	0	0	0	0	0	0	40,978
Greybull	77,578	10.6	7,687	1.0	4,619	0.6	0	0	2	0	735,860
Little Wind	23,495	3.3		0	0	0	0	0	0	0	713,792
Lower Wind	40,207	3.7	169,111	15.5	32,450	3.0	11,134	1.0	0	0	1,092,826
Madison		0	0	0	0	0	0	0	0	0	398,585
Muskrat	33,891	7.2	0	0	0	0	0	0	0	0	470,659
North Fork Shoshone	2,503	0.5	233	0	0	0	6,046	1.1	4	0	546,474
Nowood	86,096	6.7	1,925	0.2	22,921	1.8	2	0	13,194	1.0	1,288,377
Popo Agie	34,421	6.7	0	0	3,473	0.7	1,056	0.2	4,744	0.9	515,993
Shoshone	38,136	4.9	91,102	11.6	7,053	0.9	1,702	0.2	5,722	0.7	784,527
South Fork Shoshone	6,372	1.5	601	0.0	0	0	5,822	1.4	3	0	416,441
Upper Bighorn	125,469	5.7	14,576	0.7	0	0	972	0	0	0	2,222,514
Upper Wind	17,560	1.1	20,012	1.2	55,325	3.4	0	0	2,549	0.2	1,631,541
Upper Yellowstone	0	0	0	0	0	0	0	0	0	0	2,057
Yellowstone Headwaters	0	0	0	0	1	0	0	0	0	0	1,352,265

**Due to the size of the table and small percentage of land, some owners were omitted from the table. The total acreage value is inclusive of all landowners*

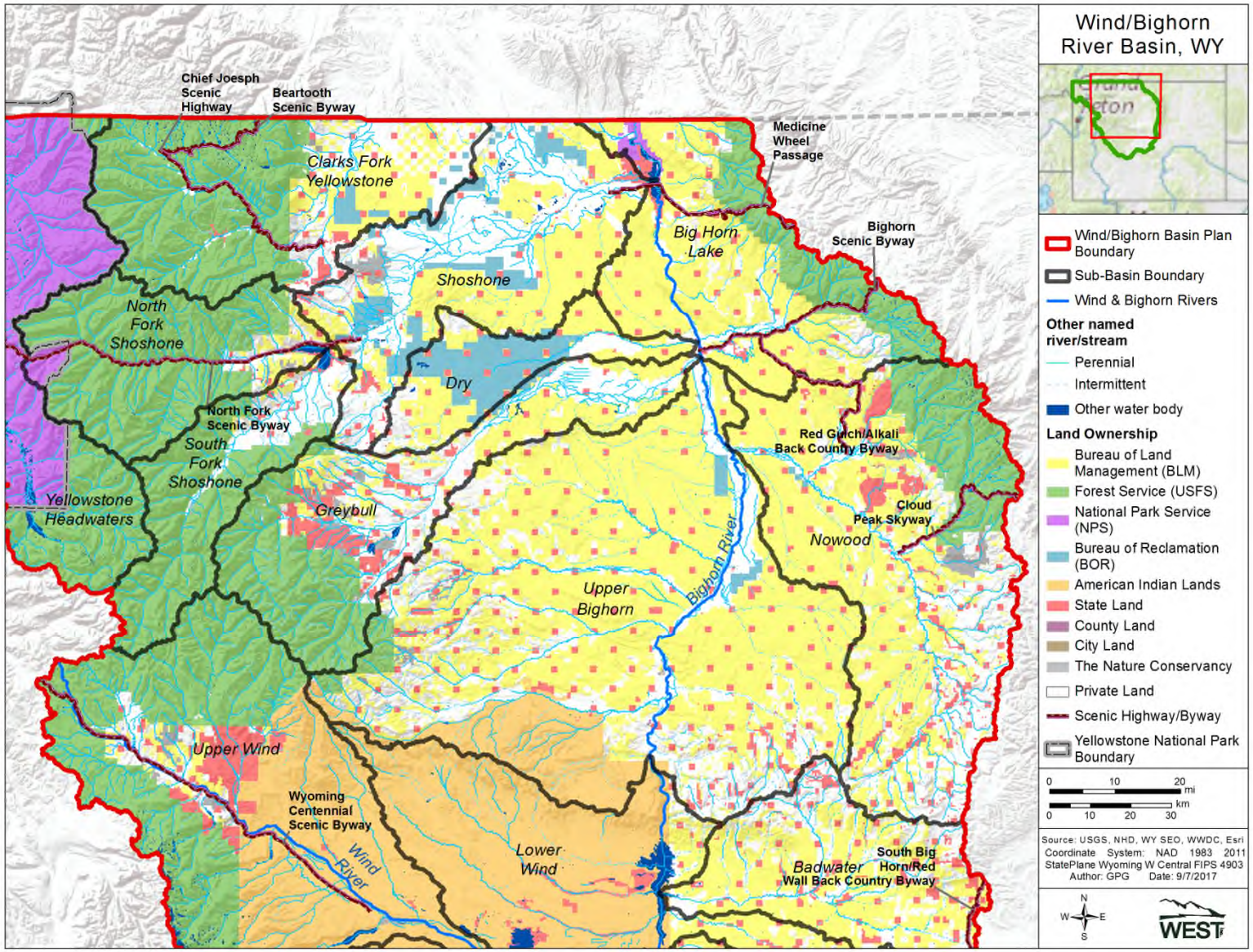


Figure 5-1. Land ownership in the Wind – Bighorn River Basin (North region).

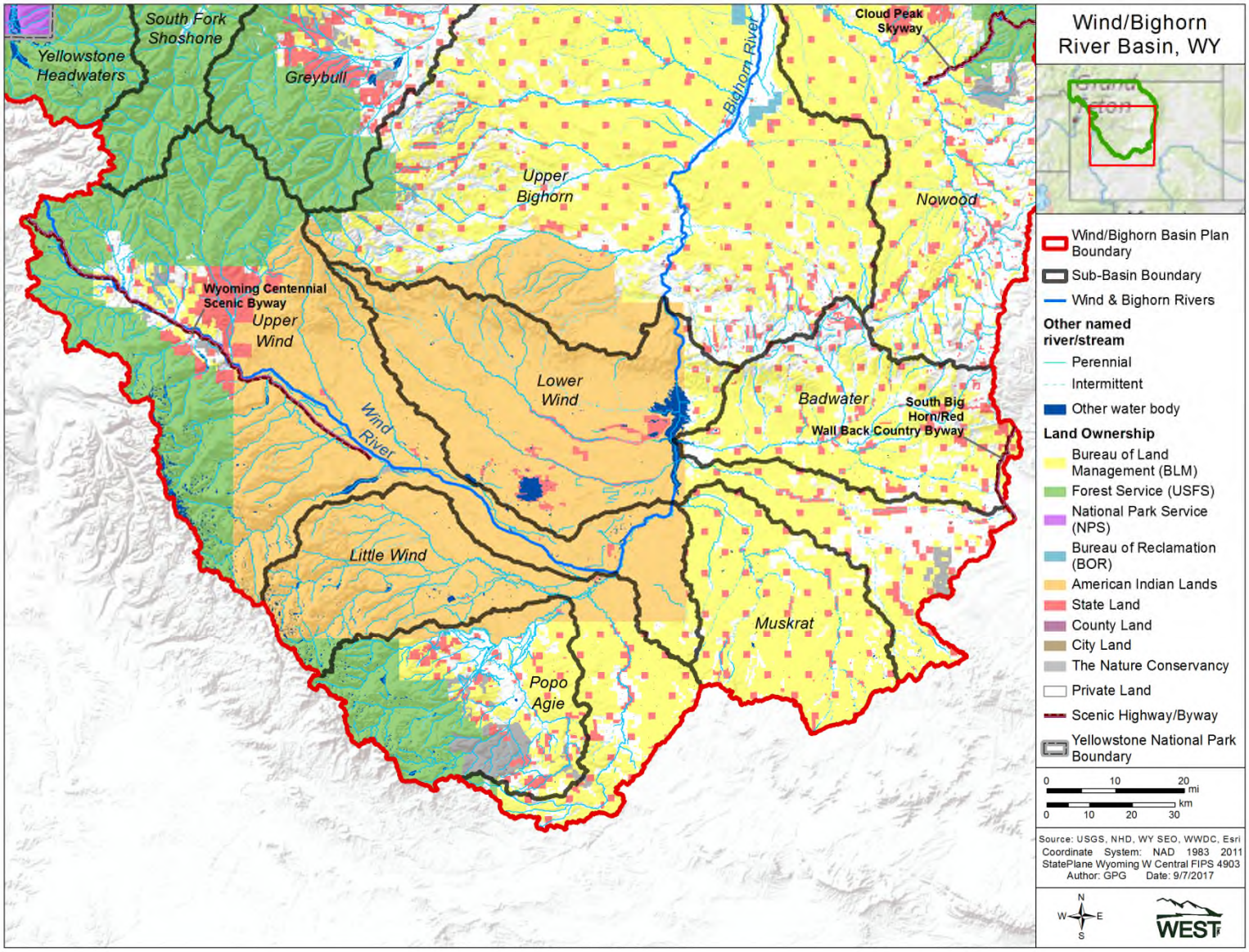


Figure 5-2. Land ownership in the Wind – Bighorn River Basin (South region).

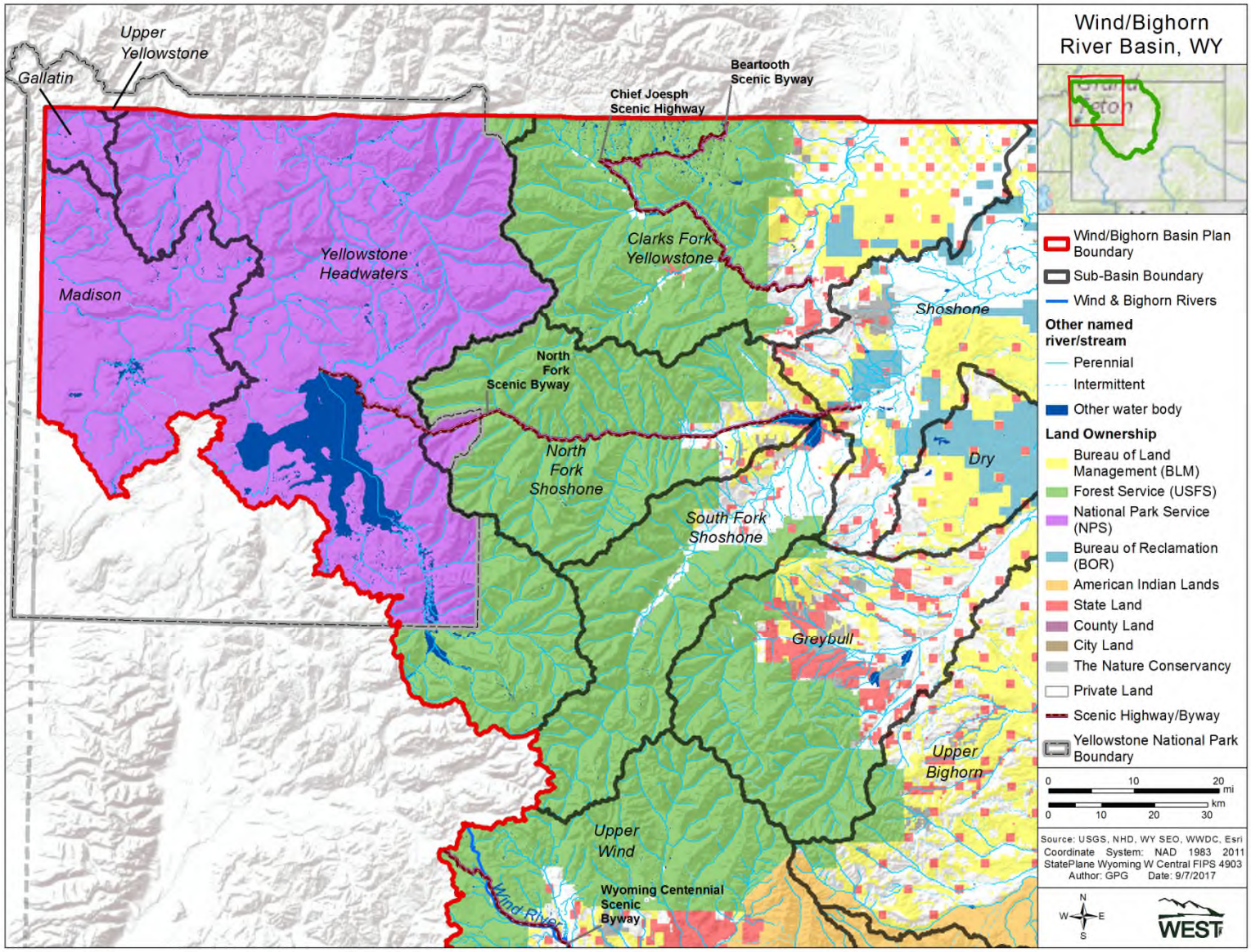


Figure 5-3. Land ownership in the Wind – Bighorn River Basin (West region).

6 ENVIRONMENTAL

This section is broken into state and federal environmental factors. Environmental water use in the Basin is demonstrated through permitted and protected resources and areas where environmental resources have been identified as important. These include state designed priority habitats and stream corridors, US Fish and Wildlife Service (USFWS) critical habitats, instream flows, and wetland complexes, among others. Further discussion on environmental water use is provided below.

Environmental water use is difficult to quantify as most environmental factors are non-consumptive or consumed at a level that makes quantifying difficult and potentially inaccurate. Where appropriate, the section does quantify water use associated with specific environmental uses. Environmental uses that cannot be specifically quantified are discussed using a qualitative approach relative to how a change in water availability may affect the environmental use. The relative scale or magnitude of environmental water uses across the Basin is discussed in the environmental model section 8.3.2.

6.1 State – Environmental

This section discusses the state-level management of environmental resources in the Basin that are associated with water use. State government bodies include the WWDC, Wyoming SEO, WGFD, and others.

6.1.1 Instream Flow Filings and Reservoir Minimum Pools

Instream flow filings are a legal means to protect and manage fish habitat. The instream flows designate a specific water flow that must be maintained in the permitted stream segment. This section provides a brief overview and identifies new filings that have been permitted since the most recent plan update (2010).

Fifty-one instream flow filings provide environmental protection for over 233 miles of streams in the Basin (Figures 6-1 through 6-3, Table 6-1), of which 34 have permits issued. The remaining filings are still in process. Twelve instream flow filings have been granted since the 2010 update (Table 6-1). This includes 10 filings in the Upper Wind sub-basin and one filing in each the North and South Fork Shoshone sub-basins.

Currently, the Greybull and Upper Wind sub-basins have the largest number of instream flow filings and total stream length (Table 6-2), and the majority instream flow water rights issued have a relatively junior status (Table 6-1). The majority of instream flow rights protect low order streams at higher elevations in their respective watersheds. Most of these protected stream segments are also in areas identified as WGFD priority habitats or other designated habitats (Nowood and Big Horn Lake sub-basins; Figure 6-1). There are a few instream flow rights on higher order streams, most notably on the main stem of the Shoshone River (Figure 6-1) and the Clarks Fork River (Figure 6-3).

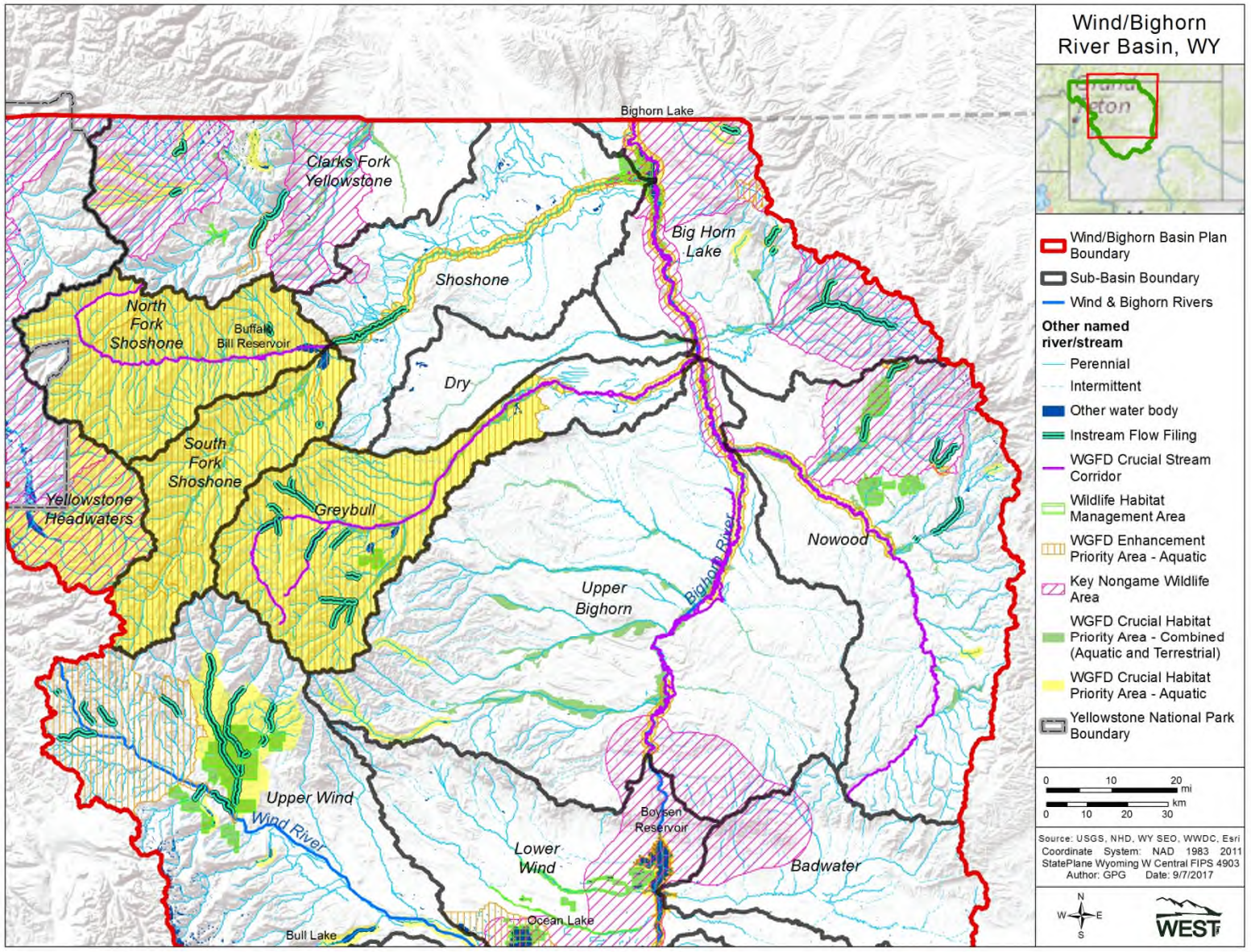


Figure 6-1. State - environmental uses in the Wind – Bighorn River Basin (North region).

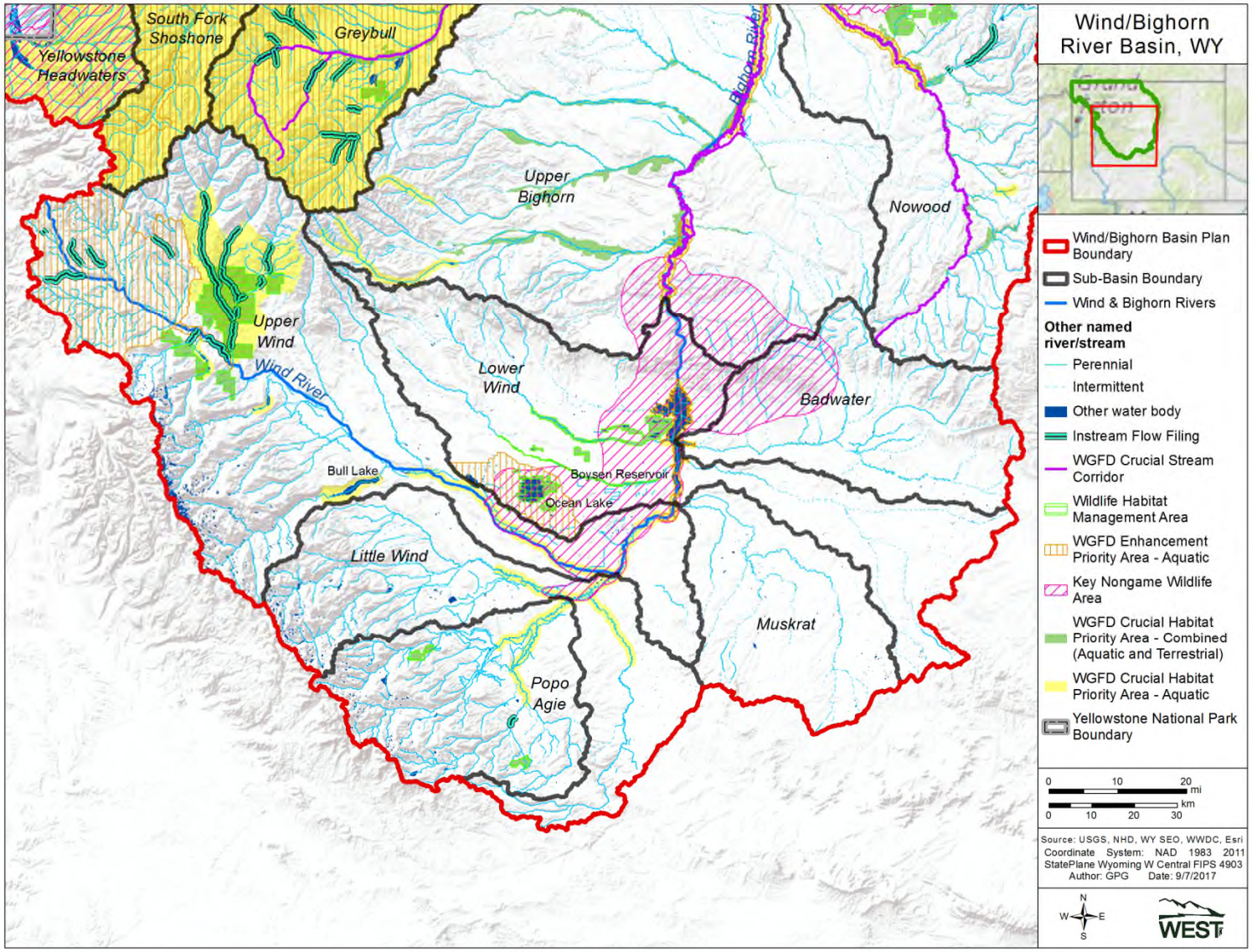


Figure 6-2. State - environmental uses in the Wind/Bighorn River Basin (South region).

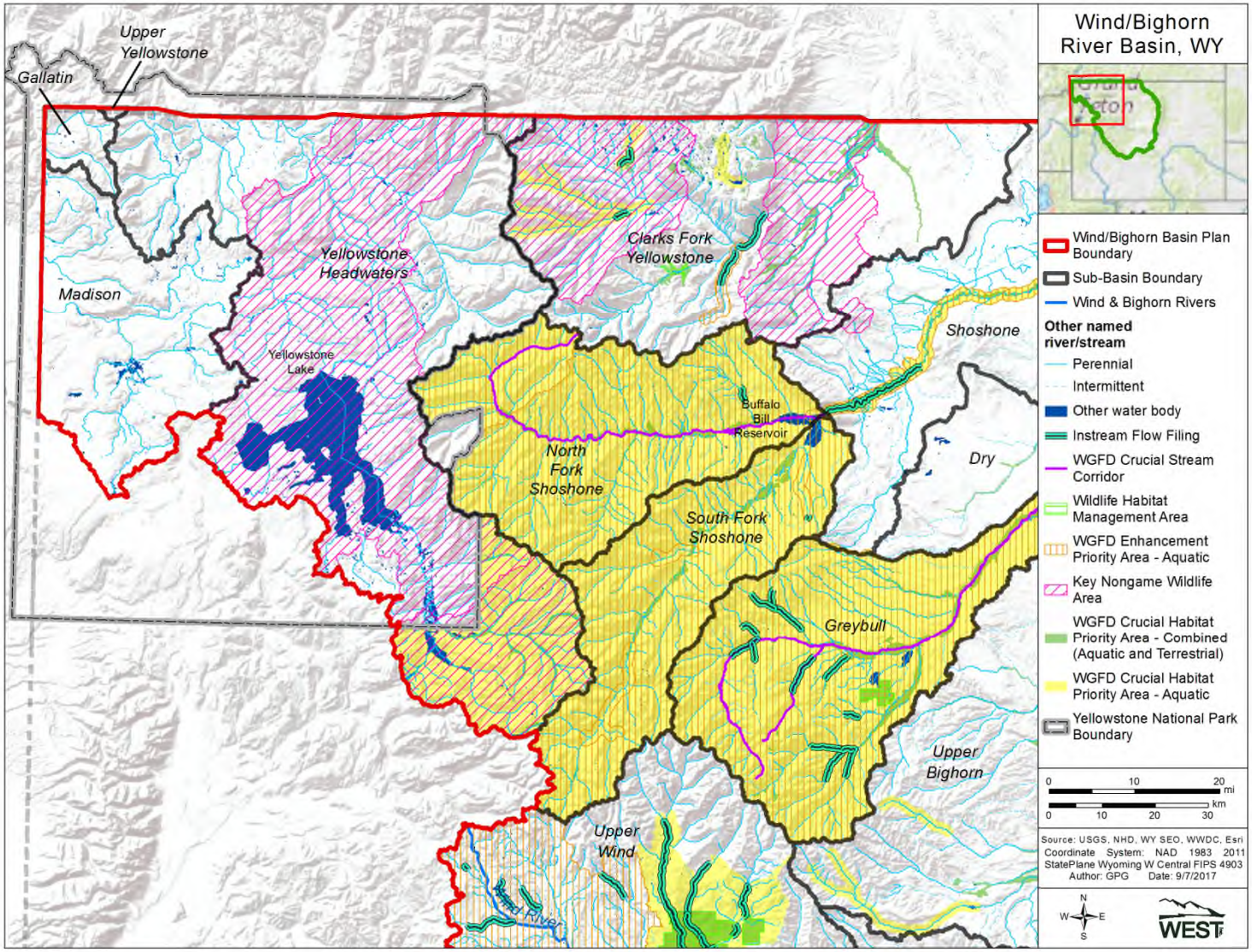


Figure 6-3. State - environmental uses in the Wind – Bighorn River Basin (West region).

Table 6-1. Wind – Bighorn River Basin instream filings detailed breakdown.

Sub-basin	Name	Priority	Date Issue	Length (Miles)
	Shell Creek No.1 I.F. Segment No.1	10/8/1993	11/26/1999	11.1
	Shell Creek No.2 I.F. Segment No.2	10/8/1993	11/26/1999	5.5
	Beaver Creek, South			0.9
	Beaver Creek, North			3.4
	Cedar Creek	10/16/2014		4.3
Big Horn Lake	Trout Creek (Bighorns)			2.9
	Clark's Fork River I.F. Segment No.1	12/4/1986	5/6/1988	6.1
	Crandall Creek			1.7
Clarks Fork	Dead Indian Creek			5.2
Yellowstone	Muddy Creek (Sunlight Basin)			3.1
	Middle Fork Wood River I.F. No.1	1/21/2005	1/14/2008	4.7
	Francs Fork I.F. Segment No. 1	7/8/2003	10/23/2008	5.3
	Greybull River I.F. Segment No. 1	2/10/2004	10/23/2008	4.4
	WGFD-Dick Creek I.F. No.1	1/21/2005	1/15/2008	2.2
	South Fork Wood River I.F. No.1	1/21/2005	1/15/2008	3.9
	West Timber Creek I.F. Segment No. 1	7/8/2003	10/23/2008	4.4
	Jack Creek I.F. Segment No. 1	7/8/2003	10/23/2008	2.5
	Wood River Above Middle Fork I.F. No.1	1/21/2005	1/14/2008	4.0
	Wood River Below Middle Fork I.F. No.1	1/21/2005	1/14/2008	1.6
	Pickett Creek I.F. Segment No. 1	7/8/2003	10/23/2008	4.7
	North Fork Pickett Creek I.F. No. 1	2/10/2004	10/23/2008	2.4
	Piney Creek I.F. Segment No. 1	2/10/2004	10/23/2008	2.4
Greybull	Pickett Creek I.F. Segment No. 2	7/8/2003	10/23/2008	3.4
North Fork Shoshone	Trout Creek I.F. Segment No.1	6/16/2006	9/26/2013	1.9
	Medicine Lodge Creek I.F. Segment No.1	12/17/1990	2/9/2010	4.1
	Tensleep Creek I.F. Segment No.1	7/2/1987	1/13/1991	8.0
	Tensleep Creek I.F. Segment No.1 (BOC)	4/9/1979	9/21/2007	0.6
	Dry Medicine Lodge Creek	7/30/2013		4.0
	Buckskin Ed Creek	10/16/2014		3.9
Nowood	Soldier Creek	10/16/2014		5.4
Popo Agie	Little Popo Agie River I.F. Segment No. 1	10/08/1993	1/17/2006	1.6
Shoshone	Shoshone River I.F. Segment No.1	12/31/1991		15.6
South Fork Shoshone	Marquette Creek I.F. Segment No.1	6/16/2006	9/26/2013	0.5
	Wiggins Fork Upper I.F. Segment No. 1	12/29/2009	6/17/2013	36.7
	Bear Creek Upper I.F. Segment No. 1	12/29/2009	6/17/2013	7.4
	Wiggins Fork Lower I.F. Segment No. 1	12/29/2009	6/17/2013	1.5
	Big Wind River I.F. Segment. No.1	03/09/1989	06/22/1997	5.5
	East Fork Lower I.F. Segment No. 1	12/29/2009	6/17/2013	4.8
	Geyser Spring I.F. Segment No. 1	04/19/1949	09/26/2007	2.7
	East Fork Above Wiggins Fork I.F Segment No. 1	12/29/2009	6/17/2013	1.6
	Bear Creek Middle I.F. Segment No. 1	12/29/2009	6/17/2013	3.8
	Bear Creek Lower I.F. Segment No. 1	12/29/2009	6/17/2013	2.7
	East Fork BLM Upper I.F. Segment No. 1	12/29/2009	6/17/2013	1.6
	East Fork Wind River I.F. Segment No. 1	12/29/2009	6/17/2013	5.1
	East Fork BLM Lower I.F. Segment No. 1	12/29/2009	6/17/2013	0.9
	Wiggins Fork (Lower)			3.7
	Burroughs Creek			4.3
	Middle Fork Long Creek			4.1
	Sheridan Creek			7.0
	Stonefly Creek			0.6
Upper Wind	West Fork Long Creek			4.2

Table 6-2. Wind – Bighorn River Basin instream flow filings summary by sub-basin.

Sub-Basin	Number of Instream Flow Filings	Stream Length (miles)
Big Horn Lake	6	28
Clarks Fork Yellowstone	4	16
Greybull	13	46
North Fork Shoshone	1	2
Nowood	6	26
Popo Agie	1	2
Shoshone	1	16
South Fork Shoshone	1	1
Upper Wind	18	98
Wind/Bighorn River Basin Totals	**51**	**234**

Detailed information for the instream flow filings was provided in the *2010 Technical Memorandum* (MWH Americas 2010b) and is available on the WGFD (https://wgfd.wyo.gov/) and WSEO websites (http://seo.wyo.gov/surface-water/instream-flow). Additionally, instream flow rights on USFS managed land were presented in the 2010 update (MWH Americas 2010b).

Previous Basin Plans (2003 and 2010) presented information on minimum pool levels for permitted reservoirs in the Basin. No new reservoirs have been permitted since the 2010 update; therefore, no new information is available for this update. A brief summary from the previous reports is provided below.

Several reservoirs in the Basin have storage permitted for a variety of environmental uses. These uses, as they appear on the water rights, include fish or fish and wildlife. Recreational uses defined on permits can be considered environmental to the extent that water in storage is used for recreational purposes, is not released for other consumptive or non-consumptive uses, and/or can be environmentally beneficial for fish habitat and wildlife consumption. Reservoirs with permitted capacity for stock water similarly serve a dual environmental function. Reservoirs with fish or fish and wildlife uses or pools listed in their permitting documents can be found in the *Wind-Bighorn River Basin Plan Final Report* (BRS 2003).

Five reservoirs have minimum pool levels (i.e., dead storage allocation) that provide protection for fisheries and recreation use (Table 6-3).

Table 6-3. Permitted minimum pool level for reservoirs in the Wind – Bighorn River Basin.

Reservoir Name	Dead Storage Allocation (acre-feet)
Boysen Reservoir	40,084
Buffalo Bill Reservoir	3,413
Bull Lake Reservoir	722
Deaver Reservoir	83
Pilot Butte Reservoir	2,648
Total	**46,950**

6.1.1.1 Wyoming Game and Fish Department – Environmental

WGFD is a state agency that provides oversight and management for the natural resources in Wyoming, including E&R management. WGFD has prepared a number of documents that

identify, categorize, and provide management recommendations for Wyoming E&R resources. These documents include the *State Wildlife Action Plan* (SWAP; WGFD 2010 and 2017a) and *Strategic Habitat Plan* (SHP updated in 2009 and 2015). The SWAP identifies wildlife resources throughout the state by terrestrial habitats and aquatic regions (basins). The goal of the plan is to develop management strategies for wildlife based on current and future risks. The SHP identifies five goals including conservation and management, enhancement, increased recreation, increased public awareness, and promotions of collaborative efforts (WGFD 2015). Only data on aquatic resources were included in this report.

6.1.2 Wyoming Game and Fish Department –Aquatic Priority Habitat Areas

WGFD developed a SHP in 2001 with the most recent update in 2015. The SHP recognized the important role habitat issues play in the future of Wyoming's wildlife. Several habitats and vegetation communities were identified as important to maintain or enhance. The SHP specifically acknowledged declines in water flows, water quality, loss of water flow to diversions, and loss of native fish to entrainment as risk factors effecting Wyoming resources. Through the SHP, WGFD identified priority habitats that are "crucial" for wildlife and those habitats that have been degraded and have potential for "enhancement".

This section identifies the priority areas designated by WGFD as aquatic habitat crucial areas, aquatic habitat enhancement areas, crucial stream corridors, wildlife habitat management areas, and key nongame wildlife areas.

The following sections describe lands identified and managed for conservation by WGFD. Priority areas were not identified in YNP and the Wind River Reservation where WGFD does not have wildlife management authority.

6.1.3 Crucial Habitat Priority Areas - Aquatic

Crucial Habitat Priority Areas (CHPA) are areas that are considered to be crucial to conserving and maintaining populations of aquatic wildlife for the present and future. These areas are identified as having significant biological or ecological value that needs to be protected or managed to maintain viable healthy populations of aquatic wildlife. These areas address Goal 1 in the SHP. These areas in the region are deemed as valuable by WGFD. WGFD provides examples of core crucial area values including: "*crucial winter range, sage grouse core areas, seasonal habitats, Species of Greatest Conservation Need (SGCN) diversity and uniqueness, quality of watershed hydrologic function, etc*." (WGFD 2015). Management and habitat protection activities will be targeted in these areas.

Many of the CHPA areas designated in the Basin target the preservation of the Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*), including an area on the eastern border of YNP that spans the entire North Fork Shoshone, South Fork Shoshone, and Greybull sub-basins, part of the Upper Wind sub-basin, the southeastern corner of the Yellowstone Headwaters sub-basin, large sections of the Wind and Popo Agie Rivers, and smaller stream sections on the western slope of the Big Horn mountain range (Figures 6-1 through 6-3). The Yellowstone

cutthroat trout requires relatively clear, cold streams, rivers, or lakes to, and suggested conservation actions include managing flows for critical life stages and habitat.

All other CHPA in the Basin are corridors that include waterways (e.g., river) and the immediately surrounding landscape. Designated crucial area along the Bighorn River is intended to protect the sturgeon chub (*Macrhybopsis gelida*), which requires swift flows, braided channels and high turbidity to thrive. Two species specifically targeted by CHPA across the Basin include sauger (*Sander canadensis*) and burbot (*Lota lota*). Three small sections of CHPA areas have been designated for burbot on the east slope of the Wind River Range and Boysen reservoir. CHPA for sauger were designated from Boysen reservoir upstream along the Popo Agie, Little Wind, and other tributaries. Other fish species targeted for conservation by the CHPA include flathead chub (*Platygobio gracilis*), stonecat (*Noturus flavus*), shorthead redhorse (*Moxostoma macrolepidotum*), river carpsucker (*Carpiodes carpio*), bluehead sucker (*Catostomus discobolus*), northern leatherside chub (*Lepidomeda copei*), sturgeon chub, Snake River cutthroat trout (*Oncorhynchus clarki behnkei*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), mountain whitefish (*Prosopium williamsoni*), Bonneville cutthroat trout (*Onocorhynchus clarkii utah*), shovelnose sturgeon (*Scaphirhynchus platorynchus*), channel catfish (*Ictalurus punctatus*), plains minnow (*Hybognathus placitus*), and western silvery minnow (*Hybognathus argyritis*). Amphibians include boreal toad (*Bufo boreas boreas*) and Great Basin spadefoot toad (*Spea intermontana*).

6.1.4 Combined Habitat Priority Areas

WGFD also identifies combined crucial areas in the SHP. The combined areas are designed where significant overlap between aquatic and terrestrial crucial habitat occurs. For the purpose of the report, combined crucial areas are presented and identified separately, but are assumed to provide the same value as crucial aquatic areas. In many cases, the combined areas cover more significant portions of the water resources and subsequent E&R uses across the Basin.

Limited specific information is available for the combined priority areas in the Basin. A large section of combined habitat is designated “Extensive Riparian” (Figures 6-1 through 6-3). These areas have been designated throughout the Basin, exclusively along major stream corridors. WGFD highlights these areas as providing diverse and productive habitat for wildlife and additional properties supporting sediment filtering, shade, water conservation, and general productivity for aquatic environment. Two other combined areas occur in the Basin; Upper Sweetwater Watershed and Upper Wind River Basin. Specific information on these two combined areas was not available for this report.

A detailed description for each individual CHPA can be found on the WGFD website (https://wgfd.wyo.gov/Habitat/Habitat-Priority-Areas/Statewide-Maps). The CHPA are included in the environmental model and discussed in more detail below.

6.1.5 Enhancement Habitat Priority Areas - Aquatic

Enhancement Habitat Priority Areas (EHPA) have been identified by WGFD as areas that have the potential to provide wildlife habitat, but are currently in a state that needs restoration or improvements. The areas may be targeted by WGFD to address Goal 2 in the SHP. If properly managed and addressed, the EHPA may provide a value similar to the CHPA. WGFD provides examples of issues including: *"loss of aspen communities, habitat fragmentation, development, loss of connectivity, water quality effects, water quantity limitations, lack of fish passage, loss of fish to diversions, degraded habitat, etc.* (WGFD 2015)*"*

The EHPA span many of the same areas covered by the CHPA or cover areas immediately adjacent to the CHPA (Figures 6-1 through 6-3). This includes major river corridors in the Basin and the large complex along the eastern boundary of YNP. Additional smaller EHPA exist east of Dubious, around Boysen Reservoir, and along the Clark's Fork River. Because these areas do not currently provide high value habitat, they are not discussed in great detail or included in the environmental model section.

6.1.6 Crucial Stream Corridors

Crucial stream corridors are river segments that have been identified by WGFD to be unique, have high species richness, lack migration barriers, remain in relatively natural conditions, and provide connectivity between source and sink locations. The corridors include main stem, off shoot channels, and braided channel areas.

Crucial stream corridors have been mapped along large sections of the Nowood River, Greybull River, Francs Fork, North Fork of the Shoshone River, and Bighorn River (Figures 6-1 through 6-3). Nearly all of the crucial stream segments are higher order and physically larger rivers routed through the Bighorn Basin. The North Fork Shoshone is a higher order stream located in a forest habitat, above the Buffalo Bill Reservoir. Small sections of crucial stream corridors fall outside of the CHPA, including a six-mile section along the Greybull River between Burlington and Otto, a 16-mile section along the Bighorn River from approximately Kirby to Worland, and 45 miles of the Nowood River from the headwaters to the town of Ten Sleep.

6.1.7 Wildlife Habitat Management Area

Wildlife Habitat Management Areas (WHMA) lands were purchased by or donated to the Wyoming Game and Fish Commission for the purpose of providing wildlife habitat needs on a seasonal or year round basis (personal communication with Ian Tator, May 10, 2017). WGFD designated WHMA as both crucial and enhancement areas and, as such, the areas are managed to achieve the wildlife objectives set forth in the SHP. The areas also provide a dual purpose for the state, supporting recreational activities including hunting, fishing, and other passive recreation.

There are 13 WHMA covering approximately 154,048 ac occur in the Basin (Figures 6-1 through 6-3). The WHMA provide habitat for a variety of Wyoming wildlife including big game, game birds, waterfowl, and fisheries. Public access (at least seasonally) is provided to each WHMA. The Renner and Medicine Lodge WHMA cover 15,900 and 12,700 ac of the Nowood sub-basin,

respectively, and provide fishing, wildlife viewing, and other passive recreation opportunities. Mexican Creek and Red Canyon WHMA in Popo Agie sub-basin provide wildlife habitat that is continuous with other federally managed wildlife habitat. Whiskey Basin, Spence & Moriarity, and Kirk Inberg/Kevin Roy WHMA cover a large swath of Wind River headwaters in the Upper Wind sub-basin. The Sand Mesa and Ocean Lake WHMA protect wetlands and waterbodies in the Lower Wind sub-basin that serves a dual purpose of waterfowl habitat and filtering irrigation return flows before the runoff contaminates Boysen Reservoir. The Sunlight WHMA provides 1,414 ac of wildlife habitat along Sunshine Creek in the Clarks Fork Yellowstone sub-basin, the Sunshine WHMA covers 200 ac in the Greybull sub-basin, and the Yellowstone WHMA covers 19,214 ac around the Yellowtail Reservoir in the Shoshone and Bighorn Lake sub-basins.

Detailed information on each WHMA can be found on the WGFD website (https://wgfd.wyo.gov/accessto/whmas.asp). These areas are included in the environmental, recreation, and protection models (due to land ownership) and in the recreation model as an additional factor (see discussion below).

6.1.8 Key Nongame Wildlife Areas

Key Nongame Wildlife Areas (KNWA) were identified by WGFD as habitat the supports birds and mammals that are classified by WGFD as SGCN. These areas contain high densities of wildlife, high species richness, and unique habitat characteristics with low habitat fragmentation. Data provided by WGFD for each KNWA includes a description of the area relative to uniqueness and a list of birds and mammals that occur in the area that are classified as SGCN.

Eight KNWA covering approximately 2,717,386 ac occur in the Basin (Figures 6-1 through 6-3). The KNWA in the Basin cover large spans of land in the high elevation forests, foothills, and lower Bighorn Basin. Most of the KNWA include water resources such as rivers, streams, lakes, and riparian areas. The Medicine Bow Lodge and Yellowtail KNWA are considered unique due to the intact riparian area that supports high species richness. These KNWA are located along the western slope of the Bighorns. Medicine Bow Lodge supports four bird and nine mammals listed as SGCN, while Yellowtail supports nine birds and seven mammals listed as SCGN. The Wind River Canyon KNWA is considered important as a water-associated bird staging area, supporting 19 birds and nine mammals listed as SGCN. The remaining KNWA (Heart Mountain/Chapman, Beartooth, and Yellowstone) do not provide significant water-associated species habitat.

Due to the high level of environmental resources supported by the KNWA, these features have been included in the environmental model discussed below.

6.1.9 Other Conservation Groups

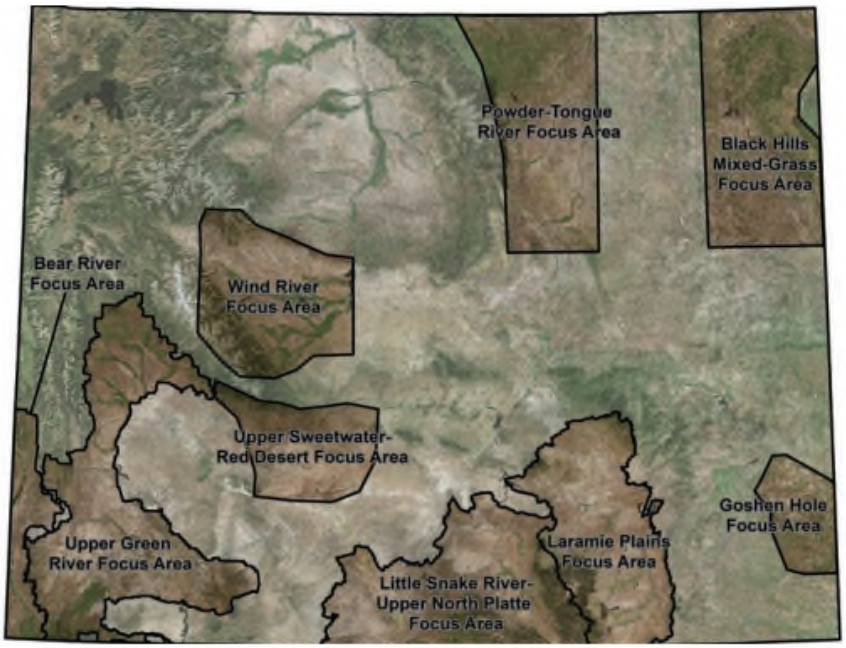
A number of conservation programs and groups have been established in the Basin and include programs managed by The Nature Conservancy, Trout Unlimited, Ducks Unlimited, and Wyoming Stock Growers Agricultural Land Trust; as well as federal, state, and local conservation programs such as Partners for Fish and Wildlife (PFW), Wyoming Wildlife and Natural Resource Trust (WNRT), and various county conservation districts. These programs

and groups often team with one another to implement projects in the Basin to improve and protect aquatic and riparian habitat. These projects include, but are not limited to, installation of fish passage structures, wetland restoration, riparian habitat enhancement, removal of diversion structures, updating culverts and underpasses, grazing management near water sources, prescribed burns, and numerous other projects. Locations of projects managed by these conservation groups were not plotted on the environmental use maps or included in the model; however, they are presented to recognize the grassroots efforts that are ongoing in the Basin. These groups have been working in the region for decades and will continue to target projects with the goal of restoring, enhancing, and conserving habitat. Additional information on the individual groups and specific projects can be found on the respective websites.

While individual conservation projects do not constitute a use of water resources, they demonstrate the value of water for the environment, as well as the public interest in protecting riparian habitat, aquatic habitat, and water quality. As such, the location of these group projects can be used to identify areas where environmental practices have been implemented to increase the environmental function and values associated with water resources. Table 6-4 demonstrates the PFW accomplishments in the Wind River Focus Area and the map insert depicts the focus area location. Future project development should be cognizant of the efforts made to support environmental resources in the Basin.

Table 6-4. Summary of Partners for Fish and Wildlife accomplishments in the Wind River Focus Area

Enhancement	Quantity
Upland (sagebrush/aspen) Enhancement	10,000 acres
Wetland Restoration/Enhancement	200 acres
Riparian Enhancement	10 miles
Stream Restoration	10,000 feet
Fish Passage Structures	2 units



Map of Partners for Fish and Wildlife (PFW) Focus Areas, including the Wind River Focus Area in the Wind – Bighorn River Basin (USFWS 2017a).

6.2 Federal - Environmental

This section discusses the federal-level management of environmental resources in the Basin that are associated with water use. Federal government agencies include USFWS, BOR, US Army Corps of Engineers, USFS, and BLM, and others.

6.2.1 Wild and Scenic Rivers

Wyoming has 408 miles of rivers which are designated as wild & scenic, of which approximately 21 miles are in the Basin. A segment of the Clarks Fork of the Yellowstone River, from Crandall Creek Bridge downstream to the northern boundary of Clarks Fork Canyon was designated as "wild" in 1990. The segment is inside the boundary of the Shoshone National Forest (NF), and is subsequently managed by the USFS. This river segment has its own *Comprehensive River Management Plan* (Clarks Fork Plan; USFS 2009) that specifies protection for a river corridor of 0.25 mile on each side of the river's ordinary high water mark. This section of the Clark's Fork River is provided protection as defined by the Wild and Scenic River Act (1968) as outlined by the Department of Energy. Additional state protection is provided by the instream flow filing. This instream flow water right was executed in 1988 and protects approximately six miles of the segment (Table 6-1).

The Clarks Fork River segment provides E&R opportunities. The area provides habitat for a variety of species including big game, large carnivorous mammals, rodents, and birds of prey including the federally protected golden eagle (*Aquila chrysaetos*) and bald eagle (*Haliaeetus leucocephalus*). The presence of wildlife provides passive recreation opportunities to visitors

including photography and wildlife viewing. The stretch of river is also considered one of the most challenging whitewater rafting opportunities in the state.

A full description of environmental and recreational opportunities and restrictions are provided in the Clarks Fork Plan (USFS 2009). This area is included in environmental and protection models discussed in more detail below.

6.2.2 Wilderness Areas

The Wilderness Act of 1964 (The Wilderness Act 1964) allows Congress to designate WAs within existing federal public land, which may in-turn be managed by any of four federal land management agencies, including USFS, BLM, USFWS, and NPS. A wilderness designation is the highest level of conservation protection for federal lands, in that the Wilderness Act prohibits permanent roads and commercial enterprises, except commercial services that may provide for recreational or other purposes of the Wilderness Act. Wilderness Areas (WA) generally do not allow motorized equipment, motor vehicles, mechanical transport, temporary roads, permanent structures or installations. In other words, WAs are closed to water development.

The remote nature and protected status of the Basin's WAs provides a sanctuary for habitat and wildlife, increasing the environmental value. The WAs are often the headwaters for large watersheds and contain a variety of natural water features including streams, lakes, wetlands, and glaciers. Additionally, USFWS designated critical habitat for the Canada lynx occurs in the WAs.

There are five WAs located in the Shoshone NF—Washakie WA, North Absaroka WA, Absaroka-Beartooth WA, Popo Agie WA, and Fitzpatrick WA; one area located in the Bridger-Teton NF, Teton WA; and one in the Bighorn NF—Cloud Peak WA (Figures 6-1 through 6-3). These WAs protect large portions of headwaters in the Upper Wind, Greybull, Yellowstone Headwaters, North Fork Shoshone, South Fork Shoshone, and Clarks Fork Yellowstone sub-basins, and to a lesser extent, headwaters in the Nowood, Big Horn Lake, and Lower Wind sub-basins. The Fitzpatrick WA, specifically, is peppered with glaciers and natural lake features common to the Wind River Range. The Cloud Peak WA also contains a large number of natural lake features. The North Absaroka WA, Absaroka-Beartooth WA, and Washakie WA include USFWS designated critical habitat for Canada lynx.

The WAs in the Basin also provide a variety of recreational activities. These areas are common destination locations for hiking, backpacking, camping, fishing, and other passive recreation activities.

Additional information on the individual WAs can be found on the USFS website (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3852605.html). The WAs are included in the environmental and protection models discussed in more detail below.

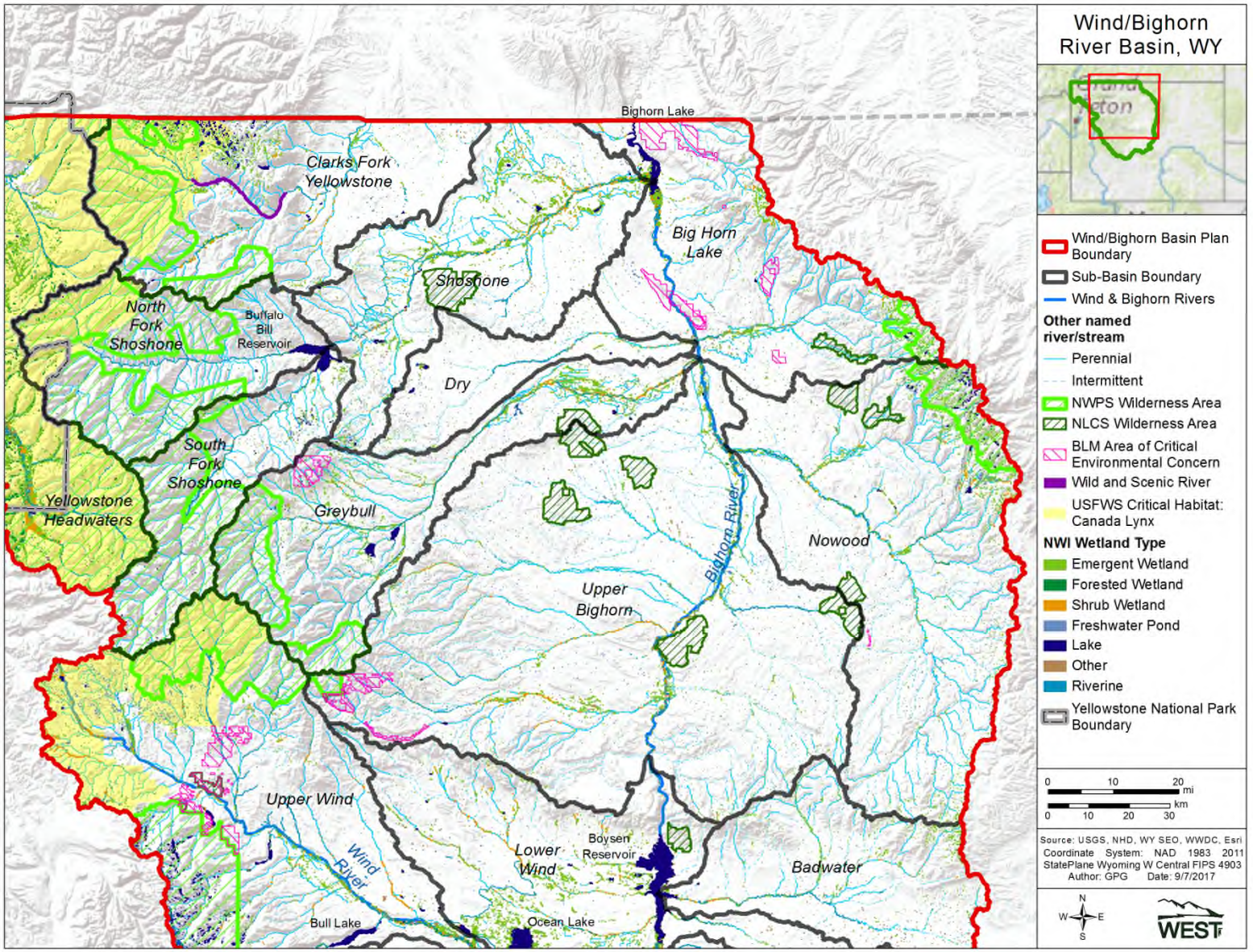


Figure 6-4. Federal - environmental uses in the Wind – Bighorn River Basin (North region).

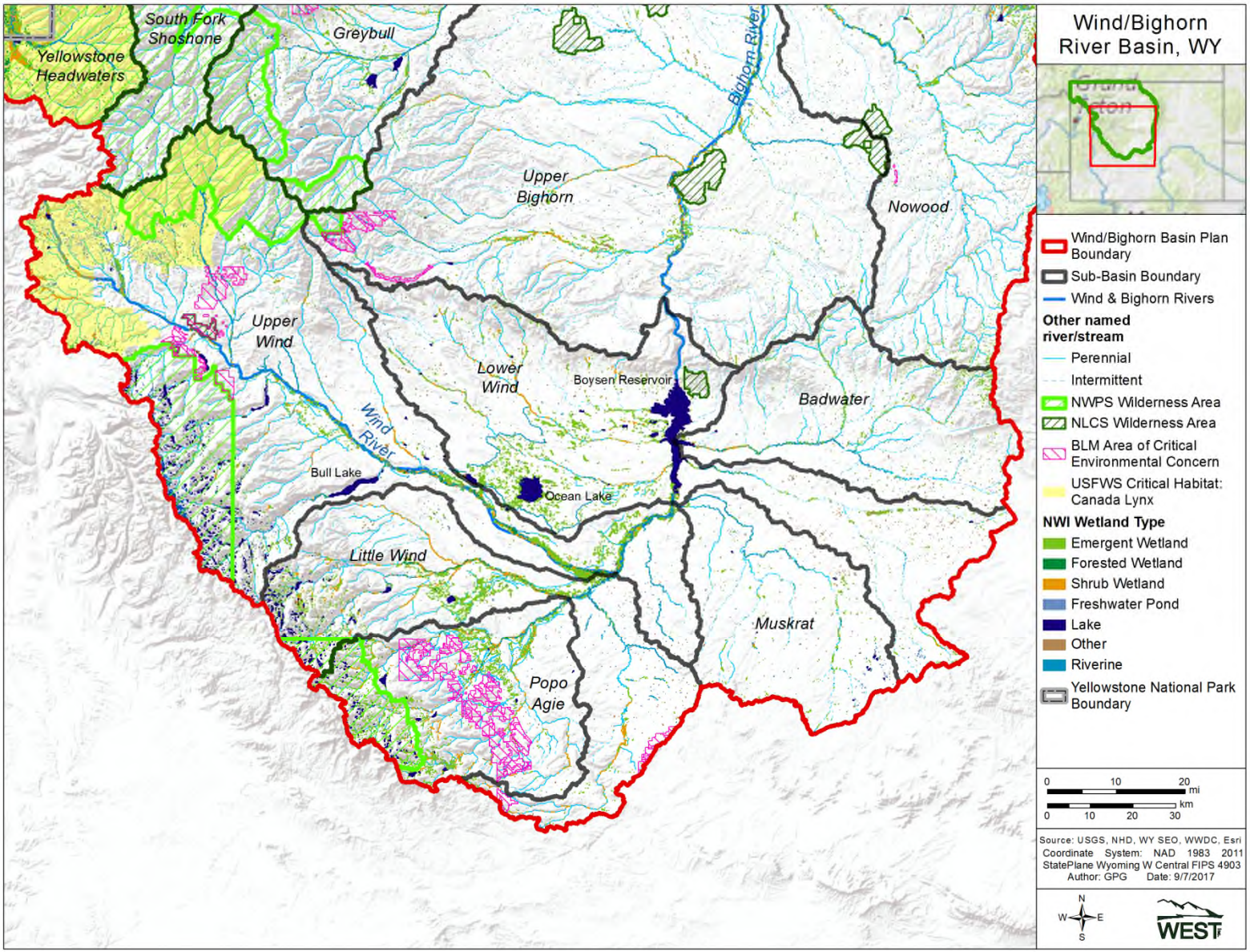


Figure 6-5. Federal - environmental uses in the Wind/Bighorn River Basin (South region).

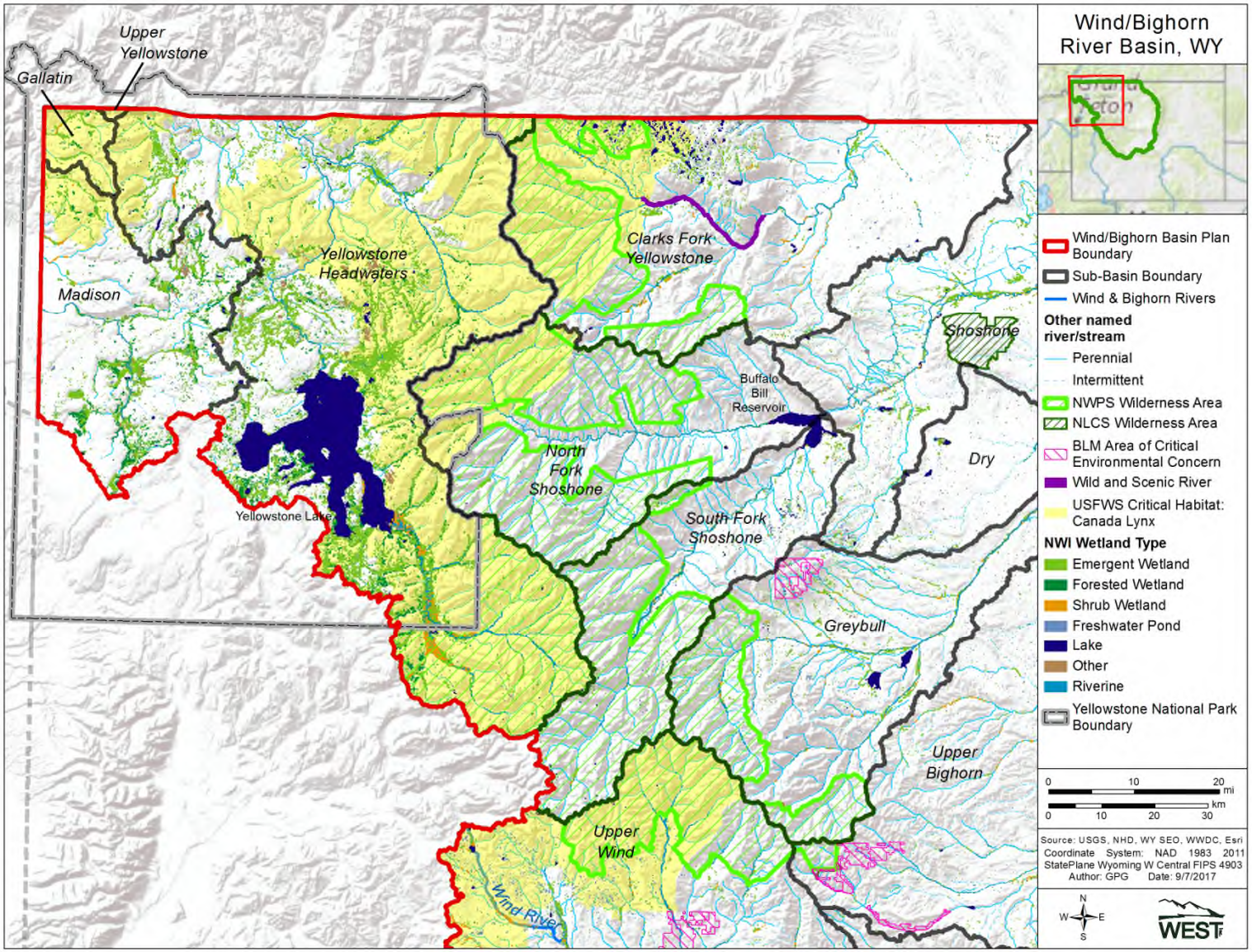


Figure 6-6. Federal - environmental uses in the Wind – Bighorn River Basin (West region).

BLM National Landscape Conservation System wilderness study areas also occur throughout the Basin. The study areas are specifically managed by BLM, but do not currently receive the full protection under the Wilderness Act. Multiple wilderness study areas exist in the northeast section of the Basin in the Upper Bighorn and Nowood sub-basins. Other study areas are scattered throughout the Basin (Figure 6-4 through 6-6). Most of the study areas are not associated with water resources. Two exceptions include the Owl Creek and Sweetwater Canyon study areas. Owl Creek is the dividing line between Rock Creek and the south fork of Owl Creek, while Sweetwater Canyon supports environmental and recreation opportunities along Sweetwater River. Because these areas do not receive the same protection as designated wilderness areas, they are not included in the protection model discussed below.

6.2.3 USFWS Threatened and Endangered Species

The USFWS Information for Planning and Consultation (IPaC; USFWS 2017b) database contains spatial information regarding the presence of federally listed species (threatened, endangered, candidate) and critical habitat within the Basin. The IPaC report for the Basin identified three bird, four mammal, one fish, and four plant species listed under the Endangered Species Act as threatened, endangered, or a candidate species (Table 6-5). Many of the species listed do not occur in the Basin, but may be affected by changes in water flow to downstream habitats. While all species require some level of water to survive, certain species are more commonly associated with water as part of their suitable habitat or life cycles. Each species' habitat requirements and potential water use are identified in Table 6-5.

Table 6-5. Federally threatened and endangered species with potential to occur in the Wind – Bighorn River Basin

Common Name	Scientific Name	USFWS Status	Habitat Requirements	Potential Water Use in River Basin
Birds				
piping plover	*Charadrius melodus*	Threatened[1]	Sand bars along rivers.	Low - stopover during migration, very edge of corridor
whooping crane	*Grus americana*	Endangered[1]	Agricultural fields, marsh/pond areas.	Low - stopover during migration, very edge of corridor
least tern	*Sterna antillarum*	Endangered[1]	Sand bars along rivers.	Low - stopover during migration, very edge of corridor
Mammals				
black-footed ferret	*Mustela nigripes*	Experimental[2] Population, Non-Essential; A species listed as experimental and non-essential	Prairie habitat associated with prairie dog colonies	None – not associated with water
Canada lynx	*Lynx canadensis*	Threatened[1]	Mature forest in areas where snow cover is abundant	Low – not commonly associated with water; does have critical habitat in river basin

Table 6-5. Federally threatened and endangered species with potential to occur in the Wind – Bighorn River Basin

Common Name	Scientific Name	USFWS Status	Habitat Requirements	Potential Water Use in River Basin
grizzly bear	*Ursus arctos horribilis*	Threatened[1]	Habitat generalist, but commonly associated with forested areas around the greater Yellowstone area	Moderate – may forage in rivers systems
North American wolverine	*Gulo gulo luscus*	Threatened[1]	Mature forest	Low – not associated with water
Fish				
pallid sturgeon	*Scaphirhynchus albus*	Endangered[1]	Mississippi and Missouri Rivers and some tributaries. Requires swift, turbid waters.	None – does not occur in River Basin (downstream)
Plants				
western prairie fringed orchid	*Platanthera praeclara*	Threatened[1]	Associated with tall grass prairies in the plains	None – does not occur in River Basin;
whitebark pine	*Pinus albicaulis*	Candidate[3]	Alpine forests	Low – not associated with water
Ute ladies'-tresses	*Spiranthes diluvialis*	Threatened[1]	Mesic areas near streams or other water sources; wetlands	Moderate – commonly associated with habitats where water is present
desert yellowhead	*Yermo xanthocephalus*	Threatened[1]	Mesic areas in wind-excavated hollows that accumulate drifting snow.	Low – not associated with perennial surface water

Source: USFWS IPaC database (USFWS 2017b)
[1]USFWS 2017c
[2]USFWS 2017d
[5]USFWS 2017e

The IPaC database identified four plant species with the potential to occur in the Basin (desert yellowhead [*Yermo xanthocephalus*], Ute ladies'-tresses orchid [*Spiranthes diluvialis*], western prairie fringed orchid [*Platanthera praeclara*], and whitebark pine [*Pinus albicaulis*]). Of these, the Ute ladies'-tresses is the only species associated with riparian and wetland habitat. This species is believed to have the potential to occur in floodplains at lower elevations in the Basin (USFWS 2016, 2017f), but has never been detected during surveys in the Basin in Wyoming (Fertig et al. 2005; Heidel 2007). The desert yellowhead is a rare species located in Fremont County, Wyoming. Critical habitat for the species is designated in the Basin, but is not associated with any water resources. The whitebark pine is a high elevation species that is not associated with water. The western prairie fringed orchid is associated with water, but is not found in the state. Projects that may alter downstream water sources may need to consider effects to the species.

The pallid sturgeon (*Scaphirhynchus albus*) does not occur in the Basin, but is found downstream. Any project that may alter downstream water conditions may need to consider impacts to the sturgeon during project planning.

The greater Yellowstone grizzly bear (*Ursus arctos* ssp.) population was recently delisted; therefore, no longer receives regulatory protection. However, other non-distinct populations are still listed as threatened and provide protection under the Endangered Species Act. Grizzly bears may use water resources in the Basin for forage opportunities. Impacts to areas identified as suitable grizzly bear habitats should be evaluated for any future water projects or management activities. The wolverine (*Gulo gulo luscus*) is also found in dense boreal forest habitats and not typically associated with water. Projects that affect these communities may need to evaluate impacts to the species as appropriate. The black-footed ferret (*Mustela nigripes*) is not commonly associated with water resources or other mesic conditions. Future projects would only need to consider direct impacts to the species and or habitat as warranted.

Piping plover (*Charadrius melodus*), whooping crane (*Grus americana*), and least tern (*Sternula antillarum*) were identified by the IPaC database as birds that may occur in the Basin. These birds may occur in the Basin during migration to and from nesting grounds to the north along the Central Flyway. WGFD reports suitable whooping crane habitat exists in the Ocean Lake WHMA.

The IPaC report also identified USFWS designated critical habitat for Canada lynx (*Lynx canadensis*) high in the forested regions of the Upper Wind, Clarks Fork Yellowstone, Yellowstone Headwaters, North Fork Shoshone, and Madison sub-basins (Figures 6-4 through 6-6). The Canada lynx is generally found in dense boreal forests, especially where snowshoe hare (*Lepus americanus*) densities are high, but it may also venture into open forests and rocky areas. As a result, the Canada lynx does not rely on water sources for life stages beyond hydration. Any proposed water projects or changes in use in designated critical habitat areas should evaluate how they may reduce the availability of water for the Canada lynx or alter the forest cover.

Additional information on individual species can be found on the USFWS endangered species website (https://www.fws.gov/endangered/). The USFWS has designated potential suitable habitat and species occurrence for each listed species across the state. This information was not plotted on maps for this report, but was included in the environmental model section discussed below. Additionally, designated critical habitats were included in the environmental and protection models discussed in detail below.

6.2.4 USFWS National Wetlands Inventory

Wetlands and riparian areas are important ecologically in that they can improve water quality, store sediment, provide habitat, and maintain stream flows. Wetlands are significant environmental features, specifically related to the state's water management planning. Addressing impacts to waters regulated by the USACE under the Clean Water Act are commonly associated with water management planning across the state and in the Basin.

Additionally, wetlands provide a variety of recreation opportunities including hunting, fishing, and general passive and active recreation activities.

The USFWS National Wetlands Inventory (NWI) is a publicly available dataset that provides detailed information on the abundance, characteristics, and distribution of US wetlands. The NWI categorizes wetlands by type, according to the Cowardin et al. (1979) classification system. The dataset was most recently updated in 2016. Wetland type is important as higher functional value is commonly associated with woody wetlands (e.g., palustrine shrub-scrub or palustrine forested) and projects that impact these wetland types may require a greater level of mitigation.

Nearly 400,000 ac of wetlands (based on NWI mapping) occur across the Basin (Table 6-6, Figures 6-4 through 6-6). The Yellowstone Headwaters sub-basin contains over 40% of the total wetlands and 30% of the total woody wetlands found within the entire Basin. The majority of wetlands in the sub-basin are around Yellowstone Lake in an area designated by WGFD as the Yellowstone KNWA (Figure 6-6). Other important wetland complexes in the Basin occur along the main stem of the Wind River, upstream of Boysen Reservoir (Figure 6-5) and in the headwaters of the Bighorn River, along small order streams in the Bighorn Mountains (Figure 6-4). Many of these riparian areas are mixed wetland classification (palustrine emergent and palustrine shrub-scrub/palustrine forested) with significant braided channel systems, typical of high functioning systems. There are also several environmentally significant lakes and reservoirs within the Basin that provide habitat for fish, birds, and other wildlife, including Yellowstone Lake, Buffalo Bill Reservoir, Boysen Reservoir, and Bighorn Reservoir. Agriculture activities are present in and around the wetland features throughout the Basin's lower elevation river corridors. Agriculture has likely impacted natural wetlands and created new wetlands through irrigation practices and water management to support crop and forage grass growth.

In general, the Basin is an arid landscape, with less than 3% of the habitat designated as potential wetlands and waterbodies. Wetlands across the Basin are typical of Montane and Arid West communities, where high elevation regions contain numerous small streams and lakes and lower elevation basins contain larger rivers surrounded by mesic habitats.

NWI data were included in the environmental and protection models discussed in detail below. Wetlands were prioritized based on the functional value they provide and level of regulatory concern and mitigation that may result from impacts.

Table 6-6. National Wetland Inventory acreage in the Wind – Bighorn River Basin by sub-basin.

Sub-basin	Palustrine Emergent	Palustrine Shrub-scrub	Palustrine Forested	Pond	Lake	Riverine	Other	Total
Badwater	1,754	361	6	128	841	908	289	**4,286**
Big Horn Lake	5,540	1,257	215	474	6,417	1,423	101	**15,428**
Clarks Fork Yellowstone	3,635	800	75	790	2,950	1,958	94	**10,301**
Dry	667	109	1	128	465	356	112	**1,838**
Gallatin	1,193	144	135	35	35	2	3	**1,548**
Greybull	5,560	2,689	94	381	2,190	2,900	113	**13,927**
Little Wind	8,113	3,727	515	596	4,695	1,470	176	**19,292**
Lower Wind	10,912	1,446	54	507	26,112	1,148	722	**40,901**
Madison	13,790	340	4,930	477	630	515	1,266	**21,948**
Muskrat	1,005	13	0	192	245	972	251	**2,676**
North Fork Shoshone	985	154	222	45	3,668	1,449	11	**6,534**
Nowood	5,460	1,052	213	743	1,618	663	168	**9,917**
Popo Agie	6,779	2,478	257	500	2,998	489	81	**13,583**
Shoshone	7,300	1,861	719	657	1,583	2,213	220	**14,554**
South Fork Shoshone	860	272	122	121	3,316	1,826	41	**6,557**
Upper Bighorn	4,802	2,755	319	1,007	224	3,534	573	**13,215**
Upper Wind	13,095	4,822	1,459	1,621	11,566	7,459	305	**40,326**
Upper Yellowstone	2	0	<1	0	<1	0	0	**3**
Yellowstone Headwaters	49,094	4,618	9,528	1,439	87,435	5,448	1,742	**159,304**
Total	**140,545**	**28,897**	**18,861**	**9,842**	**156,989**	**34,734**	**6,268**	**396,137**

6.2.5 BLM Areas of Critical Environmental Concern

The BLM has identified sections of land in Wyoming as Areas of Critical Environmental Concern (ACEC). The ACEC are areas within the public land where special management attention is required to protect and prevent irreparable damage to important historical, cultural, or scenic values, fish and wildlife resources, or other natural systems or processes, or to protect human life and safety from natural hazards.

Eight ACEC (15 polygons) exist throughout the Basin and total 166,290 acres (Figures 6-4 through 6-6). The ACES are scattered throughout the Basin with most polygons located along the base of the Bighorn and Shoshone National Forests (NFs). In general, the ACEC do not support significant water resources. These areas do provide public access for recreational opportunities and in some cases have been sited to support wildlife migration routes and rare plant species.

Three ACEC in the Basin were specifically identified as providing support to water resources. The Lander Slope ACEC is located along the base eastern slope of the Wind River Range and is identified as maintaining and supporting water quality within the Middle Fork Popo Agie River watershed; the Upper Owl Creek ACEC supports fisheries along the southeast Shoshone NF border; and the Spanish Point Karst ACEC is located along the western slope of the Bighorn Range and supports stream segments and water quality along Trapper Creek, Dry Medicine Lodge Creek, and Medicine Lodge Creek.

7 RECREATION

There are many water-based recreation destinations throughout the Basin that are located on public land, including over 3,000,000 ac of NFs, over 4,200,000 ac of BLM land, and over 170,000 ac of state-managed land (Figures 5-1 through 5-3). The State Trust Land owns over 600,000 ac (one section in each township) of land in the Basin, but these lands are not typically used for water-based recreation.

Recreation use in the Basin includes fishing, boating, whitewater rafting, waterfowl hunting, boating, camping, hiking, general sightseeing (such as bird watching), and a variety of other passive recreation activities. Recreation activities associated with water use are fairly concentrated and often occur on land specifically identified for public access, such as USFS land, state parks, and national parks. Further discussion on recreation water use is provided below. The Wyoming Office of Tourism published the 2016 Visitor Profile for Wyoming which showed an increase in nearly all tourism categories in Wyoming (Insights Strategic Marketing and Research 2017). The top activities that motivate tourism included: scenic drive (69%), visiting state or national parks (66%), and wildlife watching (52%), with other water-based destination including hiking/backpacking (34%), visiting hot springs (22%), camping (21%), bird watching (12%), and fishing (12%).

Many of the environmental areas discussed above also provide recreation opportunities. For example, crucial stream corridors and instream flow filing areas provide opportunities for fishing and whitewater rafting, while YNP is managed for both recreational and environmental uses.

7.1 National Parks

The only national park in the Basin is YNP (Figure 5-3), which was established in 1872, making it the first national park to be established in the US. The park covers 1,622,483 acres of lakes, canyons, rivers and mountains in northwestern Wyoming. YNP has numerous recreational opportunities, and there were a record 4,257,177 million visits reported in 2016 (Warthin 2017). Visitation rates are highest during the summer months, but the park is also open to winter use from Christmas through early March. Water-based recreation activities are common in YNP, including fishing in the park's many rivers, streams, and lakes. Boating and kayaking opportunities are also popular on Yellowstone and Lewis Lakes. The park is known for its many geothermal features, especially Old Faithful Geyser, and its wildlife, including grizzly bears, wolves (*Canis lupus*), free-ranging herds of bison (*Bison bison*), elk (*Cervus canadensis*), moose (*Alces alces*) and a variety of other species. YNP is home to 67 species of mammals, nearly 300 species of birds, 16 species of fish, five species of amphibians, and six species of reptiles (NPS 2017b). Additionally, there are roughly 1,386 native plant taxa in YNP that represent vegetation communities typical of the Rocky Mountains, the Great Plains, and the Intermountain region to the west (NPS 2017b).

7.2 US National Forests

The Shoshone NF, Bridger-Teton NF, and the Bighorn NF cover large swaths of the headwaters in the Basin. The Shoshone NF spans most of the alpine and sub-alpine areas in the western portion of the Basin, including parts of the Yellowstone Headwaters, Upper Wind, Upper Bighorn, Greybull, South Fork Shoshone, North Fork Shoshone, Popo Agie, and Clarks Fork Yellowstone sub-basins, while the Bridger-Teton NF covers a small area below the southern Yellowstone NP limits. The Bighorn NF covers most of the alpine and sub-alpine areas in the eastern portion of the Basin, including parts of the Big Horn Lake and Nowood sub-basins. NFs are managed by the USFS for multiple uses, including recreation, water, timber, minerals, fish, wildlife, wilderness, and aesthetic values. As discussed previously, large sections of both NFs are designated as WAs that protect the area in perpetuity for both E&R uses. Water-based recreational activities in both USFS include fishing, boating, rafting, camping, wildlife viewing, skiing, and other activities that are discussed in the following sections.

7.3 Reservoirs and State Parks

Large reservoirs provide the public with water-based recreation activities in the form of boating, fishing, swimming, rafting, jet skiing, wake boarding/waterskiing/tubing, camping, and other passive and active recreation opportunities. Large natural (and managed) lakes provide similar recreation opportunities; however, these features were discussed above. The two largest reservoirs in the Basin (Boysen and Buffalo Bill) are discussed in more detail below. These reservoirs have also been designated state parks. A large number of smaller state park designated areas also exist around the Basin, but are not associated with water use.

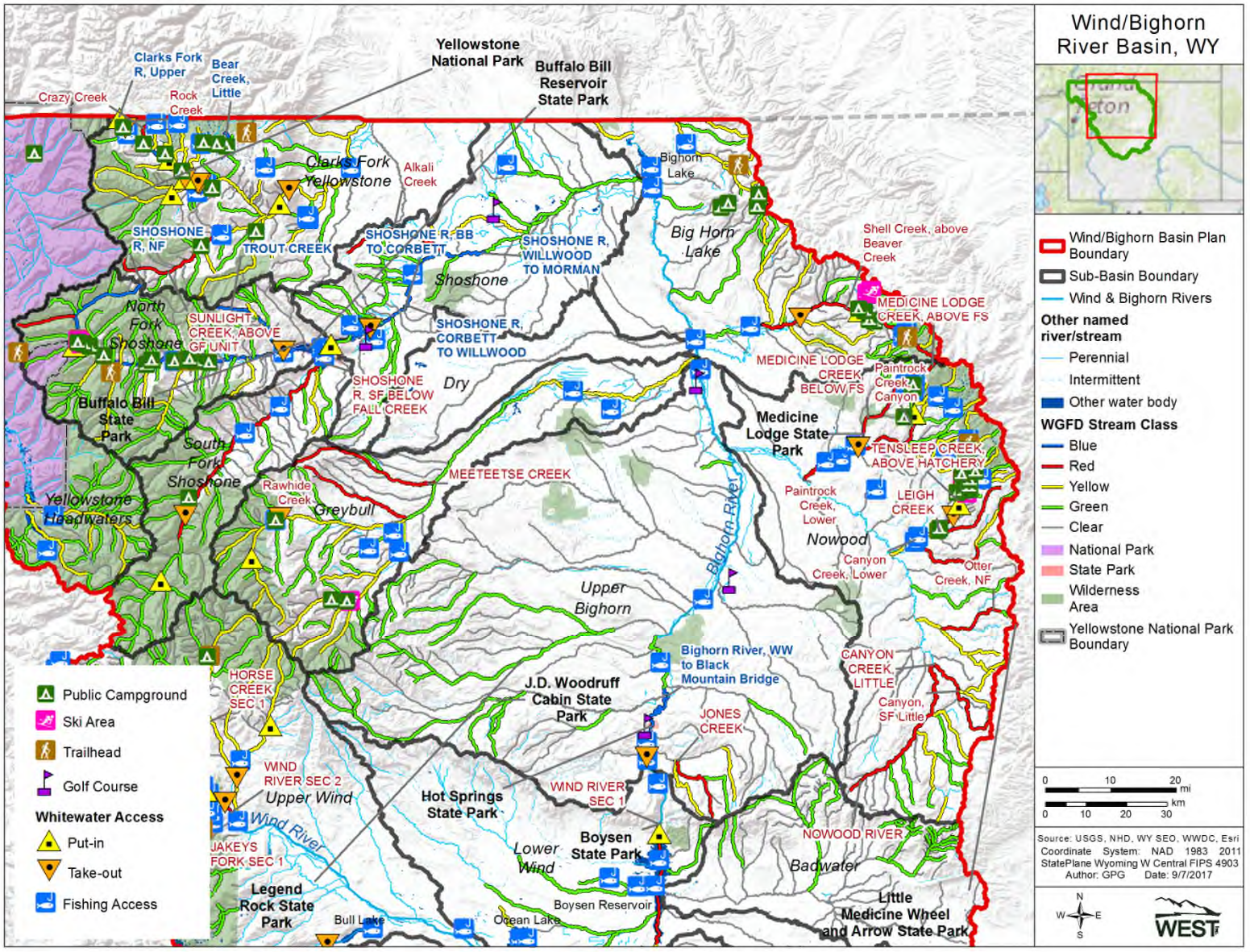


Figure 7-1. Recreational water uses in the Wind – Bighorn River Basin (North Section).

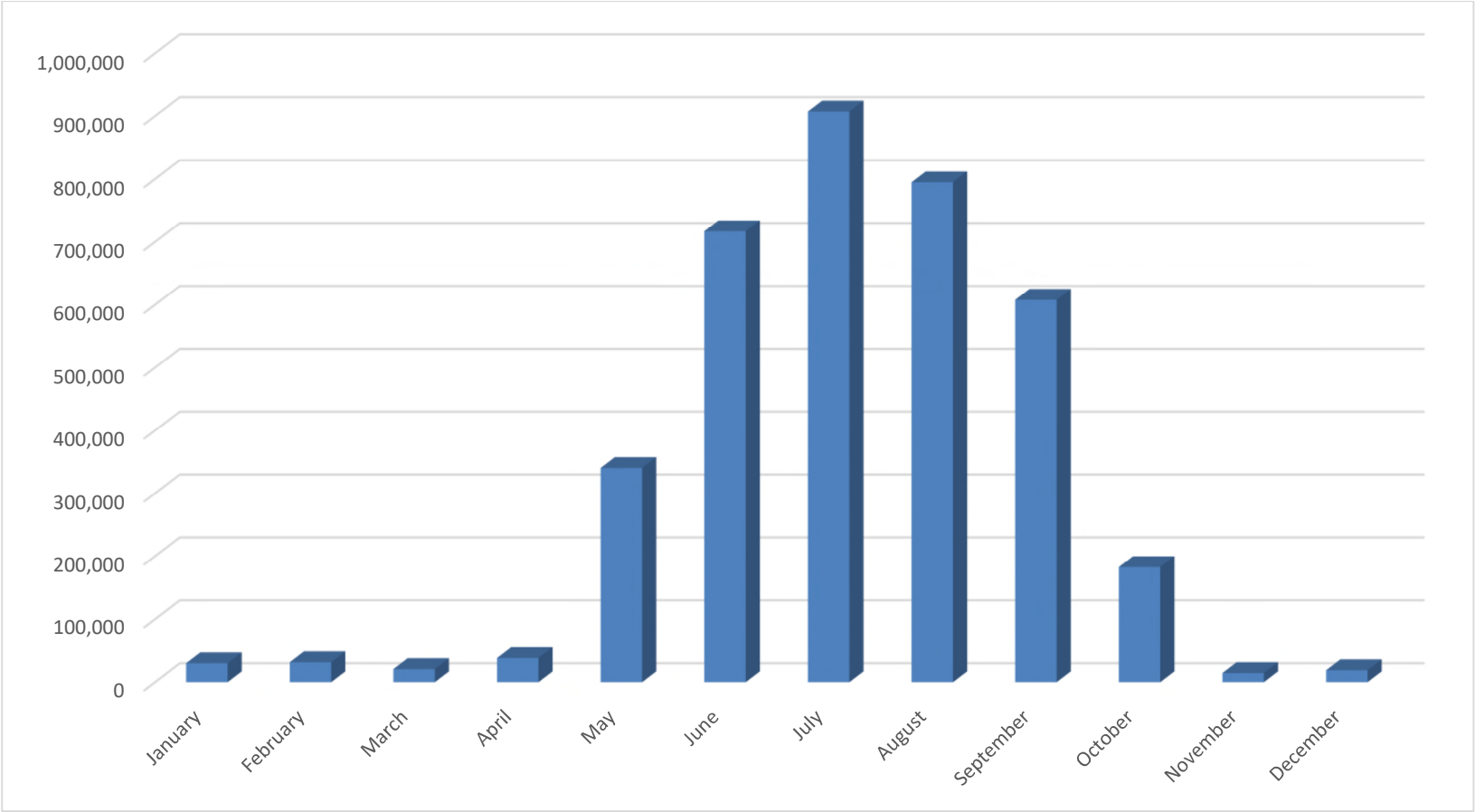


Figure 7-2. Average Monthly Visits to Yellowstone National Park (2012-2016).
Source: National Park Service 2017a

There are approximately 40 major reservoirs and lakes in the Basin (Figure 7-1, 7-3, and 7-4). Of these, 12 are recognized as major recreation sites in Wyoming and include: Bighorn Lake, Boysen Reservoir, Bull Lake, Lake Cameahwait, Deaver Reservoir, Greybull Valley Reservoir, Newton Reservoir, Pilot Butte Reservoir, Ocean Lake, Ten Sleep Reservoir, and Yellowstone Lake (BOR 2009, WSPHT 2009). These lakes and reservoirs are managed by various agencies and offer a variety of recreational activities ranging from waterfowl and pheasant hunting, wildlife watching, fishing, hiking, boating, and camping. As reported in the previous update, boating comprises approximately 4.4% of tourist activities in the state of Wyoming (Wyoming Business Council 2009). These activities are a major reason tourists travel to Wyoming, with many coming to the area solely to recreational fish and explore the scenery offered by the extensive riverine resources.

7.3.1 Boysen Reservoir and State Park

Boysen Reservoir was created by the construction of Boysen Dam, an earth-fill dam on the Wind River in central Wyoming, which was completed in 1952. It is near the town of Shoshone in Fremont County. Surrounding the reservoir is Boysen State Park, run by the state of Wyoming. It includes 11 campgrounds spread around the reservoir and nearby area. The reservoir is a popular sporting area with numerous species of fish including walleye (*Sander vitreus*), perch (*Perca* spp.), crappie (*Pomoxis* spp.), channel catfish, as well as rainbow and brown trout and several other species. Ice fishing is also popular during the winter months when other recreation activities are unavailable. Boysen Marina sits near the shore on the northeast side of the reservoir and has a bait shop and cafe and offers boat and jet ski rentals.

On average, greater than 100,000 visitors trek to Boysen Reservoir each year. Visitation at the reservoir has increased over last five years with visitation data from 2014 and 2015 greater than the 5-year average (Table 7-1). The BOR has reported the follow water elevations as required to launch a boat:

- Brannon Ramp: 4,703 feet
- Cottonwood Ramp: 4,711 feet
- Fremont Bay Ramp: 4,713 feet
- Lakeside Ramp: 4,719 feet
- Tough Creek Ramp: 4,711 feet

Table 7-1. State park visitation rates in the Wind – Bighorn River Basin.

Park	Five-year Average	2014 Visitation	2015 Visitation
Hot Springs State Park	1,530,173	1,821,006	2,022,365
Sinks Canyon State Park	188,227	212,019	251,340
Boysen State Park	100,247	114,904	114,314
Buffalo Bill State Park	60,010	64,728	79,831
Buffalo Bill Dam Visitor Center	75,997	77,228	77,539

Source: Wyoming Division of State Parks 2015

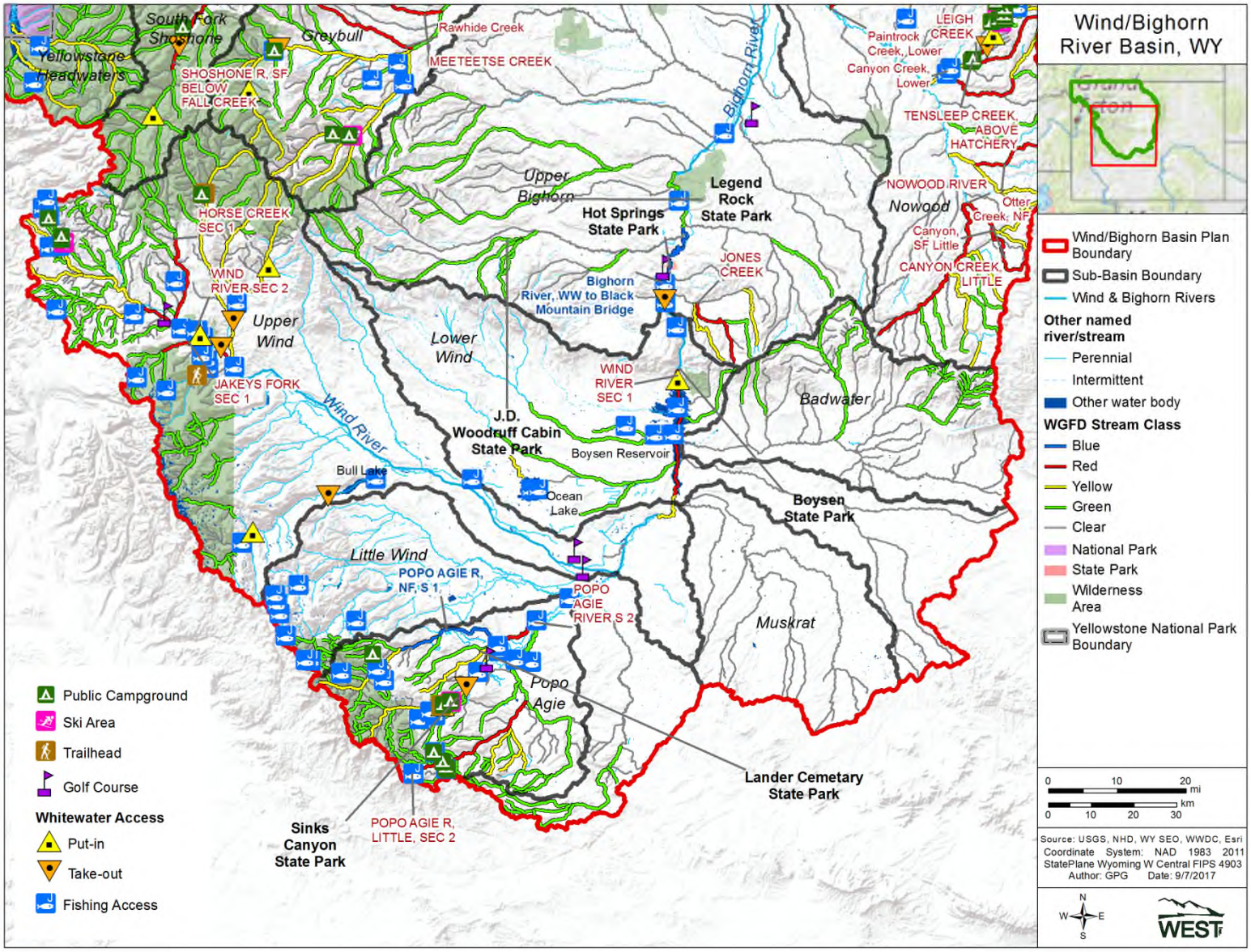


Figure 7-3. Recreational Water Uses in the Wind – Bighorn River Basin – South Section.

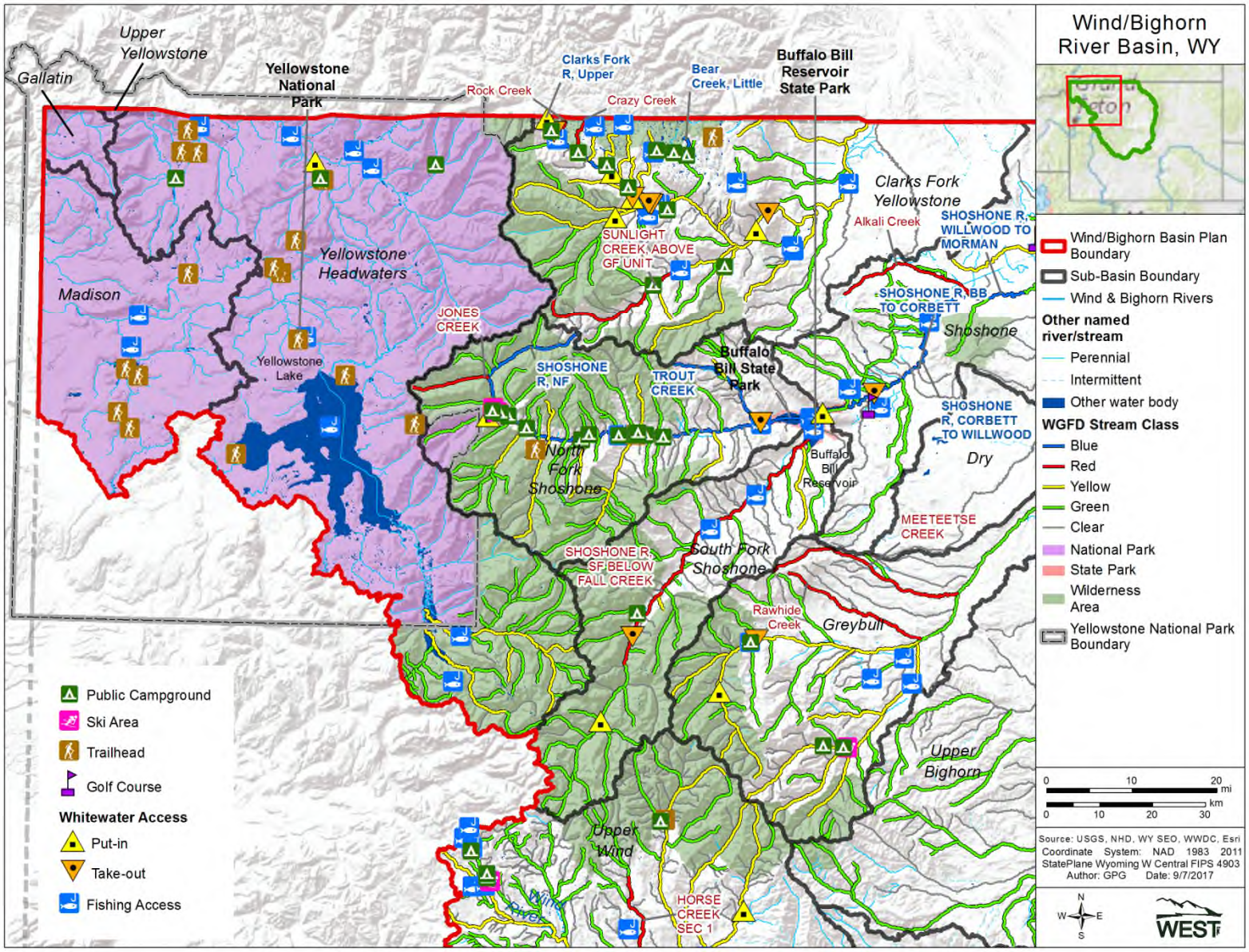


Figure 7-4. Recreational water uses in the Wind – Bighorn River Basin – West Section.

If the water at Boysen drops below these elevations, recreation uses may be inhibited. Additionally, early-season runoff often floods major campground sites, making recreation activities less common. Similarly, late-season drawdowns can make accessing the reservoir more difficult and hazardous for boating on the water.

7.3.2 Big Horn Lake and Bighorn Canyon National Recreation Area

Bighorn Lake was created by the construction of Yellowtail Dam in 1965 on the Bighorn River. While the dam is in southern Montana, the reservoir is located in northern Wyoming and Southern Montana. The Bighorn Canyon National Recreation Area (NRA) encompasses the reservoir in both Wyoming and Montana. The Bighorn Canyon NRA is administered by the NPS, while the reservoir is managed by the BOR. The Bighorn Canyon NRA and Bighorn Lake have had nearly 250,000 visitors each year on average for the past five years (NPS 2017a). Recreation opportunities include biking, boating, camping, fishing, hiking, horseback riding, wildlife viewing, and other activities. The lake supports fisheries including walleye, sauger, brown and rainbow trout, yellow perch (*Perca flavescens*), carp (*Cyprinidae* spp.), catfish *Siluriformes* spp.), ling (*Molva molva*.), and crappie. A presentation by WGFD (2007) reported the following specifications to support fisheries within Big Horn Lake:

- Elevations below 3,620 feet eliminates fisheries
- Maximum elevation of 3,630 feet may provide access and fishing for turbid tolerant species
- Maximum elevation of 3,640 feet would support deep water fish
- Best management practices – elevation above 3,630 feet and never below 3,020 feet; greater than 3,630 feet by May 15; 3,640 feet or higher by mid-summer; draw down to 3635 feet by September 1

Bighorn Lake has a maximum conservation pool elevation of 3,640 feet above sea level, and at 100% of conservation storage there are 17,300 ac of water surface in the reservoir that is open for fishing and boating. Additionally, the BOR has reported the following water elevations as required to launch a boat:

- Barry's Landing Ramp: 3,580 feet
- OK-A-BEH Ramp: 3,580 feet
- Horseshoe Bend Ramp: 3,617 feet

If the water at Big Horn Lake drops below these elevations, recreation uses may be inhibited. Additionally, early-season runoff often floods campground and lake access sites, making recreation activities less common. Similarly, late-season drawdowns can make accessing the reservoir more difficult and hazardous for boat on the water

7.3.3 Buffalo Bill Reservoir and State Park

Buffalo Bill Reservoir was created by the construction of Buffalo Bill Dam, a concrete arch-gravity dam on the Shoshone River, which was completed in 1910, in 1971 the dam was listed on the National Register of Historic Places, and in 1973 it was named a National Civil

Engineering Landmark. The dam is located five miles west of Cody, Wyoming in Park County, and Buffalo Bill State Park surrounds the reservoir. Recreational opportunities at the park include hiking, camping, boating, fishing, and hunting among other things. There are 99 established campsites in the park; 37 sites in the North Shore Bay campground, and 62 sites in the North Fork campground. There are also day use areas and several miles of trails in the park. There are 8,000 ac of water in the reservoir that are open for fishing and boating, and there are additional blue-ribbon quality streams above and below the reservoir.

The state park includes the reservoir and dam visitor center. Each of these facilities receives over 50,000 people per year. Visitation at the reservoir and dam visitor center has increased over last five years with visitation data from 2014 and 2015 greater than the five-year average (Table 7-1). Additionally, the BOR has reported the follow water elevations as required to launch a boat:

- Bartlett Lane Area: 5,351 feet
- North Shore Bay Area: 5,351 feet

If the water at Buffalo Bill Reservoir drops below these elevations, recreation uses may be inhibited. Additionally, early-season runoff often floods major campground sites, making recreation activities less common. Similarly, late-season drawdowns can make accessing the reservoir more difficult and hazardous for boat on the water.

7.3.4 Hot Springs State Park

Hot Springs State Park in Thermopolis, Wyoming became Wyoming's first state park in 1897, and it is best known for its hot springs, which flow at a constant temperature of 135 degrees Fahrenheit. The park offers free bathing at the State Bath House, where temperatures are moderated to a therapeutic 104 degrees Fahrenheit. The park features a managed herd of bison, a suspension foot bridge across the Big Horn River, picnic shelters, boat docks, flower gardens, and terraces made of naturally forming travertine (calcium carbonate) caused by a flowing mineral hot spring. The park encompasses commercial hotels and several state-run and privately operated entities.

The state park is the most visited state park in Wyoming, with over 1,500,000 visitors over the last five years. Visitation at the reservoir has steadily increased over last five years with visitation data from 2014 and 2015 greater than the five-year average (Table 7-1). Visitation rates in 2015 topped 2,000,000 people.

7.3.5 Sinks Canyon State Park

Sinks Canyon State Park is located just south of Lander, Wyoming on the middle fork of the Popo Agie River in the Wind River Mountains. The park was named for a geologic phenomenon where the river disappears into a limestone cavern and reappears a quarter-mile further down the canyon in a large pool. The canyon has a variety of recreational opportunities including nature studies, photography, camping, fishing, hiking, rock climbing, and mountain biking. This area is a gateway into the larger Wind River Range.

On average, the state park receives nearly 200,000 visitors each year. Visitation at the reservoir has steadily increased over last five years with visitation data from 2014 and 2015 greater than the five-year average (Table 7-1). Visitation rates in 2015 topped 250,000 people.

7.4 Fishing

Fishing is a major water-based recreation activity in the Basin, and in 2011, over 300,000 anglers took 2,900,000 fishing trips in Wyoming over 3,100,000 fishing days (USFWS 2011). According to the 2015 overnight visitor use census for Wyoming, fishing was the primary motivation for 7% of all trips to Wyoming, and 16% of tourists participated in fishing during their stay (Strategic Marketing and Research 2016). A slight decrease was reported in 2017, as only 12% of tourists participated in fishing activities in 2016. However, by 2030, fishing in Wyoming is projected to grow as follows:

2030 Low Growth Scenario

- Residential approximately 322,000 angler-days
- Non-residential approximately 166,000 angler-days

2030 Moderate Growth Scenario

- Residential approximately 354,000 angler-days
- Non-residential approximately 223,000 angler-days

2030 High Growth Scenario

- Residential approximately 423,000 angler-days
- Non-residential approximately 299,000 angler-days

WGFD has identified over 60 publicly accessible fishing locations in the Basin along rivers, streams, lakes, reservoirs and other waterbodies (Figure 7-1, 7-3, and 7-4). Many of these fishing spots are readily accessible via public lands, or through the WGFD Walk-in Fishing Area program that secures seasonal access to private land or inaccessible public lands that is restricted to foot traffic only. There are 16 Walk-in Fishing Area locations in the Basin that occur along Bitter Creek, Shoshone River, Ladder Creek, Paint Rock Creek, Nowood River, and Bighorn River. The remaining fishing spots are accessible through public land.

WGFD has a system for classifying stream fisheries (WGFD 2006) that ranks Wyoming streams and rivers according to the number of pounds of trout per mile measured in each segment (Table 7-2). Blue ribbon streams are classified as having over 600 pounds of trout per linear stream mile, and red ribbon streams are classified as having between 300 pounds and 600 pounds of trout per linear stream mile. Blue ribbon and red ribbon streams are recognized as “special resources” under the Wyoming Stream Mitigation Procedure, which was promulgated by USACE (2013).

Table 7-2. Wyoming Game and Fish Department stream fisheries classifications.

Category	Percent of Stream Miles	Pounds of Sport Fish Per Mile
Blue Ribbon	3	≥600
Red Ribbon	6	≥300 and <600
Yellow Ribbon	28	≥50 and <300
Green Ribbon	63	≥1 and <50
Orange Ribbon	Unknown	Any cool/warm water game fish present

Blue ribbon fisheries are designated along the North Fork of the Shoshone River, Trout Creek, Clark's Fork River, Bear Creek, Bighorn River just beyond the Wind River Canyon, and the North Fork of the Popo Agie River (Figure 7-1, 7-3, and 7-4, Table 7-3). Multiple red ribbon streams occur throughout the Basin including segments of the South Fork of the Shoshone, tributaries to the Greybull River and Bighorn, headwaters of the Nowood, and other scattered stream segments in the Shoshone and Bighorn NF. Green and yellow ribbon fisheries occur throughout the Basin, mostly in NF areas. The main stem of the Bighorn River is classified as an orange ribbon fishery. All of the large reservoirs discussed above provide opportunity for sport fishing.

Table 7-3. Blue ribbon stream segments within the Wind Bighorn Basin.

Stream Reach	Sub-basin	Length (miles)
Bighorn River, Wedding of the Waters to Black Mountain	Lower Wind	18
Shoshone River, Willwood to Morman	Shoshone	16
Shoshone River, Corbett to Willwood	Shoshone	8
Shoshone River, Buffalo Bill Reservoir to Corbett	Shoshone	16
Shoshone River, National Forest	North Fork	65
Trout Creek	North Fork	16
Clarks Fork River, Upper	Clarks Fork	20
Bear Creek, Little	Clarks Fork	8
Popo Agie River, North Fork	Popo Agie	21
TOTAL		**188**

Updated angler data from the past 10 years was not available to support this report. A 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation report was reviewed; however, based on the limited sample size (approximately 300 people surveyed) and presented standard error this report was not deemed appropriate for the use in this report. Additional efforts were also made to obtain fishing licenses purchase information and associate these data with fishing practices. These data were ultimately determined to be incomplete and potentially biased. The most up to date fishing data can be found in the 2010 updates.

7.5 Waterfowl Hunting

Waterfowl hunting is a major recreation activity in the Basin that mostly occurs at lower elevations in the watershed along the Bighorn and Shoshone Rivers in Bighorn and Washakie counties. The Basin occurs in the Central flyway on the eastern side of the Continental Divide, and provides several areas for hunting ducks and geese although coot (*Fulica* spp.), snipe (*Gallinago* spp.), rail (*Rallidae* spp.), and sandhill crane (*Antigone canadensis)* are also hunted. Between 2011 and 2015, waterfowl hunting in the Basin accounted for approximately one third of the state-wide duck harvest (Table 7-4) and approximately one quarter of goose harvest

(Table 7-5). Maintenance and improvement of existing wetlands and riparian areas, and establishment of new areas will help maintain and improve habitat for waterfowl. By 2030, waterfowl hunting in Wyoming is projected to grow as follows:

2030 Low Scenario

- Duck hunting approximately 18,050 hunting-days
- Goose hunting approximately 10,420 hunting-days

2030 Moderate Scenario

- Duck hunting approximately 39,010 hunting-days
- Goose hunting approximately 22,510 hunting-days

2030 High Scenario

- Duck hunting approximately 50,090 hunting-days
- Goose hunting approximately 28,910 hunting-days

Table 7-4. Duck hunter and harvest data for the Wind – Bighorn River Basin from 2011-2015.

Management Area	Statistic	Five-year Average (2011-15)	2011	2012	2013	2014	2015	WGDF Objective*
Bighorn River	# of Hunters	1,138	1,145	1,104	1,174	1,220	1,048	2,200
	# of Recreation Days	6,602	6,720	6,971	6,661	7,620	5,039	12,000
	Harvest	11,466	9,785	13,819	13,202	11,726	8,797	20,000
Yellowstone River	# of Hunters	13	8	5	no data	no data	26	100
	# of Recreation Days	25	8	28	no data	no data	39	400
	Harvest	40	8	32	no data	no data	80	500

	Total 2011-15	2011	2012	2013	2014	2015
Total Basin Harvest	79,861	16,237	16,509	17,164	16,085	13,866
Total Statewide Harvest	228,116	47,387	50,233	53,296	30,456	46,744
% of Statewide Harvest in Basin	35.0%	34.3%	32.9%	32.2%	52.8%	29.7%

Source: Wyoming Game and Fish Department (WGFD) 2017b
Objectives source: Huck 2015

Table 7-5. Goose hunter and harvest data for the Wind – Bighorn River Basin from 2011-2015.

Management Area	Statistic	Five-year Average (2011-15)	2011	2012	2013	2014	2015	WGDF Objective*
	# of Hunters	735	638	409	880	1,033	717	1,200
	# of Recreation Days	4,158	3,580	2,962	4,822	6,230	3,196	5,600
Bighorn River	Harvest	5,274	3,012	4,883	7,354	6,686	4,433	1,200
	# of Hunters	10	8	no data	no data	6	16	no data
	# of Recreation Days	16	8	no data	no data	9	30	no data
Yellowstone River	Harvest	18	8	no data	no data	24	22	no data

	Total 2011-15	2011	2012	2013	2014	2015
Total Basin Harvest	34,471	4,744	5,865	8,773	8,508	6,581
Total Statewide Harvest	134,555	21,732	31,993	30,861	29,147	20,822
% of Statewide Harvest in Basin	25.6%	21.8%	18.3%	28.4%	29.2%	31.6%

Source: Wyoming Game and Fish Department (WGFD) 2017b
*Objectives are only for Canada Goose, source: Huck 2015

WGFD has divided the Basin into three waterfowl management areas: Bighorn River, Yellowstone River, and Wind River. Most of the duck and waterfowl hunting occurs in the Bighorn River and Wind River management areas, with little to no waterfowl hunting occurring in the Yellowstone River management area (Tables 7-4 and 7-5). In the Bighorn River management area, between 2011 and 2015, there were an average of 1,138 duck hunters harvesting 11,466 ducks over 6,602 hunting days, and an average of 735 goose hunters harvesting 5,274 geese over 4,158 hunting days. In the Wind River management area during the same time period there were an average of 534 duck hunters harvesting 4,482 ducks over 2,602 hunting days, and an average of 336 goose hunters harvesting 1,610 geese over 1,465 hunting days. By comparison, there were less than 20 hunters each year, duck and goose, in the Yellowstone River management area, except for 2015 when there were 26 duck hunters hunting in the management area.

7.6 Whitewater Rafting and Kayaking

Whitewater rafting is a major recreation activity in the Basin, and there are 19 established river rafting stream segments between designated “put-in” and “take-out” locations (Figure 7-1, 7-3, and 7-4) that cover approximately 200 river miles in the Basin (Table 7-6). The majority of rafting segments are high up in their respective watersheds in the Shoshone NF and Bighorn NF, with a two notable exceptions: the Shoshone River below Buffalo Bill Dam to Wyoming Highway 120, and the Wind River below Boysen Dam to the canyon mouth 12 miles downstream. As a general rule, the quality of river rapids tends to increase with flow, and beyond a lower limit, some rapids are unpassable in pontoon boats.

Table 7-6. River rafting stream segment locations, difficulty, flow ranges, and length in the Wind – Bighorn River Basin.

Stream Segment	Stream Class	Recommended Flow Range (as reported)	Length (miles)
Bull Lake Creek North Fork to Bull Lake	IV – V+	NA	12
Middle Popo Agie Highway 181 bridge to Sinks Cavern	IV – V	200 – 1,000 cfs	6
Shell Creek Cabin Creek to Forest Service boundary	II – V	200 – 1,000 cfs	11
Tensleep Creek Highway 16 to Bottom of Switchbacks	V+	250 – 1,000 cfs	2
Clarks Fork Yellowstone Upper	III – V	NA	4
Clarks Fork Yellowstone Honeymoon	IV – V+	NA	3
Clarks Fork Yellowstone The Box	V+	500 – 1,200 cfs	23
Clarks Fork Yellowstone Lower	III – V	0.90 – 6 ft (depth)	3
Crandall Creek (Trailhead to Clarks Fork Yellowstone River	III – V	750 – 5,000 cfs	4
Greybull Venus Creek to Forest Service Boundary	I – III	NA	6
Shoshone Buffalo Bill Dam to Highway 120 bridge	II – V	NA	8
Shoshone, North Fork Pahaska Tepee to Buffalo Bill Reservoir	I – III	300 – 7,000 cfs	40
Shoshone, South Fork East Fork Creek to Trailhead	II – IV	300 – 5,000 cfs	13
Clarks Fork Yellowstone Styx and Stones	V+	1.50 – 5.50 ft (depth)	5
Paintrock Creek North Fork to the Valley Floor	V+	NA	12
Wind three miles to seven miles below Dubois (Fish Canyon)	II – III	NA	3
Wind Boysen Dam to canyon mouth (Wind River Canyon	I – III	NA	12
Wind, East Fork Wilderness boundary to Wiggins	I	NA	11
Yellowstone Tower Jct. to Gardiner, MT (Black Canyon)	III – V	350 – 25,000 cfs	20
TOTAL			**197**

NA=not available

Whitewater rapids in the Basin range from beginner (Class I) to expert (Class V+) based on the International Scale of River Difficulty (American Whitewater 2009). This classification system is discussed in detail in previous Basin plans (WWDC 2010). Rapid classifications and recommended flows for whitewater segments located in the Basin vary considerably (Table 7-6 [MWH Americas et al. 2010]).

7.7 Golf Courses

There are nine golf courses in the Basin, and at least three of them are not included in municipal water use estimates (Table 7-7). The golf courses in Powell, Cody, and Worland are supported by existing municipal water rights and therefore already captured in the Basin plan. Courses in Thermopolis, Dubois, and Lander obtain water through diversions associated with nearby rivers and ditches. Information on the course in Basin and the two courses in Riverton were unable to be obtained for this report.

Table 7-7. Golf courses in the Wind – Bighorn River Basin.

Golf Course	Address	Water Supply
Powell Country Club	600 Hwy 114, Powell WY 82435	Municipal
Olive Glenn Golf & Country Club	802 Meadow Ln, Cody WY 82414	Municipal
Midway Golf Club	4053 Golf Course Rd, Basin WY 82410	unknown
Green Hills Municipal Golf Course	1455 Airport Rd, Worland WY 82401	Municipal
Legion Town & Country Club	141 Airport Rd, Thermopolis WY 82443	Wind River
Antelope Hills Golf Course	126 N Clubhouse Dr, Dubois WY 82513	Green Ditch
Renegade Golf Course	12814 Hwy 26 W, Riverton WY 82501	unknown
Riverton Country Club	4275 Country Club Dr, Riverton WY 82501	unknown
Lander Golf & Country Club	1 Golf Course Dr, Lander WY 82520	City-owned ditch right

7.8 Ski Resorts

There are currently two commercial ski resorts in the Basin: Bighorn Mountain Resort and Sleeping Giant. Bighorn Mountain Resort is located above Ten Sleep along Highway 16 in the Bighorn NF. Sleeping Giant is located west of Cody along Highway 14 in the Shoshone NF. Water rights permits were not found for either resort and due to seasonal restrictions, contact could not be made. Both ski mountains make snow depending on the annual climate. A third ski resort, Antelope Butte along Highway 14 between Shell and Dayton may open in the near future.

8 CATEGORIZATION OF USES

All of the potential E&R use identified above were evaluated and categorized as protected, complementary, or competing. These categories were categorized based on the definition provided in the Handbook and additional discussion with the WWDC and Wyoming SEO. A number of factors were considered to categorize the E&R uses including location in the Basin, land use, ownership, and existing permits, among other factors. The location and magnitude of diversions were specifically evaluated to determine the use categories. Categorization of uses included specific individual E&R activities and categorizations were assigned to larger geographic areas where multiple uses may occur along a waterbody.

Additional information is presented in the Model Development – Protection section that can be used to support discussions on these categories. The protection model demonstrates a relative scale of protection based on a number of identified factors.

8.1 Diversion in the Basin

Prior to evaluating and categorizing E&R uses, water diversions within the Basin were identified and plotted to support categorization discussions. Diversion data including the priority date and magnitude were not readily available for this report; therefore, only the available diversion data were plotted (Figure 8-1). Additionally, the amount of diverted water needed to support irrigation practices across the Basin were obtained from the *Wind-Bighorn Basin Plan* (MWH Americas et al. 2010); *Technical Memorandum: 1) Task 4B – Spreadsheet Model and Hydrologic Database* (2010c) and 2) *Task 3A – Agricultural Water Use* (2010a). The location of diversion and volume

of water needed to support irrigation practices provides information to support the categorization discussion below.

Diversions exist in large numbers throughout the Basin with over 700 locations identified that are permitted for at least 10 cubic feet per second. No diversions exist in the northwest Basin covered by YNP. Additionally, a small number of diversions are located along the Bighorn River relative to the size of the river. The Bighorn River tributaries appear to be more commonly diverted. The *Technical Memorandum Task 3A – Agricultural Water Use* (2010a) identifies 117 major diversions across the sub-basin, with the historical diversion records ranging 492 – 368,579 acre-feet. The seven largest diversions are listed in Table 8-1 and specifically identified on Figure 8-1.

Table 8-1. Major diversion in the Wind-Bighorn River Basin.

Sub-basin	Diversion Name	Annual Diversion (acre-feet; historic average)	Diversion Location	
			Latitude	Longitude
Upper Wind	Wyoming Canal	368,579	43°13'32.14"N	108°57'15.42"W
Upper Bighorn	Big Horn Canal	147,505	43°56'08.43"N	108°02'17.11"W
Upper Bighorn	Upper Hanover Canal	151,266	43°51'09.28"N	108°10'48.70"W
Shoshone	Elk Lovell Canal	100,704	44°44'23.39"N	108°35'48.49"W
Shoshone	Garland Canal	267,434	44°35'22.49"N	108°57'15.79"W
Shoshone	Heart Mountain Canal	207,971	44°30'49.68"N	109°07'41.82"W
Shoshone	Willwood Canal	101,975	44°40'19.18"N	108°54'34.45"W

At a sub-basin scale, the Upper Wind and Shoshone require the most diverted water for irrigation practices, with Upper Bighorn and Greybull sub-basins also requiring over 100,000 acre/feet of diverted water to support irrigated lands. This is consistent with the annual historical diversions detailed in the *Technical Memorandum Task 3A – Agricultural Water Use*. Detailed information on the water use and diversions within the Basin can be found in the *Wind-Bighorn River Basin Plan* (2010).

8.2 Categorization of E&R Uses

E&R uses were categorized based on the relationship between current and future water conditions and their ability to significantly alter E&R uses. The categorization process did assume that current conditions support existing E&R uses and that a change in water regimes is unlikely to be significant and wide spread. While individual E&R uses may be impacted or enhanced by individual diversion or other water projects, this exercise did not try to identify every potential situation for each individual body of water and associated use. Instead, a broad-scale approach was taken to categorize E&R uses based on common traits (e.g., all wilderness areas are protected or all reservoirs recreation is competing). The model section of this report (see Section 8.3) can be used to support the categorization of uses, by identifying a sliding-scale of protection and associating it to areas where high levels of E&R uses exist. Ultimately, the model approach may be more useful when evaluating E&R uses relative to potential future project planning and the effect on E&R uses.

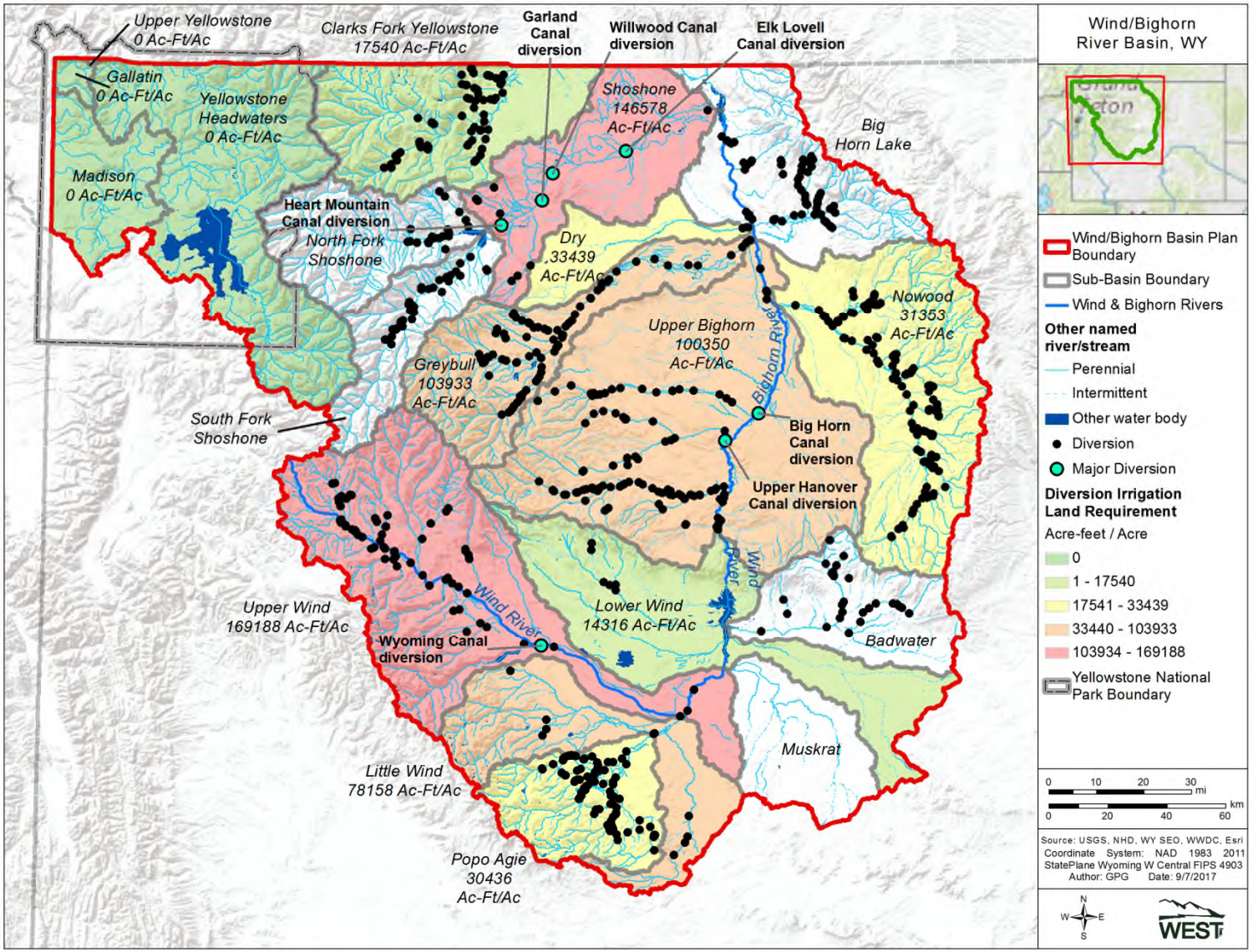


Figure 8-1. Diversion locations and magnitude of irrigation requirements (by sub-basin) in the Wind – Bighorn River Basin - Overview.

A large area of protected E&R uses in the Basin exists in YNP. This area is the most heavily trafficked area in the Basin and state, specifically for the E&R uses provided by the natural resources. Strict regulations and subsequent protections are in place for YNP. Additional protected E&R water uses in the Basin exist along the permitted instream flow segments. The stream stretches and associated E&R uses typically occur high in the watershed and/or on USFS land in the Big Horn Lake, Nowood, North Fork Shoshone, South Fork Shoshone, Shoshone, Greybull, Upper Wind, and Popo Agie sub-basins. These areas provide a high level of recreation use that include fishing, hiking, camping, boating, and other passive recreation opportunities and environmental uses including wetlands/waters, USFWS threatened and endangered species potential habitat, and WGFD priority areas. The presence high in the watershed and on USFS managed lands provides additional protection. Many of the instream flows are also associated with or directly above blue and red ribbon fisheries providing protection for the E&R use. This occurs along the Clarks Fork, Shell Creek, Medicine Lodge Creek, Tensleep Creek, and multiple tributaries to the Greybull River. Additionally, an instream flow filing exists within a section of the Clark's Fork designated as a wild and scenic river. This filing provides additional protection to the river segment. An instream flow filing also occurs immediately below the Buffalo Bill Reservoir. Waterbodies below managed water systems often are impacted by high and low flow conditions. The present of an instream flow ensures this stretch of river will maintain adequate flow to support E&R uses. Additional information on the instream flows are provided above and in previous basin plans. E&R uses are also protected in the WAs present in the Basin. A total of seven WAs existing in the Basin including three in the Shoshone NF, three in the Bridger-Teton NF, and one in the Bighorn NF. These areas protect a variety of E&R uses in the Basin. A full description of the WAs is presented above. E&R uses in the WAs are similar to those discussed for instream flow filings, but due to the remote nature, likely are used less by the public.

Other E&R uses can be considered complementary due to their location in the Basins, but are currently protected. All E&R uses above existing diversions are currently protected, unless future water diversion or management activities are permitted. Waters and E&R uses above the diversion cover a large portion of the Basin, as nearly all of the upper watersheds in the Basin are USFS managed land. These areas contain a significant amount of water and subsequent E&R uses that are currently not impacted. This includes major E&R uses along the headwaters for nearly all of the major river systems in the Basin, including the North and South Forks of the Shoshone, Clark's Fork Yellowstone River, and Wind River.

Competing recreational uses can be categorized around the large recreation reservoirs across the Basin. Due to the reliance of access (e.g., boat ramps, camp sites, etc.) to maintain specific recreation uses, these items are competing. It is not uncommon for heavy early season runoff entering the reservoirs and low-level early season water release to flood the reservoirs, inhibiting recreation opportunities. This results in a competing situation. Similarly, depending on annual climate, late season conditions may draw reservoirs down to a level where recreation becomes difficult. The specific water elevations required to access boat ramps was provided in the recreation section above. Major reservoirs including Big Horn Lake (Yellowtail Reservoir),

Boysen Reservoir, Buffalo Bill Reservoir, among other smaller reservoirs across the Basin fall into the competing categorization.

All other E&R water uses across the Basin are assumed to be complementary. This is based on the assumption that current water conditions will continue in a similar regime to historic water use. A number of large permitted diversions with senior water rights exist throughout the Basin and require water to be maintained in the stream, thereby supporting E&R uses, specifically wetlands, potential USFWS listed species habitats, WGFD priority and crucial areas. Similarly, while small in magnitude, the hundreds of other diversions that exist along the waterways cumulatively support E&R uses throughout the Basin, as water will remain in the system to complement the E&R activities. These small and large diversions due have the ability to effect E&R uses at a localized scale if modifications were to occur.

Six of the golf courses in the Basin receive water through a permitted diversion or municipal source. These six courses can be considered protected. Water rights for the three remaining courses are unknown; therefore these uses cannot be categorized. Similarly, no right was identified for the ski resorts in the Basin; therefore, no category was assigned.

8.3 Model Development

The development of protection and use models was first investigated by the WWDC and implemented in the Snake and Salt River Basin Plan Update (Pavlica 2013). The model development was prompted as a way to reevaluate the methods presented in the Handbook (Harvey Economics 2012). The Handbook outlined a consistent method to identify E&R uses, as detailed above. However, implementation of the method on full basins has identified two key factors that require further and potentially new evaluation methods:

1) The large volume of data demonstrating E&R uses across the individual basins can be overwhelming to the evaluators and readers. Many of the data are focused in localized areas making interpretation and demonstration of uses difficult.

2) The categorization of uses can be complicated by potential future changes in water regimes, as well as separating out the current relationships among E&R uses, land ownership requirements, climate effects, divertible/non-divertible, and water demands/diversions.

These factors are often so intermingled a person may make a reasonable argument to categorize a use under more than one category; this can become a slippery slope that does not answer the key questions or meet the goals and objectives of the basin planning.

To that end, the model approach has been developed and implemented to address the key questions and goals as listed below:

1) Where do the E&R uses exist and at what magnitude are they present across the Basin?

2) What protection is in place for the E&R uses and at what scale are the protections present across the Basin?

3) What E&R uses and locations may be most affected by changes in future water management and planning?

Ultimately, these models will be used in conjunction with the E&R use information presented above and water uses detailed in the individual basin plans. These models will demonstrate the relative scales, but it is still important to recognize the individual E&R uses and how they may affect or be affected by a change in water management.

8.3.1 Protection Model

The protection model was developed to demonstrate the institutional protection provided to stream segments in the basin and subsequent support of E&R uses. This model may be used to identify the level of effort required to obtain a permit or make changes to the surrounding landscape. The results of the model for each sub-basin are displayed in Appendix A.

Two primary factors were considered to inform the protection model: 1) Land ownership and 2) Individual factors. Land ownership is often a driving component related to the inherent protection of waters. Scores for land ownership protection were informed based on the answers to five questions listed below and a general understanding as to the process each landowner/manager undergoes to evaluate projects and manage resources (Table 8-2).

- Is water development allowed?
- Do proposed actions trigger National Environmental Protection Act compliance?
- Is water development a land manager objective?
- Are lands managed for environmental uses?
- Are lands managed for recreational uses?

Table 8-2. Land ownership – management scores and justification used to inform the protection model.

Land Ownership	Score	Justification
State Park	4	Protected: State application process.
National Forest Service	5	Protected: Each national forest has its own land and resource management plan with defined goals and objectives; National Environmental Policy Act (NEPA) required.
National Park Service	5	Protected: All parks "tier" to the system plan; however, there are individual Park Management Plans that have specific goals and objectives for each park; NEPA required.
Bureau of Land Management	4	Each field office has its own Resource Management Plan that identifies goals and objectives for a specific management unit; NEPA required.
Bureau of Indian Affairs	3	Bureau of Indian Affairs has its own environmental management system and review process (Environmental Management Assessment and Performance Program), but they also must comply with NEPA by showing alternatives and impacts were considered in water development projects.

Table 8-2. Land ownership – management scores and justification used to inform the protection model.

Land Ownership	Score	Justification
Bureau of Reclamation	3	Bureau of Reclamation either develops a Resource Management Plan for a specific management unit or they partner and relinquish management to state land management agencies. Water management clear Bureau of Reclamation goal.
US Fish and Wildlife Service	5	Protected land; National Wildlife Refuges are required to have a Comprehensive Conservation Plan that outlines management objectives to protect the environmental and recreational integrity of the National Wildlife Refuge. Development not typically allowed.
Wyoming Game and Fish Department	5	Protected land; Wildlife Habitat Management Areas are managed for wildlife and hunting/fishing. Development not typically allowed.
The Nature Conservancy	5	Protected land; The Nature Conservancy drafts different management plans tailored to specific environmental/land use objectives. Development not typically allowed.
Department of Defense	5	Is a federal action, requires NEPA compliance. Specific management goals/objectives.
Other	2	Level of protection based on specific owner.
State Department of Natural Resources	5	Assigned consistent with the Wyoming Game and Fish Department.
County	2	Varies, most have conditional use permit requirement; no NEPA.
State land	2	No the NEPA evaluation is required. Limited management planning.
Private	0	No evaluation required.

Other factors used to inform the protection model were the presence of WAs, instream flows, critical habitat, Wild and Scenic Rivers, and NWI wetlands. These factors were selected for inclusion in the model due to the existing permits that regulate a change in water use (e.g., instream flows) or because they are protected by laws or acts and/or require additional analysis or permitting to allow a change in water use (e.g., jurisdictional wetlands are protected and require permits to impact under the Clean Water Act). In most cases, these factors were scored as presence or absence, either receiving the full score or no score at all. Wild and Scenic Rivers and NWI wetlands were treated slightly different, as a different value is associated with the sub-categories of these datasets. The presence of Wild and Scenic Rivers was provided as an example of a protected area in the *Snake and Salt River Plan* (Pavlica 2013). Presence of NWI wetlands is also an example as wetlands are categorized by the habitat value and general rarity, which results in a different evaluation when considering impacts and required mitigation. Palustrine forested wetlands are less common and provide structural diversity that benefits wildlife. Conversely, palustrine emergent wetlands are more common and provide less functional value. Mitigation required to offset palustrine forested wetland impacts may range from 3:1 to 5:1, while impacts to palustrine emergent wetlands typically require mitigation ratios of 1:1 to 1.5:1. As such, NWI wetland categories were scored relative to their assumed functional value. The full list of factors, scores, and justification are provided in Table 8-3.

Table 8-3. Factors used to inform the protection model.

Factors	Presence/ Category	Score	Justification for Inclusion
Wilderness Areas	Yes	5	No construction allowed.
	No	0	
Instream Flow	Yes	5	Flow protected by permit
	No	0	
Critical Habitat	Yes	3	Protected under the Endangered Species Act
	No	0	
Wild and Scenic	Wild	5	Protection under the Wild and Scenic Rivers Act
	Scenic	4	
	Recreation	3	
National Wetlands Inventory	Forested	3	Protected under the Clean Water Act
	Shrub	2	
	Emergent	1	
	Waters of the US	1	

8.3.1.1 Madison & Gallatin – Protection

Protection scores ranged from low-moderate to moderate-high across the Madison and Gallatin sub-basins. Due to the model inputs, the range of protection scores may not accurately reflect the level of protection in the sub-basins. These sub-basins are located in YNP; therefore protection should be considered high for all waters and associated uses.

8.3.1.2 Yellowstone Headwaters & Upper Yellowstone – Protection

Protection scores ranged from low-moderate to high across the Yellowstone Headwaters and Upper Yellowstone sub-basins. Due to the formulation of the model, the range of protection scores may not accurately reflect the level of protection in the sub-basins. Nearly all of the sub-basins land is located in YNP; therefore, protection should be considered high for all waters and associated uses. A small section southeast Yellowstone Headwaters sub-basin is located outside the NP and received high protection scores. These areas are located in the upper watershed, within WAs and; therefore, have a high level of protection.

8.3.1.3 Clark's Fork Yellowstone – Protection

Protection scores range from low to high across the Clark's Fork Yellowstone sub-basin. High scores were fairly common in the western sub-basin, including the North Fork Crandall Creek, Closed Creek, Hoodoo Creek, and tributaries to the Clarks Fork – Yellowstone River. These areas are located in wilderness area on USFS managed land. The Clark's Fork – Yellowstone River also has a wild and scenic section that scored high. Other moderate–high and moderate scores exist along the Clark's Fork – Yellowstone River, Dead Indian Creek and tributaries to Sunlight Creek. Low and low–moderate scores exist along the Pat O'Hare Creek, tributaries to the Clark's Fork – Yellowstone River, and Sunlight Creek.

8.3.1.4 Shoshone – Protection

Protection scores ranged from low to moderate–high across the Shoshone sub-basin. Moderate–high and moderate scores are fairly limited and exist along small segments of the

Shoshone River protected by instream flow filings. Most of the other water resources were scored low or low–moderate.

8.3.1.5 Big Horn Lake – Protection

Protection scores range from low to high across the Big Horn Lake sub-basin. A high score exists along the upper end of Shell Creek. Other Shell Creek stretches and a portion of Cedar Creek were scored as moderate–high. These stream sections are permitted as for an instream flow filing and/or located in wilderness area. Moderate–high scores also exist near the Beaver Creek headwaters and are protected by an instream flow filing. Moderate scores exist along small sections of Trapper Creek and Porcupine Creek and along the Bighorn River above and below Bighorn Lake. Many of the other headwaters were scored as low–moderate, with lower portions of the streams scored as low.

8.3.1.6 North Fork Shoshone – Protection

Protection scores range from low to high across the North Fork Shoshone sub-basin. High scores exist along the upper end of the North Fork and associated tributaries (Jones Creek, Crow Creek, Grinnell Creek). These areas are protected by WAs, critical habitat, and USFS land. Moderate–high scores are common along the North Fork tributaries including Clearwater Creek, Horse Creek, Grizzly Creek, Big Creek, Eagle Creek, Fishhawk Creek, Elk Fork Creek among others in the wilderness area. The main stem of the North Fork scored moderate for most of the alignment. Low–moderate and low scores exist along the North Fork above the Buffalo Bill Reservoir and the lower end of the tributaries.

8.3.1.7 South Fork Shoshone – Protection

Protection scores ranged from low to moderate–high across the South Fork Shoshone sub-basin. Moderate–high scores exist in the upper watershed of the South Fork within the wilderness area boundary. Water resources in the lower watershed scored low or low–moderate. The main stem of the South Fork Shoshone varied, with scores trending from high to low as the river travels toward Buffalo Bill Reservoir.

8.3.1.8 Dry – Protection

Limited water resources exist in the Dry sub-basin, most of which have low or low–moderate protection scores. Small sections of moderate scores are scattered along Dry Creek. Minimal protection is provided to the sub-basin.

8.3.1.9 Greybull – Protection

Protection scores ranged from low to high across the Greybull sub-basin. High and moderate–high scores exist in the upper watershed along the western sub-basin limits. This includes the headwaters for the Greybull River and Wood River. These segments are protected by instream flow filings and WAs. Moderate scores exist along Pickett Creek and other tributary sections to the Greybull River. Pickett Creek is protected by an instream flow filing. Low and low–moderate scores are common along the majority of the Greybull River and tributaries.

8.3.1.10 Upper Bighorn – Protection

Protection scores ranged from low to moderate-high across the Upper Bighorn sub-basin. Moderate-high and moderate scores are fairly limited in the sub-basin with small sections along the South Fork Owl Creek, Cottonwood Creek, Bighorn River, and Gooseberry Creek. These areas are provided protection as National Landscape Conservation System WAs. All other water resources were scored low or low–moderate, including the main stem of the Bighorn River.

8.3.1.11 Nowood - Protection

Protection scores ranged from low to high across the Nowood sub-basin. High and moderate-high scores exist in the upper watershed along Canyon Creek, Paint Rock Creek, West Tensleep Creek, Medicine Lodge Creek and other smaller tributaries. These areas include instream flow filings and wilderness area. Moderate scores exist along small segments of the Tensleep Creek and Paint Rock Creek headwaters and along Canyon Creek. These areas are provided protection by instream flow filings and National Landscape Conservation System WAs. Low and low–moderate scores are common throughout the remainder of the Nowood sub-basin, including the Nowood River and associated tributaries.

8.3.1.12 Upper Wind – Protection

Protection scores ranged from low to high across the Upper Wind sub-basin. High scores exist near upper watershed limits along Wiggins Fork, Wind River, and Horse Creek. Moderate–high scores exist along the western border on East Fork Wind River, Bull Lake Creek, Dry Creek, and other waters in the Ross Lake area. These areas occur in wilderness area and/or have instream flow filings. Moderate scores occur along most tributaries to the Wind River on USFS land, but outside of the wilderness area. All other waters occur lower in the watershed and scored low or low–moderate. This includes most of the Wind River main stem.

8.3.1.13 Lower Wind – Protection

Protection scores were low and low–moderate across the Lower Wind sub-basin. Limited protection is provided to these water resources. Due to the methods used from the assign scores, the Boysen Reservoir State Park scored low–moderate. It is likely that these areas maybe provided additional protection due to the state park presence.

8.3.1.14 Badwater – Protection

Protection scores were low and low–moderate across the Badwater sub-basin. While a fair number of water resources exist in the sub-basin, limited protection is provided to these water resources. A small section of Badwater Creek east of Boysen scored moderate.

8.3.1.15 Little Wind – Protection

Protections scores ranged from low to moderate–high across the Little Wind sub-basin. Moderate–high scores are limited and exist along the South Fork Little Wind headwaters in wilderness area. Small segments of Beaver Creek and Little Wind River scored moderate. Most of the water resources in the sub-basin scored low or low–moderate.

8.3.1.16 Popo Agie – Protection

Protection scores ranged from low to high in the Popo Agie sub-basin. High and moderate–high scores exist in the headwaters for North, Middle, and Little Popo Agie in the wilderness area. Small sections of moderate scores exist along each of the Popo Agie forks, while low and low–moderate were scored for the remaining water resources.

8.3.1.17 Muskrat – Protection

Protection scores were low and low–moderate across the Muskrat sub-basin. Limited protection is provided to these water resources.

8.3.2 Environmental Model

The goal of the environmental model is to identify the range of environmental factors present for specific water resources in the Basin. This model can be used in conjunction with the protection model to identify areas where high levels of environmental resources exist and associated levels of protection are provided. This can be used to focus on areas where a change in water management may have a greater effect on the environmental resources present. The results of the model for each sub-basin are displayed in Appendix B.

Three categories were considered to inform the environmental model: 1) Land ownership; 2) state resources; and 3) federal resources (Table 8-4 and 8-5). These factors are consistent with the E&R use data presented in the results section. Land ownership is often a driving component related to the inherent environmental value present near Basin waters. Land ownership may affect environmental components in a number of ways. Many of the major land owners have formalized RMPs to specifically address and manage environmental resources. For example, the USFS and BLM have formalized plans identifying natural resource locations and a plan to manage these resources in line with other agency objectives. Other state agencies have developed strategic action plans to support management of environmental resources. WGFD is an example where the state agency does not own the land, but has identified areas to focus and strategize management activities. Scoring for land ownership was assigned in this manner. Scores for land ownership environmental resources were informed based on the answers to three questions listed below and a general understanding as to the process each land owner/manager undergoes to evaluate projects and manage environmental resources (Table 8-4). These scores may be different from the protection model land ownership scores due to the methods used to evaluate the land owner relative to environmental resources.

- Does the land owner have a formalized RMP?
- If yes, where do environmental resources fit in the overall objectives of the RMP?
- Is NEPA compliance (or another evaluation that includes environmental resources) required to authorize projects that may impact environmental resources?

Table 8-4. Land ownership – management scores used to inform the environmental model.

Land owner-Manager	Scores	Justification for Score
State Park	3	Has a comprehensive recreation plan that includes environmental resources, but more focus on recreation resources.
National Forest	5	Detailed Resource Management Plan (RMP) with Environmental Impact Statement (EIS) requirements for changes; heavy focus on environmental resources.
National Park	5	Detailed RMP with EIS requirements for changes; heavy focus on environmental resources.
Bureau of Land Management	4	Detailed RMP with EIS requirements for changes; primary objectives focused on promoting mixed land use of which environment is considered.
Bureau of Indian Affairs	3	Has an Irrigation RMP which includes small environmental sections.
State land	3	No clear environmental RMP. Focus on agriculture and commercial uses.
Private	0	Highly dependent on individual owner, no requirements.
Bureau of Reclamation	2	Follows standard laws/acts/regulations but does not have a clear RMP; either develops a RMP for a specific management units or they partner and relinquish management to state land management agencies.
State Fish and Wildlife	5	Has clear Strategic Habitat Plan/State Wildlife Action Plan, but in many cases does not own the land it is targeting (in this case it does own the land).
US Fish and Wildlife Service	5	Primary objective is to conserve, enhance, restore environment.
The Nature Conservancy	5	Primary objective is to conserve, enhance, restore environment.
Department of Defense	3	Has a natural resource program, but primary goal is to support military actions (natural habitat for training).
Other	0	Unknown; therefore no score provided.
State Department of Natural Resources	5	Assume these fall under Wyoming Game and Fish Department action plans.
County	2	Varies by county; most have a conditional use permit (or similar). Environment not a major focus.

State and federal environmental resources were also included to inform the environmental model. These include a variety of designated areas such as WGFD priority habitats, USFWS NWR, USFWS threatened and endangered species habitat, and NWI wetlands, among others. This report relies on the state and federal agencies and other publically available data to identify the environmental uses. It is assumed that the state and federal agencies are familiar with the important environmental resources and have targeted areas in the Basin that should be recognized. Similar to the protection model scheme, most of these uses were scored as presence or absence, either receiving the full score or no score at all. Exceptions were made to resources that included multiple categories (e.g., NWI wetlands and WGFD priority habitats). The full list of factors, scores, and justification are provided in Table 8-5.

Table 8-5. State and Federal resources used to inform the environmental model.

Resource	Presence/ Category	Score	Justification for score
State			
Wyoming Game and Fish Department (WGFD) Priority Areas	Crucial Stream	2	WGFD identifies these as specific environmental features, but they are not formally recognized in the State Wildlife Action Plan or Strategic Habitat Plan or tied to clear management objectives. Additionally, WGFD does not own the land where these features exist.
	Crucial Aquatic	4	WGFD identified features with specific management strategies as Goal 1; however, WGFD does not own the land where these features exist.
	Crucial Combined	4	WGFD identified features with specific management strategies; however, WGFD does not own the land where these features exist.
	Nongame	3	WGFD identified features with specific management strategies, does not necessarily target water resources; WGFD does not own the land where these features exist.
Instream Flow Filing	Yes	5	State permitted features with the goal of maintaining/conserving environmental factors (i.e., fisheries).
	No	0	
Federal			
National Wildlife Refuge	Yes	5	US Fish and Wildlife Service (USFWS) owned and managed lands specifically for the environment.
	No	0	
Wild and Scenic	Wild	5	Rare features identified specifically for the environmental properties; highest level of Wild and Scenic.
	Scenic	4	Rare features identified specifically for the environmental properties; second tier Wild and Scenic.
Wilderness Areas	Yes	5	Areas provided the highest level of conservation protection.
	No	0	
USFWS Threatened and Endangered	Species habitat (individual)	1	Areas identified by the USFWS as having the potential for individual listed species.
	No species habitat	0	
Critical habitat	Yes	5	USFWS designated areas that are essential to the conservation of individual species.
	No	0	
National Wetlands Inventory	Forested	5	Features identified specially for the regular presence of hydrology. These features provide demonstrable value to the environment. Forest wetlands are the least common and often require a greater level of mitigation due to the values they provide.
	Shrub	3	Same wetland definition…second tier value associated (relative to other wetland types).
	Emergent	1	Same wetland definition…third tier value associated (relative to other wetland types), most common wetland type.
	Waters of the US	2	Regulated under the Clean Water Act due to value provided to the environment.
Bureau of Land Management Critical Environmental Concern	Yes	2	Areas identified as needing additional management actions…not all are environmental related (e.g.; historic sites).
	No	0	

8.3.2.1 Madison & Gallatin – Environmental

Environmental scores ranged from low–moderate to moderate–high across the sub-basins. Due to the model inputs and designation of environmental factors within the NP boundaries (e.g., no instream flow filings or critical habitat designated with NPS boundaries), these scores may not represent the full environmental uses present in the sub-basins. These sub-basins occur in YNP and; therefore, provide a high level of environmental uses.

8.3.2.2 Yellowstone Headwaters & Upper Yellowstone – Environmental

Environmental scores ranged from low-moderate to high across the Yellowstone Headwaters and Upper Yellowstone sub-basins. Due to the model inputs, the range of environmental scores within the NPS boundaries may not accurately reflect the level of environmental uses in the sub-basins. Nearly all of the sub-basins land is located in YNP; therefore environmental uses should be considered high for all waters uses. A small section southeast Yellowstone Headwaters sub-basin is located outside the NPS and received high environmental scores. These areas are designated critical habitat by WGFD and occur in wilderness area.

8.3.2.3 Clark's Fork Yellowstone – Environmental

Environmental scores range from low to high across the Clark's Fork Yellowstone sub-basin. High and moderate–high scores were fairly common in the western sub-basin, including the North Fork Crandall Creek, Closed Creek, Hoodoo Creek, and tributaries to the Clarks Fork – Yellowstone River. These areas are located critical habitat and WGFD designated priority habitats. The Clark's Fork – Yellowstone River has a wild and scenic section that is scored as moderate–high. Other moderate scores exist along the Clark's Fork – Yellowstone River, Dead Indian Creek and tributaries to Sunlight Creek. Low and low–moderate scores exist along the Pat O'Hare Creek, tributaries to the Clark's Fork – Yellowstone River, and Sunlight Creek.

8.3.2.4 Shoshone – Environmental

Environmental scores ranged from low to moderate-high across the Shoshone sub-basin. Moderate-high scores are fairly limited and exist along small segments of the Shoshone River above Bighorn Lake and near the western sub-basin border protected by instream flow filings. The remainder of the Shoshone River scored moderate due to designation as WGFD crucial stream corridor. Most of the other water resources were scored low or low–moderate.

8.3.2.5 Big Horn Lake – Environmental

Environmental scores ranged from low to high across the Big Horn Lake sub-basin. A high score exists along a small segment of the upper end of Shell Creek. Other Shell Creek stretches and a portion of Cedar Creek were scored as moderate–high and moderate. These stream sections are permitted as for an instream flow filing, located in USFS land, and are designated as priority habitat by WGFD. Moderate–high scores also exist along the Bighorn River above and below Bighorn Lake. Moderate scores exist along Beaver Creek, Porcupine Creek, Shell Creek, and long stretches along the Bighorn River. Many of the other headwaters were scored as low–moderate, with lower portions of the streams scored as low.

8.3.2.6 North Fork Shoshone – Environmental

Environmental scores range from low to high across the North Fork Shoshone sub-basin. High scores exist along a segment of North Fork and small segments of Jones Creek, Crow Creek, and Grinnell Creek. Moderate–high scores are common along the North Fork tributaries including Clearwater Creek, Horse Creek, Grizzly Creek, Big Creek, Eagle Creek, Fishhawk Creek, Elk Fork Creek among others in the sub-basin. These areas are designated WGFD priority habitat, with the high scoring sections in critical habitat. Moderate scores make up the bulk of the remaining North Fork tributaries, with small segment of low and low–moderate scores near the Buffalo Bill Reservoir. Environmental uses scored relatively high across the sub-basin.

8.3.2.7 South Fork Shoshone – Environmental

Environmental scores ranged from low to high across the South Fork Shoshone sub-basin. High and moderate–high scores exist in the upper watershed of the South Fork within the wilderness area boundary and WGFD priority habitat. Moderate scores exist lower in the watershed outside of the wilderness area, but in WGFD priority habitat. Low and low–moderate scores exist above the Buffalo Bill Reservoir.

8.3.2.8 Dry – Environmental

Environmental scores ranged from low to moderate. Moderate scores exist along Dry Creek on BOR property. Other segments of Dry Creek and tributaries scored low or low-moderate.

8.3.2.9 Greybull – Environmental

Environmental scores ranged from low to high across the Greybull sub-basin. High and moderate–high scores exist in the upper watershed along the western sub-basin limits. This includes the headwaters for the Greybull River and Wood River. These segments are designated WGFD priority habitats, instream flow filings, and are located on USFS land. Moderate scores exist along the bulk of the Greybull River main stem, Wood River, and Pickett Creek. Low and low–moderate scores exist along the remaining Greybull River tributaries, including Willow Creek, Dorsey Creek, Cottonwood Creek, Spring Creek, Horse Creek, and Rawhide Creek.

8.3.2.10 Upper Bighorn – Environmental

Environmental scores ranged from low to moderate-high across the Upper Bighorn sub-basin. Moderate - high and moderate scores exist along sections of the Owl Creek system, Cottonwood Creek, and the Bighorn River. These upper stream segments occur in wilderness area, while the Bighorn is designated a crucial stream corridor by WGFD. Most of the water resources in the sub-basin were scored as low or low-moderate.

8.3.2.11 Nowood - Environmental

Environmental scores ranged from low to moderate–high across the Nowood sub-basin. Moderate–high scores exist in small segments along the Medicine Lodge Creek, Paint Rock Creek, Tensleep Creek, and Nowood River. Moderate scores exist in the upper watershed along Canyon Creek, West Tensleep Creek, Paint Rock Creek and other smaller tributaries.

These areas include instream flow filings WGFD priority habitats. Moderate scores exist along the Nowood River, where WGFD has designated priority habitat and crucial stream corridors. Low and low–moderate scores are common throughout the remainder of the Nowood sub-basin, including large segments along the Nowood River, Paint Rock Creek, and associated tributaries.

8.3.2.12 Upper Wind – Environmental

Environmental scores ranged from low to high across the Upper Wind sub-basin. High and moderate–high scores exist near upper watershed limits along Wiggins Fork, Wind River, and Horse Creek, and other smaller tributaries near the Ross Lake area. Moderate scores exist along the western border on the upper end of the Wind River (and associated tributaries), East Fork Wind River, Bull Lake Creek, Dry Creek, and other waters in the Ross Lake area. Many of these areas occur in wilderness area and/or have instream flow filings. Moderate scores also occurred along lower segments of the Wind River main stem. All other waters scored low or low–moderate. This includes most of the Wind River main stem and lower limits of associated tributaries.

8.3.2.13 Lower Wind – Environmental

Environmental scores ranged from low to moderate across the Lower Wind sub-basin. Moderate scores exist around Boysen Reservoir in areas designated by WGFD as KNWA, including segments along the Fivemile Creek, Muddy Creek, Cottonwood Creek, and Wind River directly above the reservoir. Water resources further from the reservoir scored low or low–moderate.

8.3.2.14 Badwater – Environmental

Environmental scores were low and low–moderate across the Badwater sub-basin. A section of KNWA habitat exists in the northwest sub-basin. While a fair number of water resources exist in the sub-basin, limited environmental uses were identified along these water resources.

8.3.2.15 Little Wind – Environmental

Environmental scores ranged from low to moderate–high across the Little Wind sub-basin. Moderate–high scores exist near the upper reaches of the South Fork Little Wind. Moderate scores are limited and exist along the South Fork Little Wind headwaters in wilderness area and along the Little Wind main stem in WGFD KNWA. Most of the water resources in the sub-basin scored low or low–moderate for environmental uses.

8.3.2.16 Popo Agie – Environmental

Environmental scores ranged from low to moderate-high in the Popo Agie sub-basin. Moderate–high scores exist in the headwaters for North, Middle and Little Popo Agie in the BLM CEC areas. Moderate scores exist in the upper watershed of the North, Middle, and Little Popo Agie. Low and low–moderate scores were common along the water resources lower in the watershed.

8.3.2.17 Muskrat – Environmental

Environmental scores were low and low–moderate across the Muskrat sub-basin. Limited environmental uses were identified along these water resources.

8.3.3 Recreation Model

The goal of the recreational model is to identify the range of recreational factors present for specific water resources in the Basin. This model can be used in conjunction with the protection model to identify areas where high levels of recreational resources exist and associated levels of protection are provided. This can be used to focus on areas where a change in water management may have a greater effect on the recreational resources present. The results of the model for each sub-basin are displayed in Appendix C.

Two categories were considered to inform the environmental model: 1) Land ownership; and 2) Other factors. These categories are consistent the E&R use data presented in the results sections. Land ownership is often a driving component related to the inherent recreational value present near Basin waters. Land ownership may affect recreational opportunities in a number of ways. Many of the major land owners have formalized RMP to specifically address, manage, and promote recreational opportunities. An example would be the State Parks Department and NPS. These entities have formalized plans identifying recreational resource locations and a plan to manage these resources in line with other agency objectives. Scores for land ownership recreational resources were informed based on the answers to the questions listed below and a general understanding as to the process each land owner/manager undergoes to evaluate projects and manage recreation resources. These scores may be different from the protection model land ownership scores due to the methods used to evaluate the land owner relative to recreation resources (Table 8-6).

- Is public access provided to the land and recreational resource?
- Is access to the land and recreational resource fee or permit based?
- Does the land owner have a formalized RMP?
- If yes, where do recreational resources fit in the overall objectives of the RMP?
- Is NEPA compliance (or another evaluation that includes recreation resources) required to authorize projects that may impact recreation resources?

Table 8-6. Land ownership – management scores used to inform the recreational model.

Land owner-Manager	Score	Justification for Score
State Park	5	Has a comprehensive recreation plan that includes environmental resources, but more focus on recreation resources. Provides both open access and fee-based.
National Forest	5	Detailed Resource Management Plan (RMP) with Environmental Impact Statement (EIS) requirements for changes; heavy focus on E&R resources; may be open access or fee-based.
National Park	5	Detailed RMP with EIS requirements for changes; heavy focus on E&R resources; typically fee-based access.
Bureau of Land Management	4	Detailed RMP with EIS requirements for changes; primary objectives focused on promoting mixed land use of which recreation is considered, but typically not the focus. Open access to public.
Bureau of Indian Affairs	2	Has an Irrigation RMP, but limited recreation based requirements. Does provide fee-based access to recreation uses.
State land	2	No clear environmental RMP. Focus on agriculture and commercial uses. Access varies based on location.

Table 8-6. Land ownership – management scores used to inform the recreational model.

Land owner-Manager	Score	Justification for Score
Private	0	Highly dependent on individual owner, no requirements.
Bureau of Reclamation	2	Follows standard laws/acts/regulations but does not have a clear RMP; either develops a RMP for a specific management units or they partner and relinquish management to state land management agencies. Application process for recreation activities.
State Fish and Wildlife	4	Has clear Strategic Habitat Plan/State Wildlife Action Plan, but in many cases does not own the land it is targeting (in this case it does own the land). Access varies based on location.
US Fish and Wildlife Service	4	Primary objective is to conserve, enhance, restore environment; recreation may not be primary object for land.
The Nature Conservancy	2	Primary objective is to conserve, enhance, restore environment. Public access for recreation is often not provided.
Department of Defense	1	Has a natural resource program, but primary goal is to support military actions (natural habitat for training); limited to no public access.
Other	2	Unknown; dependent on specific owner.
State Department of Natural Resources	4	Assume these fall under Wyoming Game and Fish Department action plans
County	2	Varies by county; most have a conditional use permit (or similar). Recreation not a major focus.

Other factors used to inform the recreation model were stream classification, whitewater rafting, and WGFD wildlife habitat management areas (Table 8-7). Stream classifications were scored on a sliding scale based on the value provided by the individual stream categories. This is consistent with the other models where factors included multiple categories.

Table 8-7. Factors used to inform the recreational model

Resources	Presence/ Category	Score	Justification for score
Stream Classification	Blue	5	Wyoming Game and Fish Department (WGFD) Fisheries scoring specifically for sport fishing; highest level
	Red	4	Second level
	Yellow	3	Third level
	Green	2	Fourth level
	Orange	1	Fifth level
	Clear	0	No fisheries identified
Whitewater Rafting Segment	Yes	5	Provides opportunity for recreation activity
	No	0	
WGFD	Wildlife Habitat Management Area	5	Managed to provide recreational opportunities

Many other factors were presented in the results section of this report and may affect recreational value, but were not included in the model. This is primarily based on the type of data available. For example, waterfowl hunting is a major water-associated recreational activity across the Basin; however, a dataset was not readily available to support this evaluation. Similarly, many of the recreation resources in the Basin are associated with land ownership.

YNP provides the public with a wide array of recreational opportunities, including fishing, hiking, and boating, among numerous others. These individual factors were not investigated, but their presence and value were included in the model through the land ownership scoring.

8.3.3.1 Madison & Gallatin – Recreation

Recreation scores were low–moderate across the sub-basins. Due to the model inputs and designation of recreation factors within the YNP, these scores may not represent the full recreation uses present in the sub-basins. These sub-basins occur in YNP and; therefore, are assumed to provide a high level of recreation uses.

8.3.3.2 Yellowstone Headwaters & Upper Yellowstone – Recreation

Recreation scores ranged from low-moderate to moderate–high across the Yellowstone Headwaters and Upper Yellowstone sub-basins. Due to the model inputs, the range of environmental scores within the NPS boundaries may not accurately reflect the level of protection in the sub-basins. Nearly all of the sub-basins land coverage is located in YNP, which is one of the largest recreation destination locations in the state. This area should be considered as providing a high recreation uses.

8.3.3.3 Clark's Fork Yellowstone – Recreation

Recreation scores range from low to high across the Clark's Fork Yellowstone sub-basin. High scores exist along the upper reach of the Clarks Fork – Yellowstone River and stream segments near the confluence with Crandall Creek and a section of a wild and scenic river. These stream segments provide sport fishing and rafting opportunities. Moderate–high and moderate scores were fairly common throughout the western sub-basin, including the North Fork Crandall Creek, Closed Creek, Hoodoo Creek, Sunlight Creek, Dead Indian Creek, and tributaries to the Clarks Fork – Yellowstone River. Low and low–moderate scores exist along the Pat O'Hare and associated tributaries.

8.3.3.4 Shoshone – Recreation

Recreation scores ranged from low to high across the Shoshone sub-basin. High and moderate-high scores are fairly limited and exist along small segments of the Shoshone River above Bighorn Lake and near the western sub-basin border designated a blue ribbon fishery and rafting area. The remainder of the Shoshone River scored moderate or low–moderate due to lower level fisheries. A number of other stream segments scored moderate including Spring Creek, Dry Creek, Cottonwood Creek, Deer Creek, and Sage Creek. Most of the other water resources were scored low or low–moderate including most of the Shoshone River main stem.

8.3.3.5 Big Horn Lake – Recreation

Recreation scores ranged from low to high across the Big Horn Lake sub-basin. A high score exists along a segment of Shell Creek designated as a red ribbon fishery. Other Shell Creek stretches, Cedar Creek, Porcupine Creek, and the Bighorn River above Bighorn Lake were scored as moderate–high. These stream sections provide fisheries and public access on NPS and USFS managed lands. Most of the other headwaters in the sub-basin scored medium and lower watershed areas scored low or low - moderate.

8.3.3.6 North Fork Shoshone – Recreation

Recreation scores range from low to high across the North Fork Shoshone sub-basin. High scores exist along the main stem of North Fork designated for blue ribbon fisheries and rafting. Moderate–high scores are common along the North Fork tributaries including Jones Creek, Horse Creek, Trout Creek, Whit Creek, Elk Fork, Eagle Creek, Fishhawk Creek, Elk Fork Creek among others in the sub-basin with moderate score assigned to the tributaries of these streams. Low and low–moderate scores are fairly limited and exist near the Buffalo Bill Reservoir or other small streams in the upper watershed. Recreation uses scored relatively high across the sub-basin.

8.3.3.7 South Fork Shoshone – Recreation

Recreation scores ranged from low to high across the South Fork Shoshone sub-basin. High scores exist along a segment of the South Fork where rafting and red ribbon fisheries are designated. Moderate scores are fairly common throughout the sub-basin's upper watershed. Low and low–moderate scores exist above the Buffalo Bill Reservoir and along a segment of the South Fork Shoshone River.

8.3.3.8 Dry – Recreation

Recreation scores low and low–moderate and were fairly scattered across the Dry Creek and associated tributaries. Limited recreation opportunities exist in the sub-basin.

8.3.3.9 Greybull – Recreation

Recreation scores ranged from low to high across the Greybull sub-basin. High and moderate–high scores exist in the upper watershed along the western sub-basin limits. This includes the headwaters for the Greybull River and Wood River where rafting and fishing are popular. Segments of Rawhide and Horse Creek scored moderate and moderate–high due to red ribbon fisheries. Moderate scores also exist throughout the upper watershed in the western sub-basin. Low and low–moderate scores were common across the central and eastern sub-basin, including most of the Greybull River main stem.

8.3.3.10 Upper Bighorn – Recreation

Recreation scores ranged from low to moderate–high across the Upper Bighorn sub-basin. Moderate–high and moderate scores exist along sections of the Owl Creek, Cottonwood Creek, Gooseberry Creek, Grass Creek, and Bighorn River below the Wind River Canyon. Most of the water resources in the sub-basin were scored as low or low–moderate; however, this sub-basin is known for recreational uses including fishing, rafting, camping, hiking, and other passive recreation activities.

8.3.3.11 Nowood - Recreation

Recreation scores ranged from low to high across the Nowood sub-basin. High scores exist along segments of Paint Rock Creek and West Tensleep Creek where rafting and red ribbon fisheries are designated. Moderate–high and moderate scores exist in the upper watershed along Canyon Creek, West Tensleep Creek, Medicine Lodge Creek, Paint Rock Creek, and

other smaller tributaries. Low and low–moderate scores are common throughout the remainder of the Nowood sub-basin, including the Nowood River main stem, lower Paint Rock Creek, and associated tributaries.

8.3.3.12 Upper Wind – Recreation

Recreation scores ranged from low to high across the Upper Wind sub-basin. High and moderate–high scores exist along Wiggins Fork, East Fork Wind River, and other small tributary section for the Wind River. These areas provide quality fisheries, rafting, and other recreation uses. Moderate scores exist along the western border on the upper end of the Wind River (and associated tributaries), Horse Creek, Bull Lake Creek, Warm Springs Creek, Dry Creek, and other waters in the Ross Lake area. These areas provide a variety of recreation uses and are located on public land (USFS). All other waters scored low or low–moderate. This includes most of the Wind River main stem and lower limited of associated tributaries.

8.3.3.13 Lower Wind – Recreation

Recreation scores ranged from low to moderate-high across the Lower Wind sub-basin. Moderate-high scores exist around Boysen Reservoir along the Muddy Creek, Fivemile Creek, and Wind River designated as green ribbon fisheries. The Wind River section below Boysen Reservoir was scored moderate. Water resources further from the reservoir scored low or low–moderate.

8.3.3.14 Badwater – Recreation

Recreation scores ranged from low to moderate across the Badwater sub-basin. Small moderate scores were assigned to small segments along the Meadow Creek, Sioux Creek, and Badwater Creek. All other water resources scored low or low–moderate.

8.3.3.15 Little Wind – Recreation

Recreation scores ranged from low to moderate across the Little Wind sub-basin. Moderate scores are limited and exist along the South Fork Little Wind headwaters and small segments of Beaver Creek. Most of the water resources in the sub-basin scored low or low–moderate for environmental uses, primarily due to lack of public access on Bureau of Indian Affairs managed lands.

8.3.3.16 Popo Agie – Recreation

Recreation scores ranged from low to high in the Popo Agie sub-basin. High and moderate-high scores exist along the Red Canyon Creek, North, Middle, and Little Popo Agie and associated tributaries. These stream segments provide high quality fisheries and rafting opportunities. Moderate scores exist along the tributaries to the North, Middle, and Little Popo Agie. Low and low–moderate scores were common along the water resources lower in the watershed.

8.3.3.17 Muskrat – Recreation

Recreation scores were low and low–moderate across the Muskrat sub-basin. Limited recreation uses were identified along these water resources.

8.4 MODEL SUMMARY

The protection model demonstrated a range of protections across the Basin. In most cases, greater protection was assigned to areas higher in the watershed. These areas typically have institutional protection associated with USFS and WA and may include USFWS critical habitats or instream flow filings. Most of the upper reaches of the watershed are above existing diversions; therefore, changes in water use are less likely to result from diversion and more likely to be effected by water storage projects. Less protection was evident along many of the larger streams. These areas typically have more private land ownership and less institutional regulations. Additionally, these areas support more agriculture (and other water uses); therefore, are more subject to impacts through diversions. This is supported by the diversion locations and irrigation water consumption demonstrated in Figure 8-1.

The environmental model followed a similar pattern to the protection model, with more environmental uses identified higher in the Basin's watershed. At a finer scale, more variability was demonstrated in the environmental model. This was often due to USFWS habitat suitability and BLM and WGFD priority areas. These agency designated habitats are present throughout the Basin in upper and lower sections of the watershed, specifically along many of the major streams (e.g., Bighorn or Shoshone Rivers). In general, higher environmental scores were apparent in the western Basin. Many environmental uses were mapped in this region, including USFWS critical habitat, and subsequently resulted in higher environmental model scores. Additionally, many of the major waterbodies, such as the Bighorn River and Shoshone River received higher scores due to the identification of critical corridors from a variety of datasets.

Higher recreation scores were demonstrated in the upper watersheds, specifically on USFS and NPS managed land. This makes sense, given the recreation opportunities and purposeful management of USFS and NPS to provide the public with open space. In general, the Basin provides a range of recreation uses, with the western sub-basins (e.g., Clarks Fork, North Fork, Popo Agie) assigned higher scores relative to other areas across the Basin. These areas are known for the fisheries, rafting, and general outdoor recreation uses. Many of the larger waterbodies in the Basin also scored high including the various forks of the Shoshone, Popo Agie, among others. It is important to recognize that fewer factors were used to inform the recreation model. This results in land ownership having a greater impact on the overall score and less recreation uses being captures. Additionally, the recreation model was not set up to capture the high recreation use commonly associated with the Basin's reservoirs. The reservoirs are common destination locations for recreation and in many cases surrounded by state parks, but not fully captured in the recreation model.

YNP is a significant feature in the Basin. This area is known for E&R uses. Because YNP is an independent feature, it is not managed in the same manner as the remainder of the Basin (or state) and/or datasets that demonstrate the E&R uses do not include the YNP area. Therefore, the model scores may not accurately represent the levels of protections afforded to YNP or the E&R uses that exist. In nearly all cases, it should be assumed that the YNP provided high E&R uses and is afford high levels of protection.

9 DISCUSSION

The WWDC developed a river basin planning framework as a consistent method to evaluate existing water resources and support existing and future water use planning. E&R water uses were included in the initial Basin planning framework, but were not fully addressed due to the non-consumptive nature of the uses. To that end, the Handbook (Harvey Economics 2012) was developed and laid out a process to identify, map, categorize, and assimilate E&R use data. WEST followed the Handbook guidance and developed new methods to further evaluate the E&R use data for the Basin.

The Wind-Bighorn River Basin is located in central and northwestern Wyoming, with 19 sub-basins. Wyoming's ability to develop and consumptively use water in the Wind-Bighorn River Basin is regulated by the Yellowstone River Compact of 1950 and the General Adjudication of All Rights to Use Water in the Big Horn River System. Surface and ground water are detailed in the 2003 and 2010 Wind-Bighorn River Basin Plans. Agriculture is by far the highest consumptive water use in the Basin. The 2010 Plan does project an increase in consumptive water use demands into the future, with a 700 acre-feet increase projected by 2020 and a 24,000 acre-feet increase by 2060. Additionally, the plan demonstrates that potential water supply shortage may occur under normal conditions. Most of the shortages are demonstrated along high-order and small stream and not the larger main stem waters. This suggests that the water quantity required to support non-consumptive E&R uses in the Basin may be reduced and subsequent impacts to the E&R uses may occur.

To assist planning with future projects, WEST gathered E&R use data and prepared models to highlight E&R use across the Basin. Multiple areas demonstrated higher E&R uses when compared with the remainder of the Basin. The western Basin demonstrated a higher E&R uses when compared to the Basin as a whole. Some areas around Boysen Reservoir and along the western slope of the Bighorn NF also demonstrated relatively high E&R uses. These areas support a variety of environmental uses including instream flow filings, wetlands, USFWS threatened and endangered species habitat, and number of WGFD designated priority habitats and are headwaters for a number of major waters in the Basin, including the Shoshone, Bighorn, Wind and Popo Agie Rivers. The presence of USFS land, known fisheries and rafting segments also makes these areas a destination location for recreation uses. The YNP region and areas around the major reservoirs and state parks did not always score high on the models, but are known for providing significant E&R uses.

In additional to the E&R use models, WEST prepared a protection model to identify areas were E&R uses may be at more risk to impacts from future project planning. The protection scores were fairly consistent with the E&R use scores, with waters high in the watershed scoring higher for all models. Evaluation of the E&R models and protection model highlighted the Shoshone River (North and South Forks) and Bighorn River as waters that may be at risk to future impacts. These water resources scored high for E&R uses, but relatively low for protection. Additionally, most of the waters in the Greybull sub-basin, including the main stem of the Greybull River, scored high for environmental uses, but had low protection scores. The large

number of diversions (Figure 8-1) and water consumption requirements to support agriculture operations in these areas suggest the need to monitor and evaluate future project planning.

Many of the other areas in the Basin where high E&R uses were demonstrated had similarly high protection scores, with some areas appearing to have greater levels of protection (i.e., higher scores) than the associated E&R use scores. This was apparent along the upper reaches of the Wiggins Fork in the Upper Wind sub-basin and the upper reaches of the Popo Agie forks (North, Middle, and Little).

Future water demands in the Basin may result in impacts to the current E&R uses. The 2010 Plan suggests that most of the water shortages may occur along the Basin's tributaries. These areas support the various levels of E&R uses across the Basin, with more protection evident in the upper watershed and less protection lower in the watershed. The 2010 Plan also suggested that excess water exists along the Basin's main stems rivers and in the waters near Big Horn Lake. These areas showed relatively high E&R uses, but low levels of protection. As long as excess water is available, impacts to the E&R uses along the main stems should not be affected. Future project planning and water management should continue to be cognizant of these issues. Water storage projects are underway in the Big Horn Lake and Nowood sub-basins, with one reservoir expansion project (Leavitt Reservoir) and one new construction reservoir project (Alkali Creek Reservoir) currently in the NEPA phase. Potential impacts to E&R uses in the area should be monitored as the projects proceed to the construction and operational phase.

This report and supporting data can be used to evaluate potential impact to E&R uses. The resources provided in this report include direct E&R uses across the Basin; general categorization of E&R uses; and the environmental, recreation, and protection models. Each of the resources should be evaluated, as no one dataset is all encompassing.

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Appendix A. Protection Model for the Wind – Bighorn River Basin

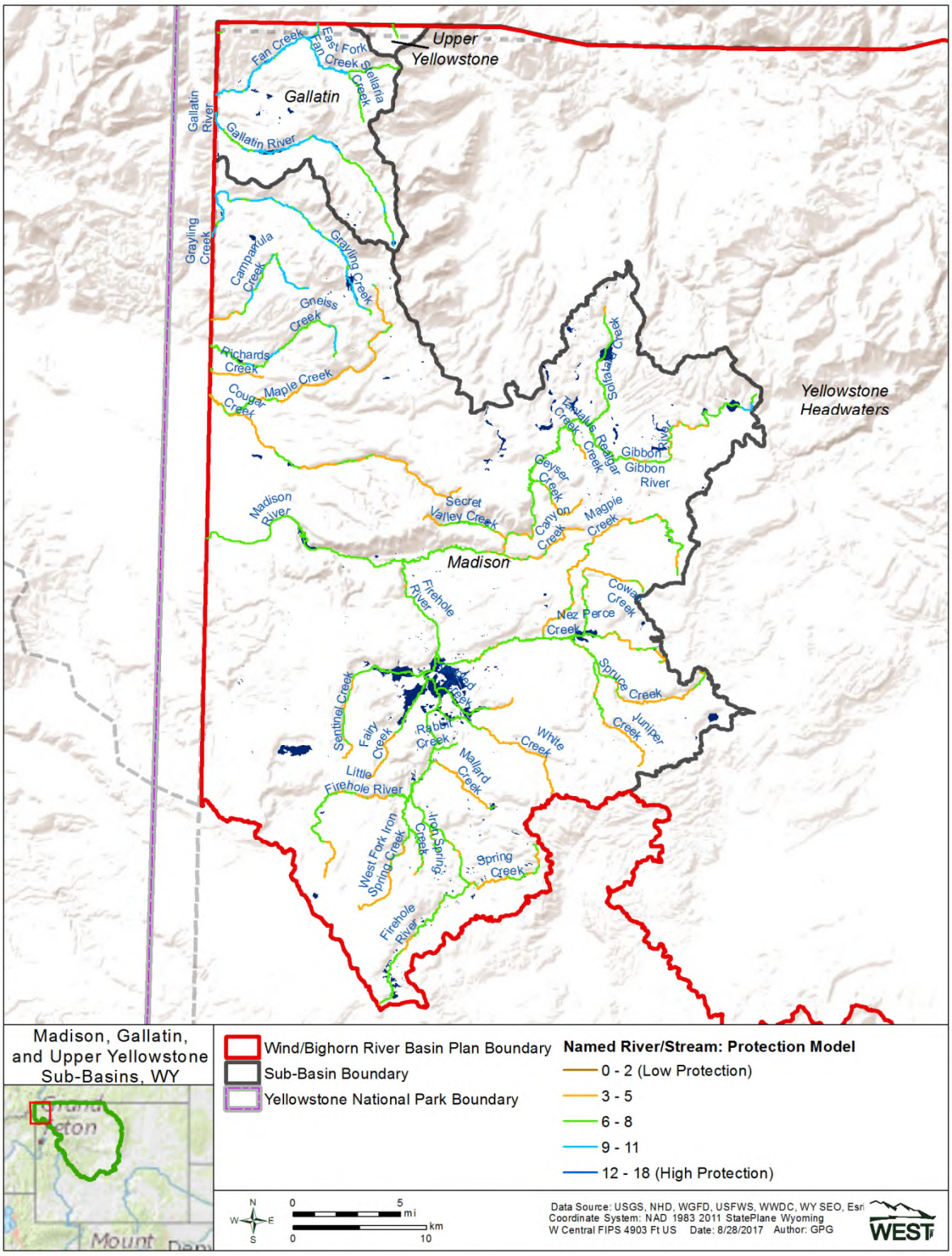

Figure A-1. Protection model results for the Madison & Gallatin sub-basins in Wyoming.

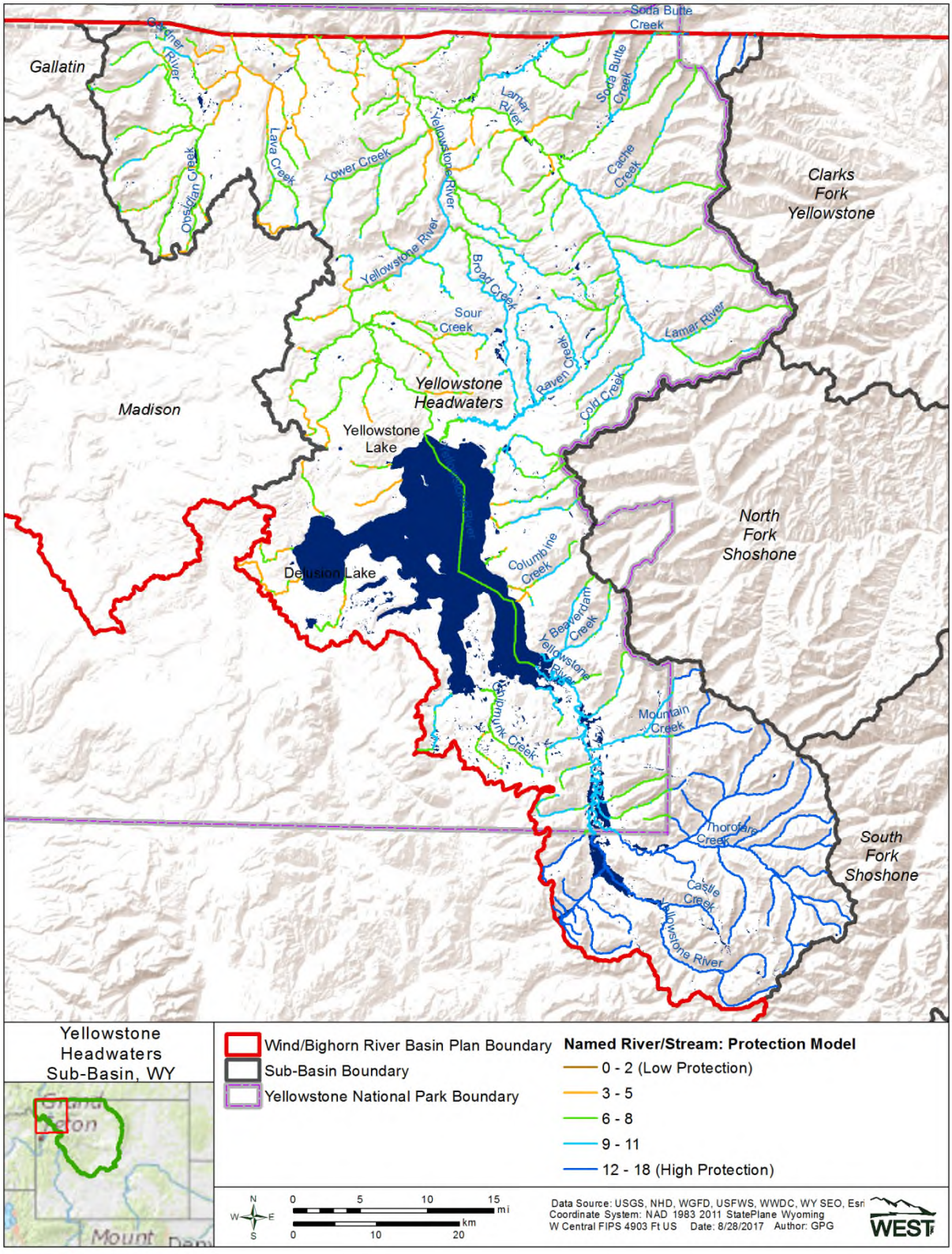

Figure A-2. Protection model results for the Yellowstone Headwaters & Upper Yellowstone sub-basins in Wyoming.

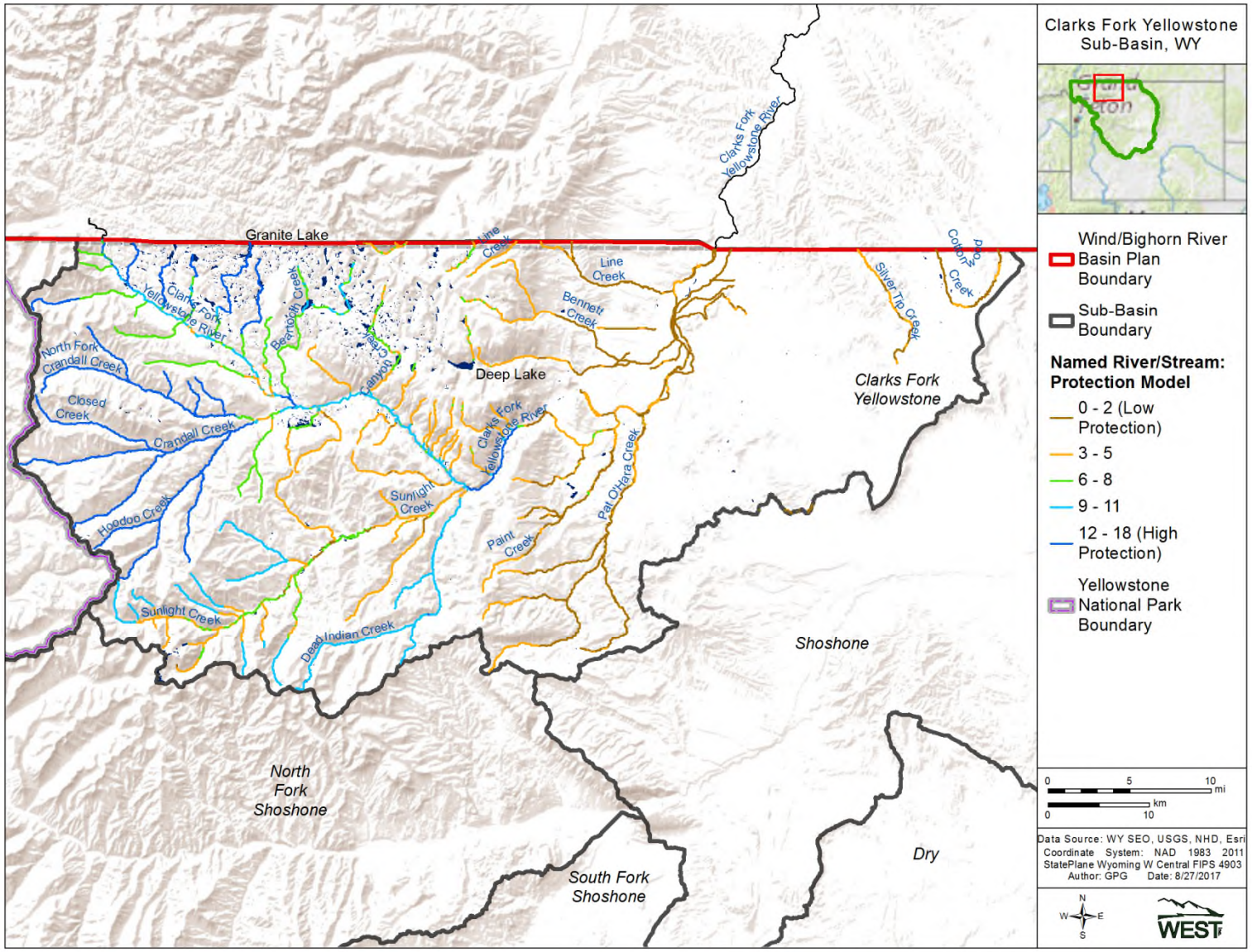

Figure A-3. Protection model results for the Clarks Fork-Yellowstone sub-basin in Wyoming.

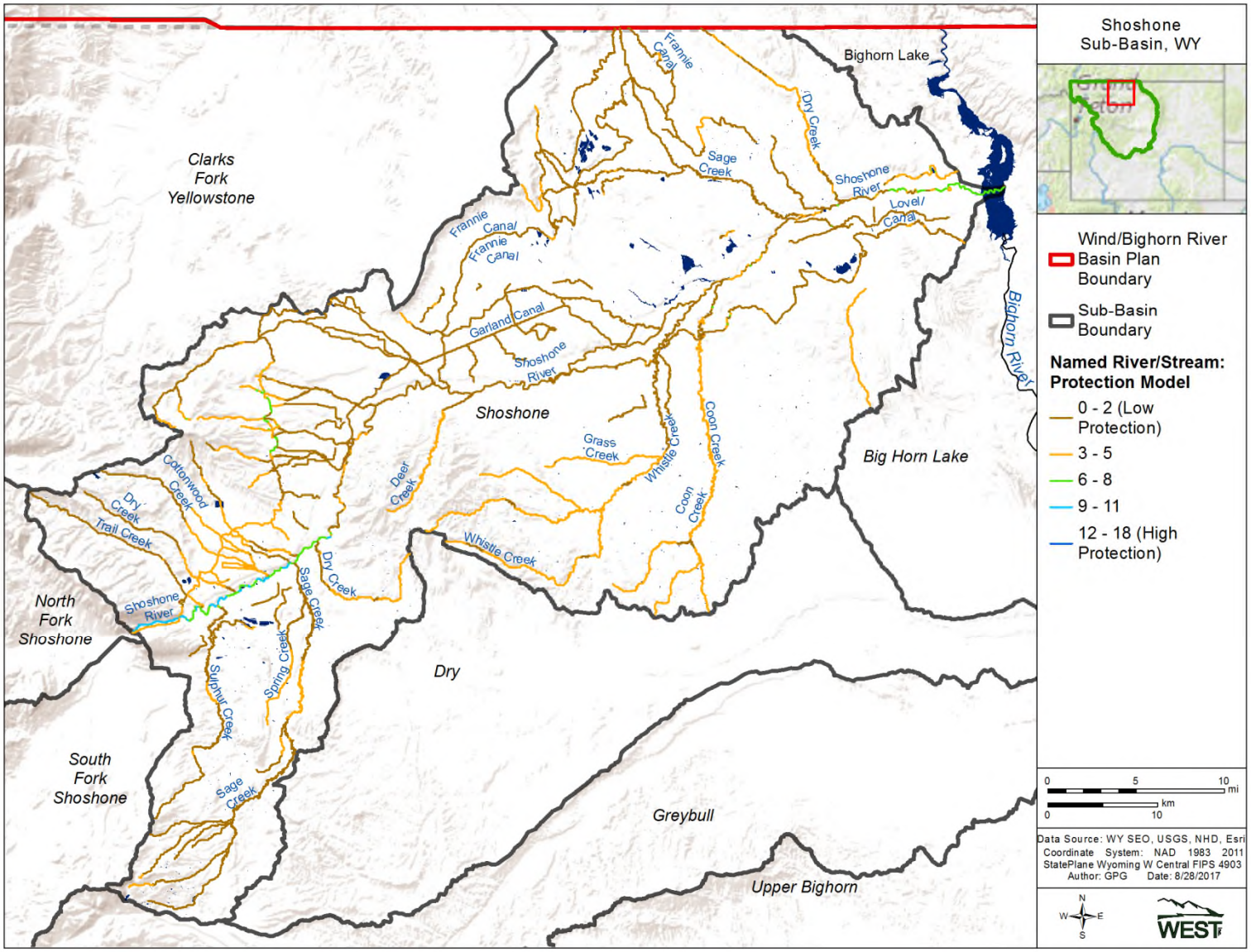

Figure A-4. Protection model results for the Shoshone sub-basin in Wyoming.

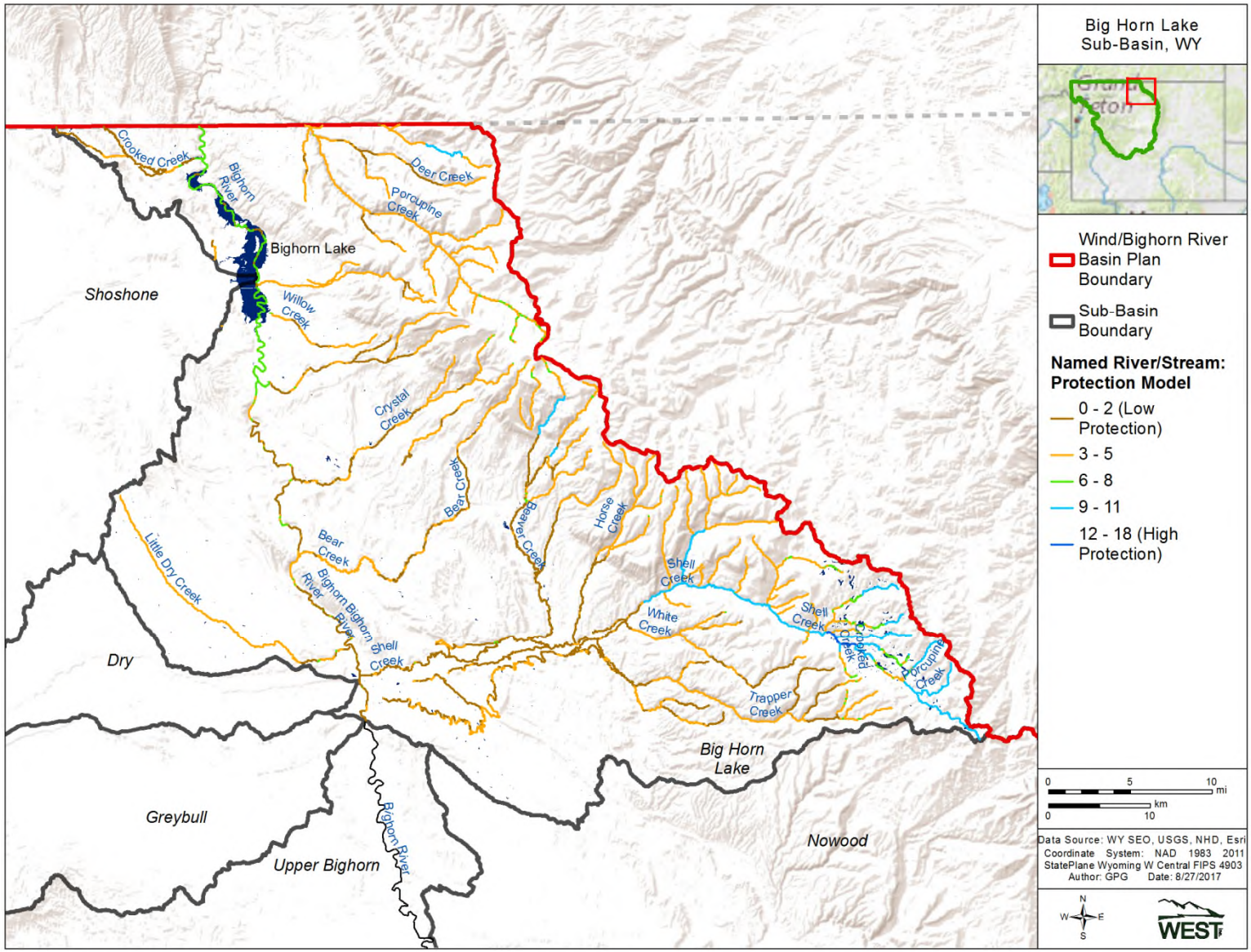

Figure A-5. Protection model results for the Big Horn Lake sub-basin in Wyoming.

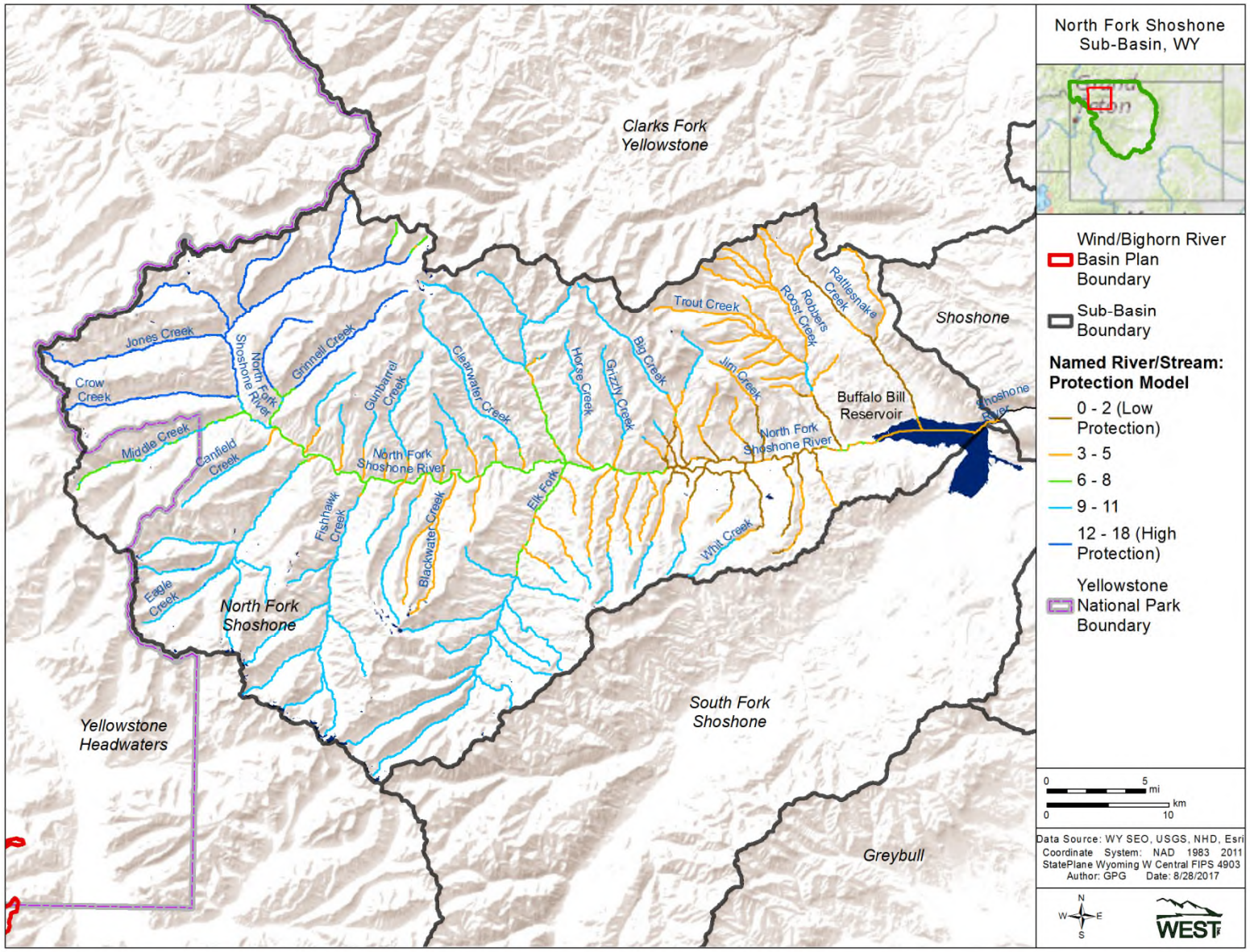

Figure A-6. Protection model results for the North Fork Shoshone sub-basin in Wyoming.

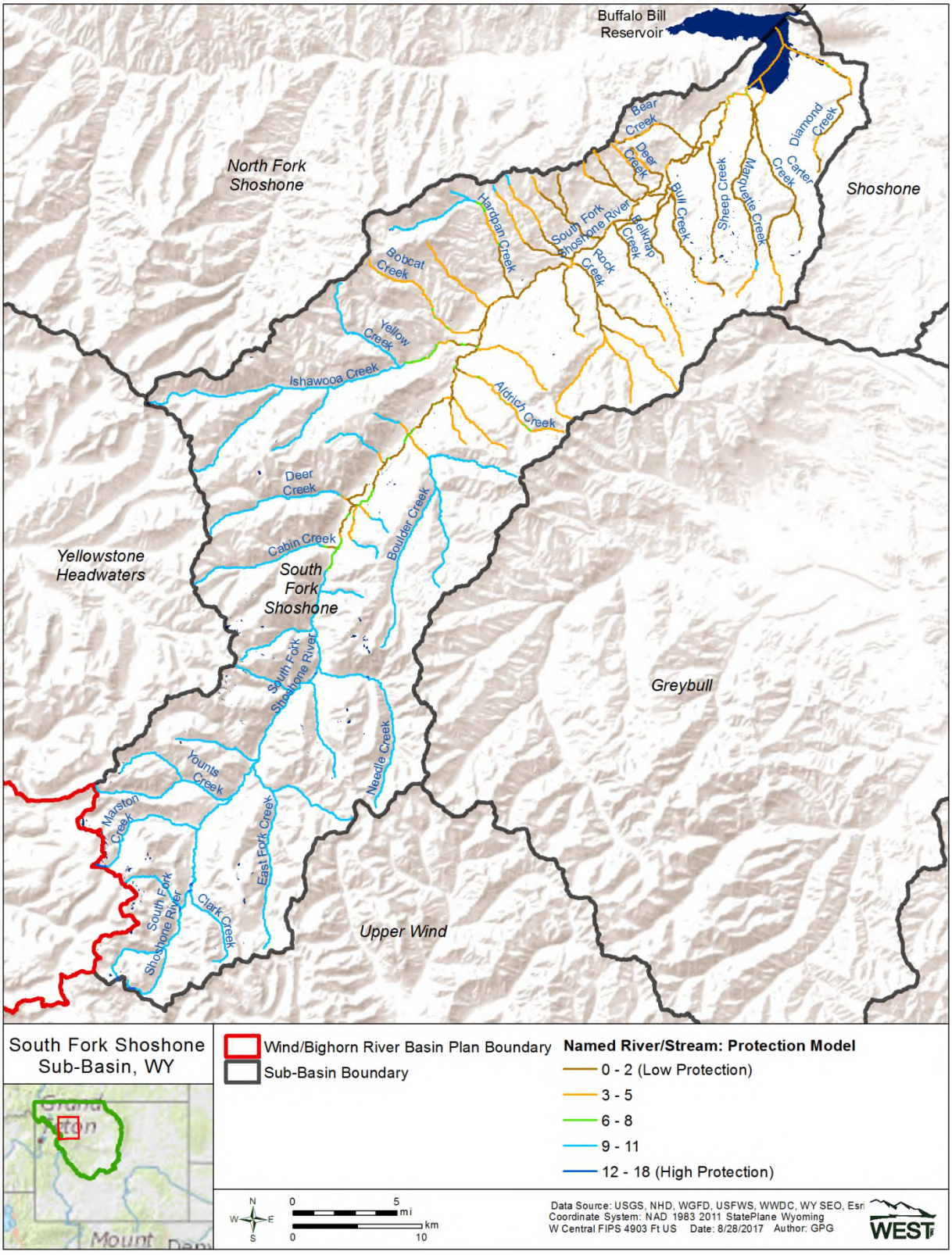

Figure A-7. Protection model results for the South Fork Shoshone sub-basin in Wyoming.

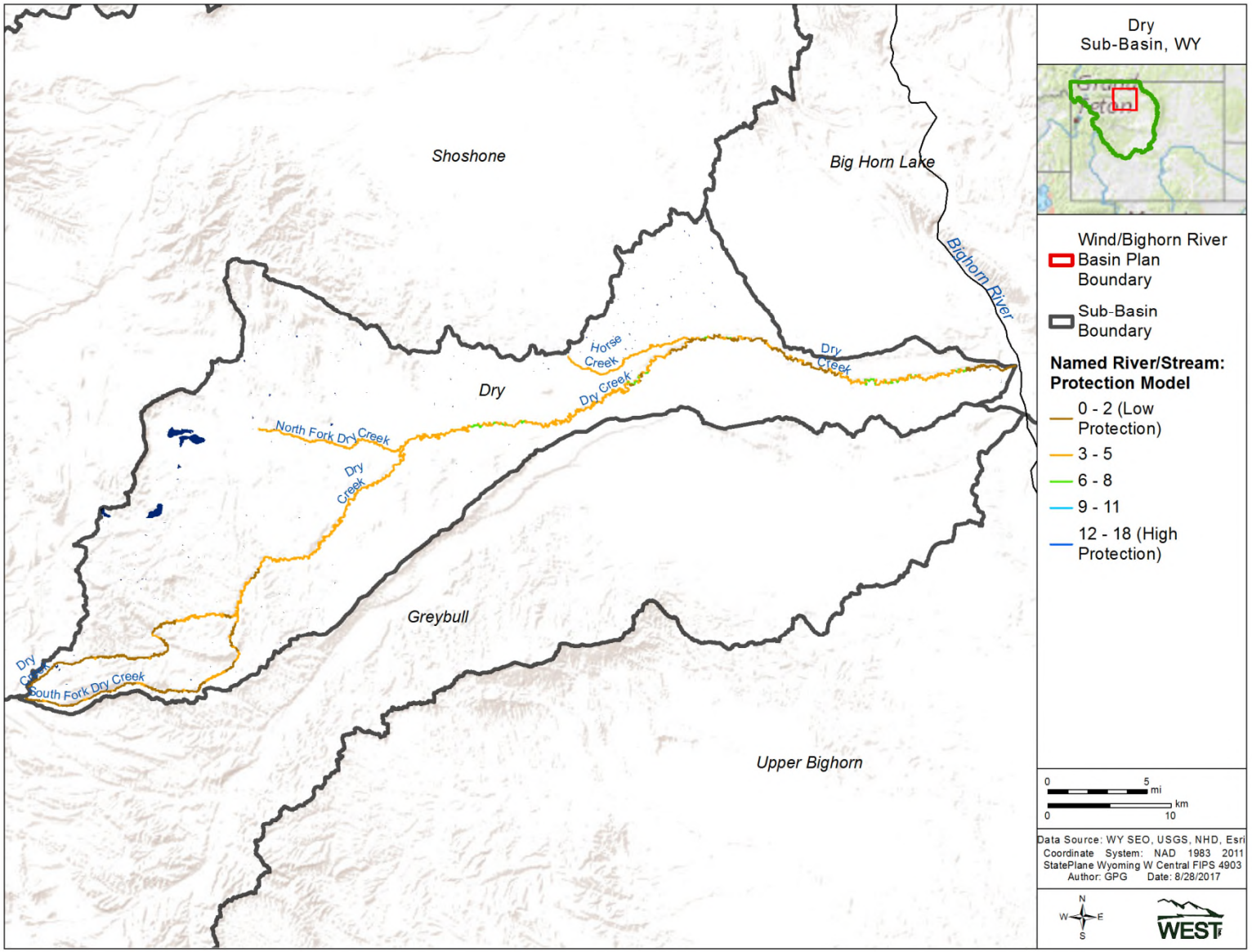

Figure A-8. Protection model results for the Dry sub-basin in Wyoming.

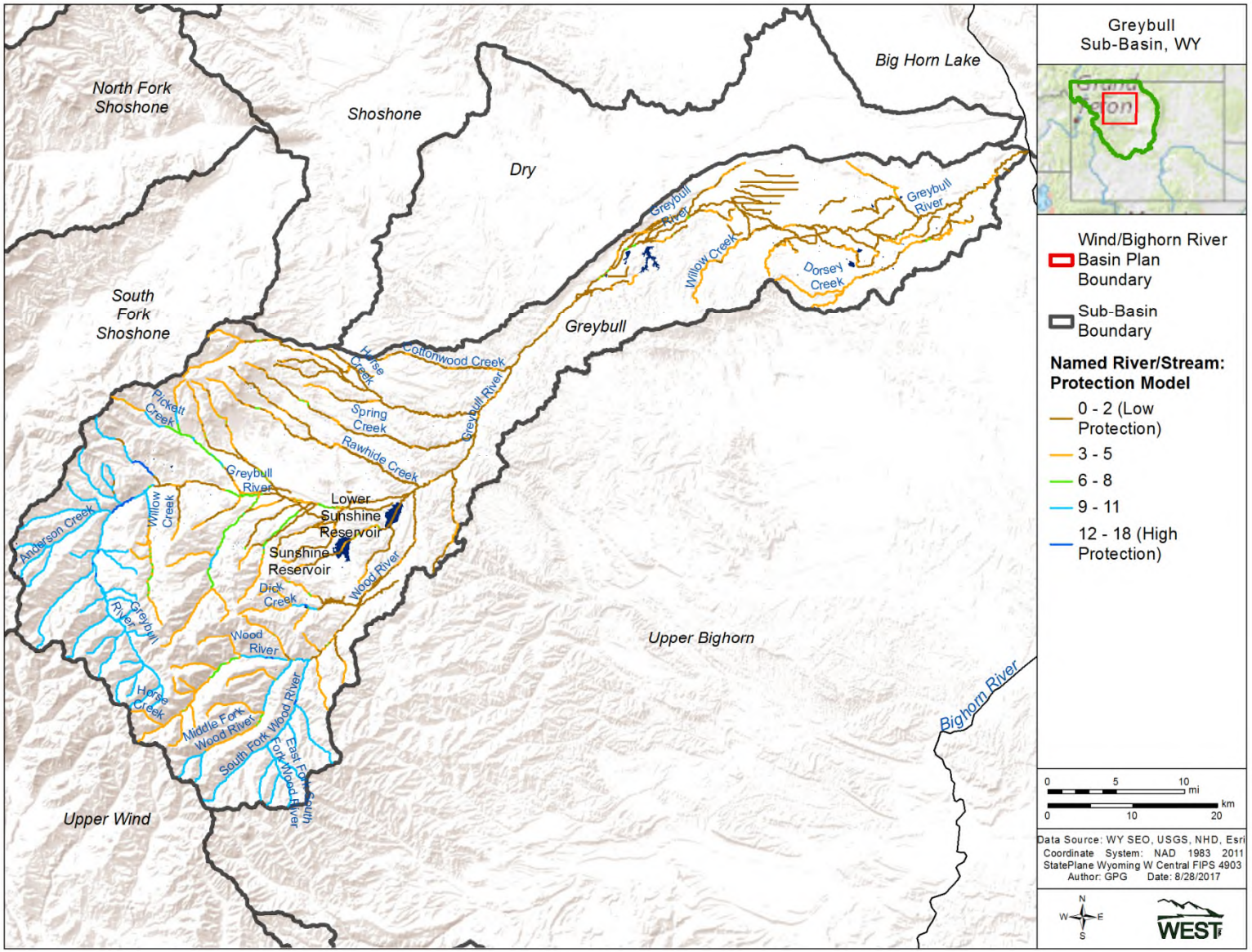

Figure A-9. Protection model results for the Greybull sub-basin in Wyoming.

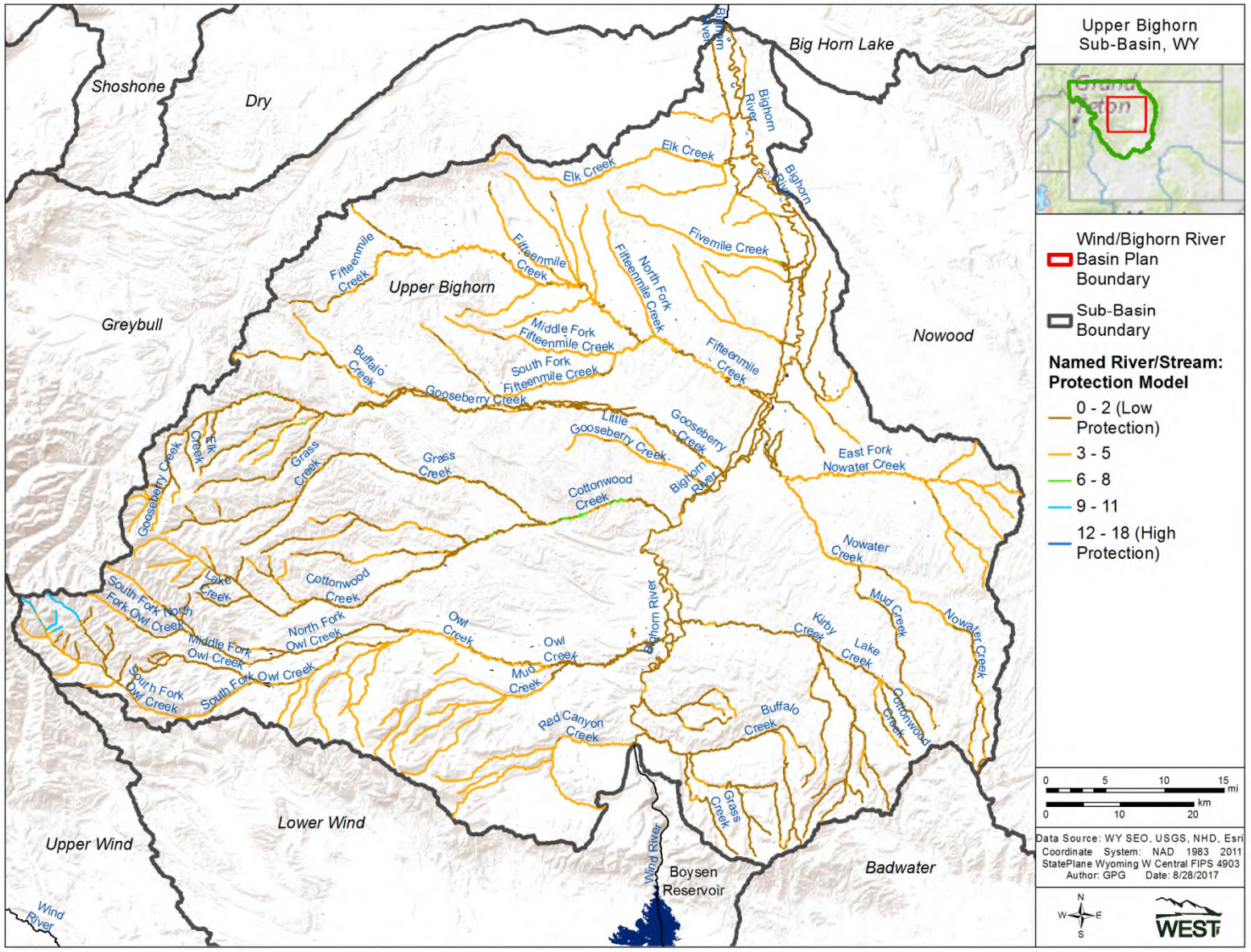

Figure A-10. Protection model results for the Upper Bighorn sub-basin in Wyoming.

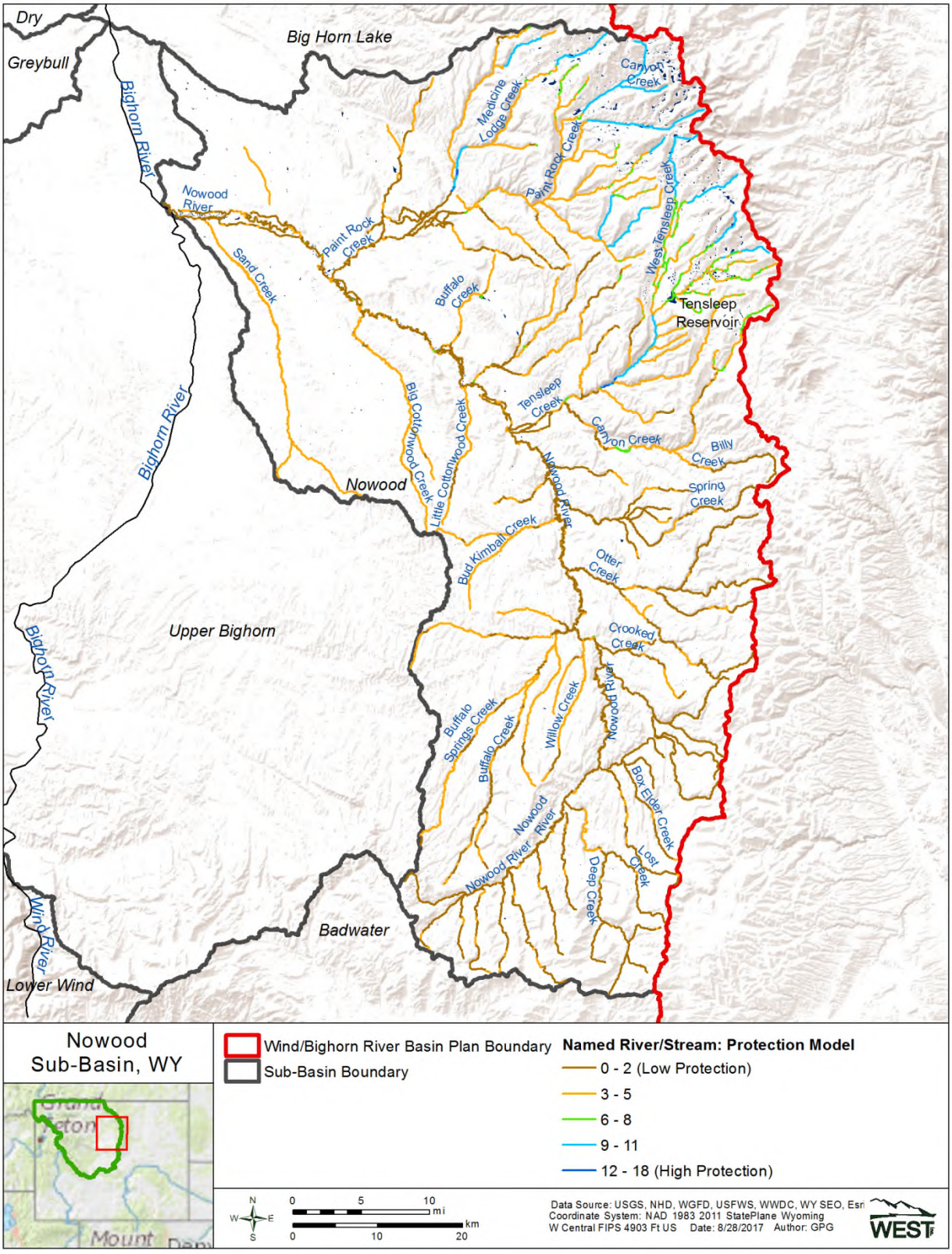

Figure A-11. Protection model results for the Nowood sub-basin in Wyoming.

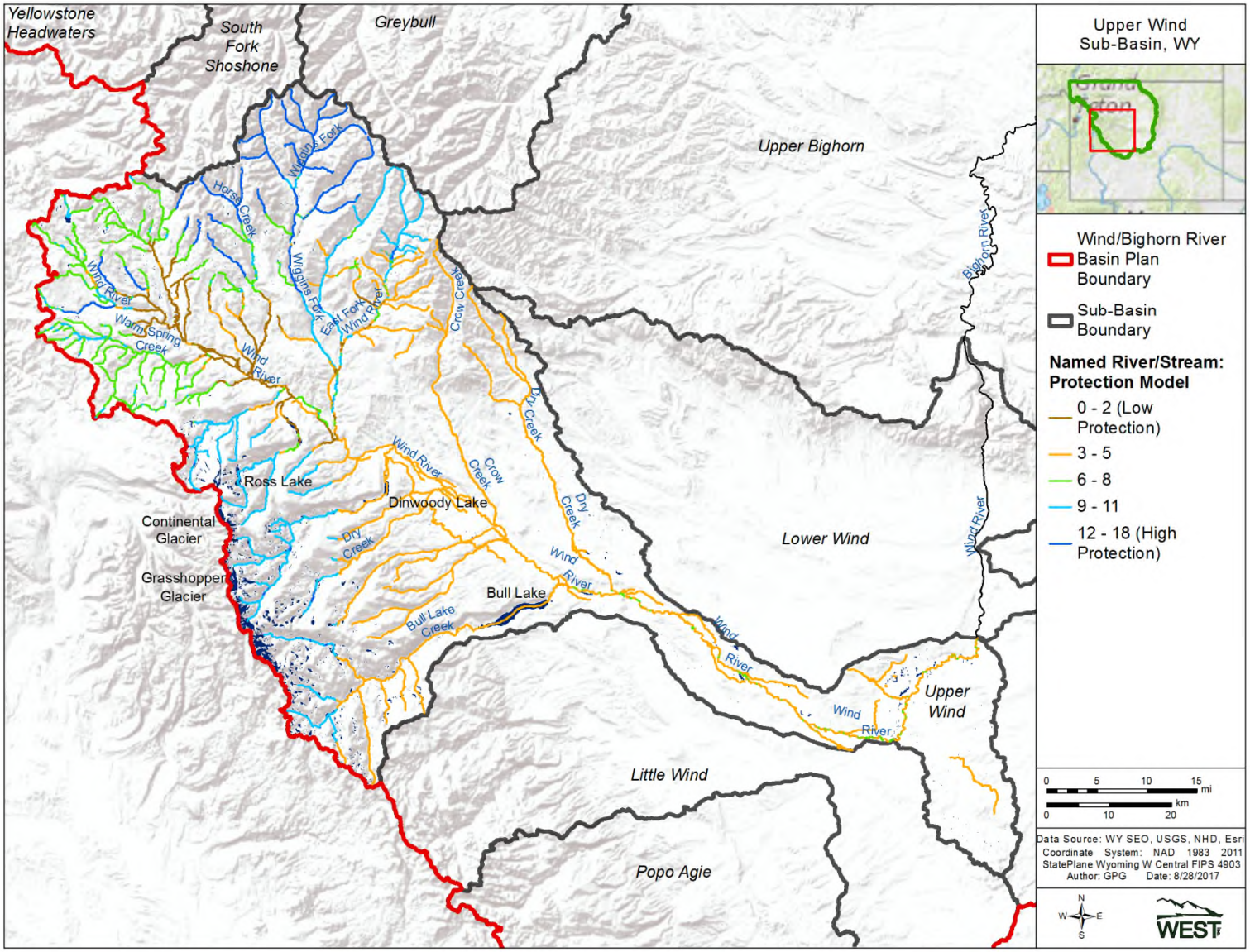

Figure A-12. Protection model results for the Upper Wind sub-basin in Wyoming.

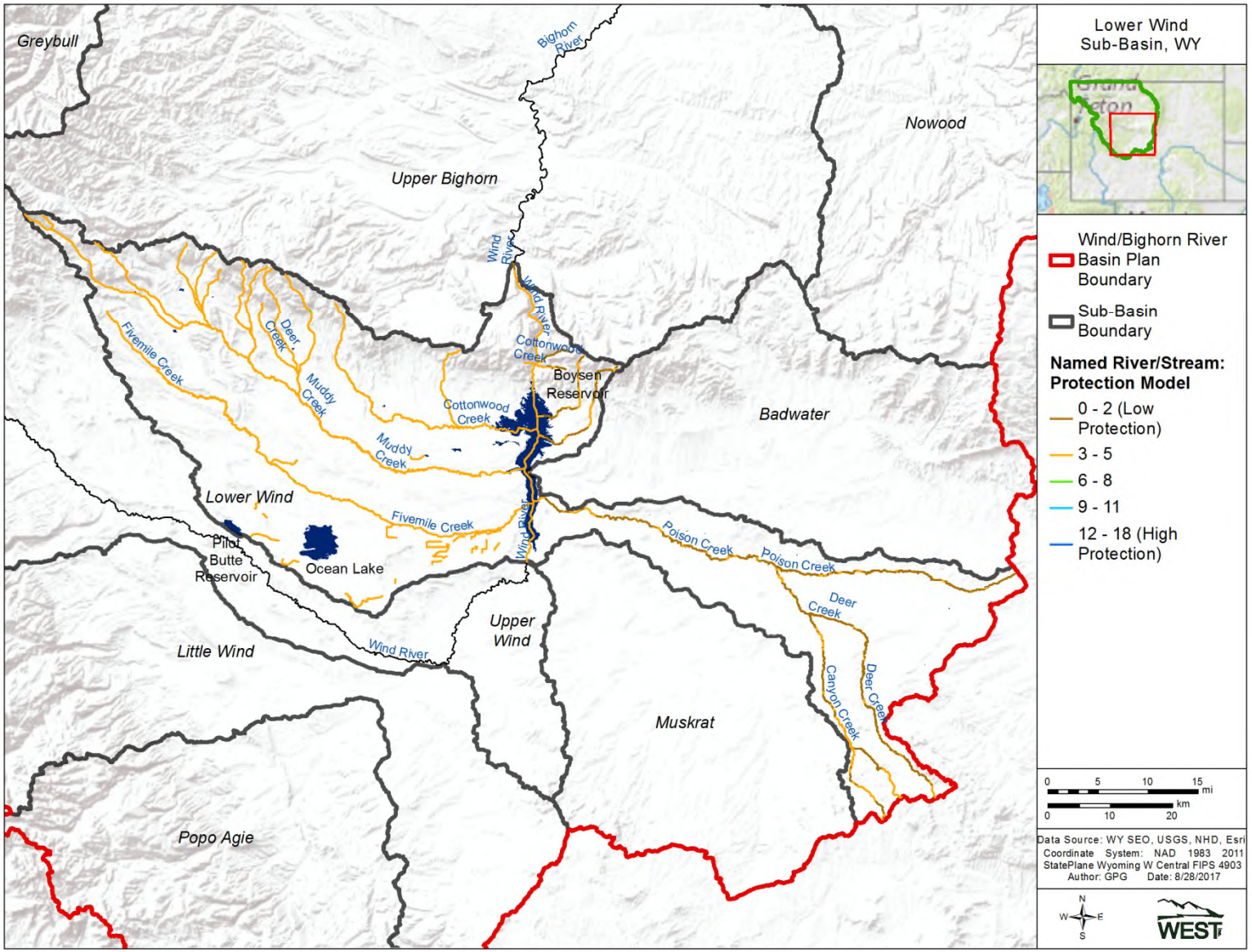

Figure A-13. Protection model results for the Lower Wind sub-basin in Wyoming.

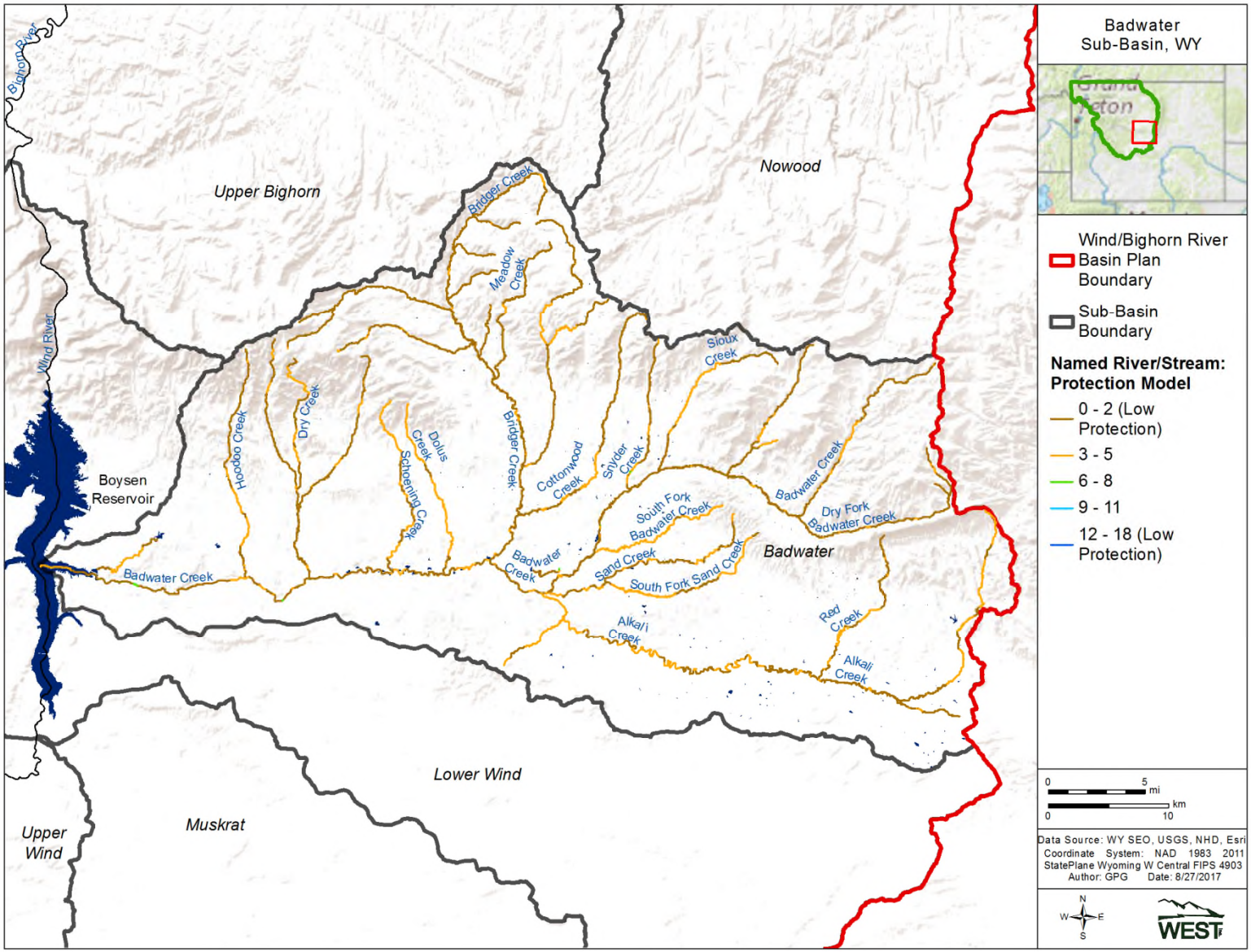

Figure A-14. Protection model results for the Badwater sub-basin in Wyoming.

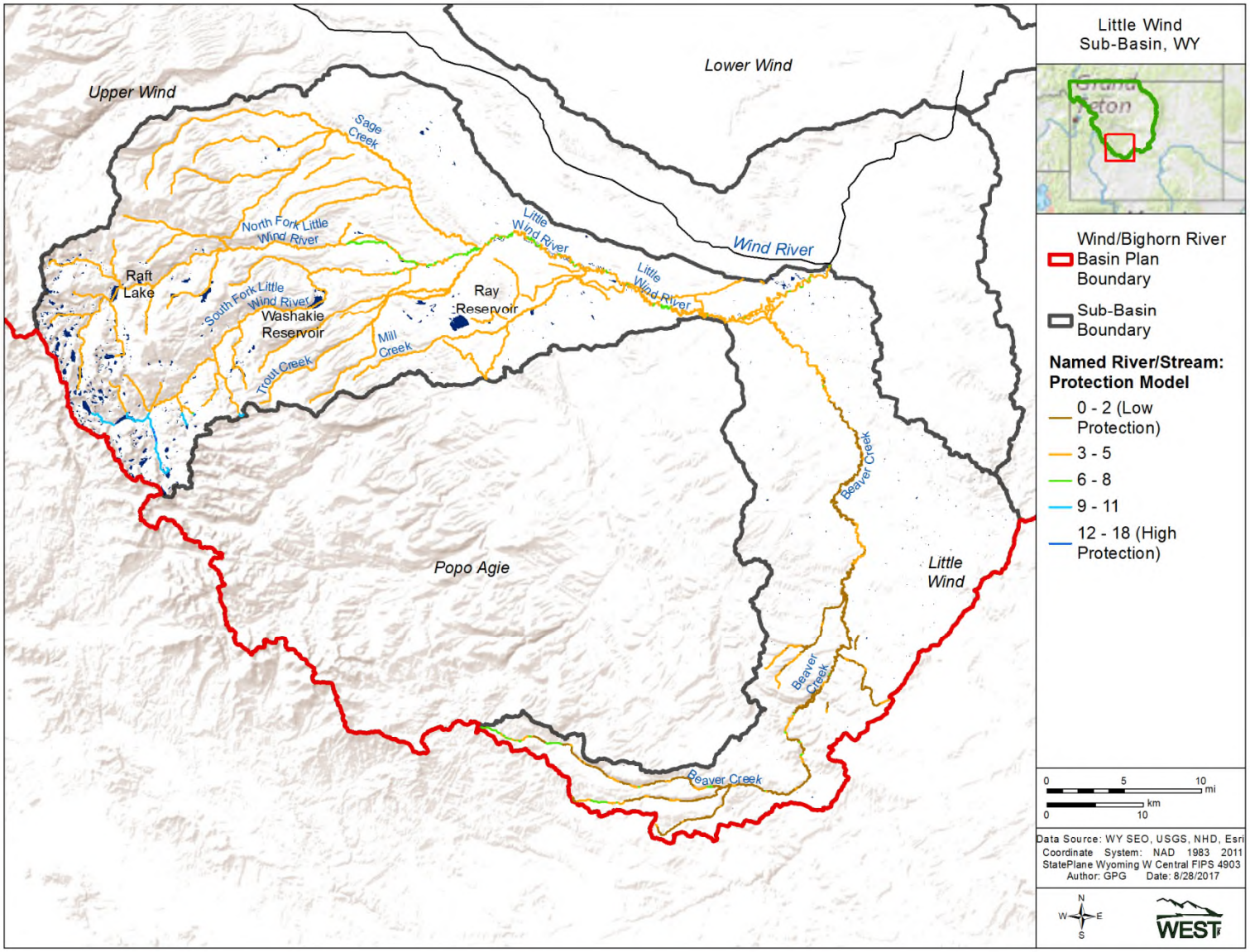

Figure A-15. Protection model results for the Little Wind sub-basin in Wyoming.

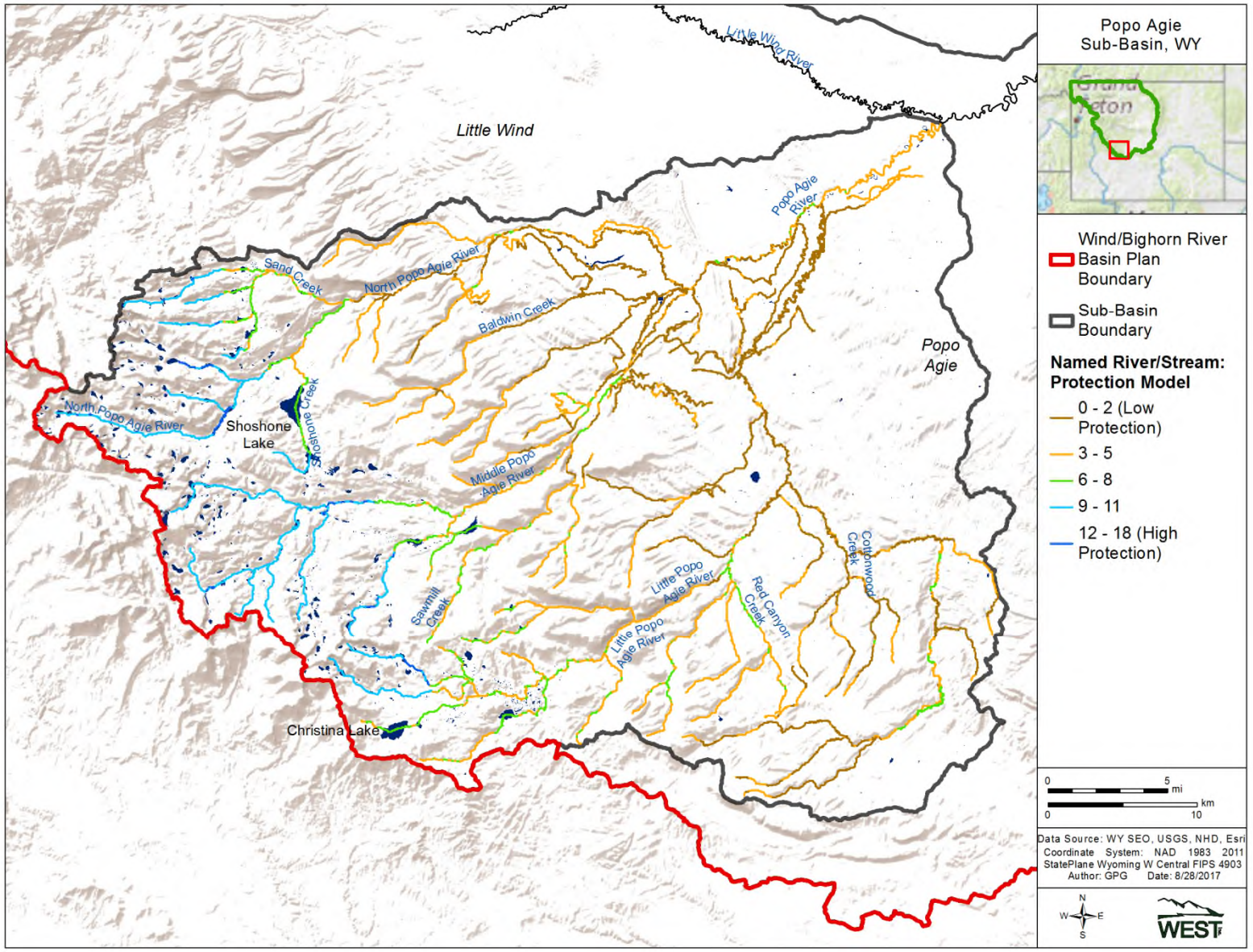

Figure A-16. Protection model results for the Popo Agie sub-basin in Wyoming.

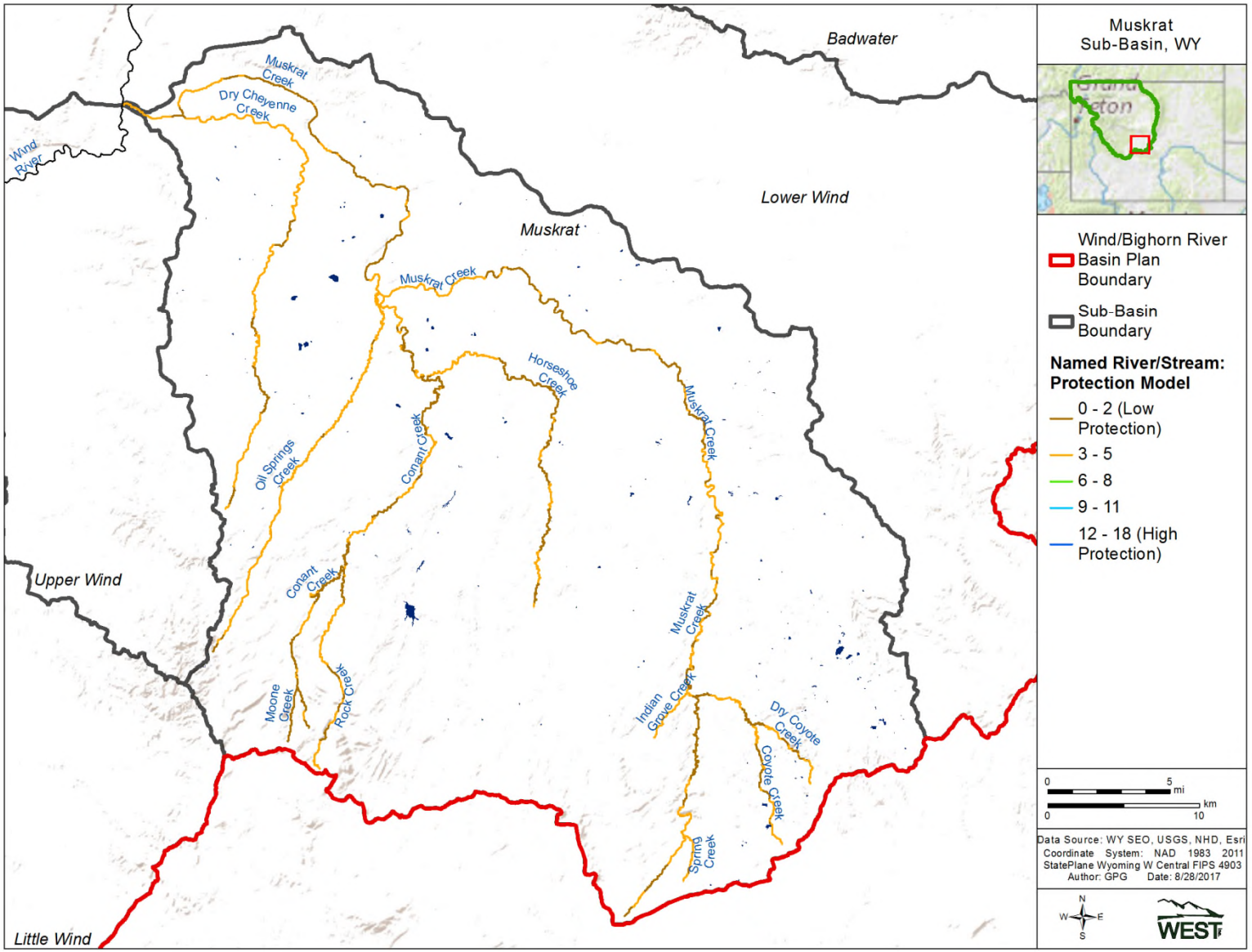

Figure A-17. Protection model results for the Muskrat sub-basin in Wyoming.

Appendix B. Environmental Model for the Wind – Bighorn River Basin

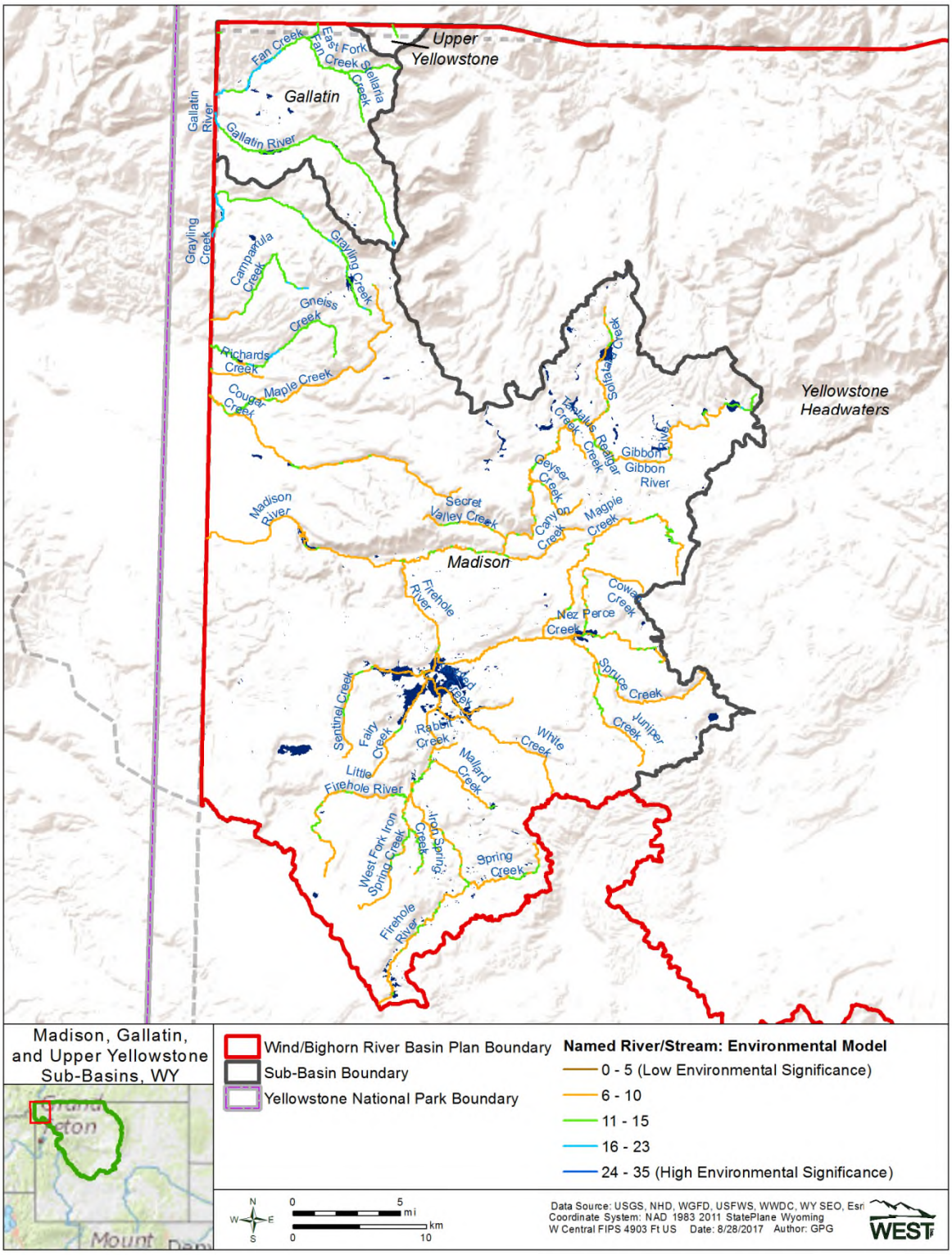

Figure B-1. Environmental model results for the Madison & Gallatin sub-basins in Wyoming.

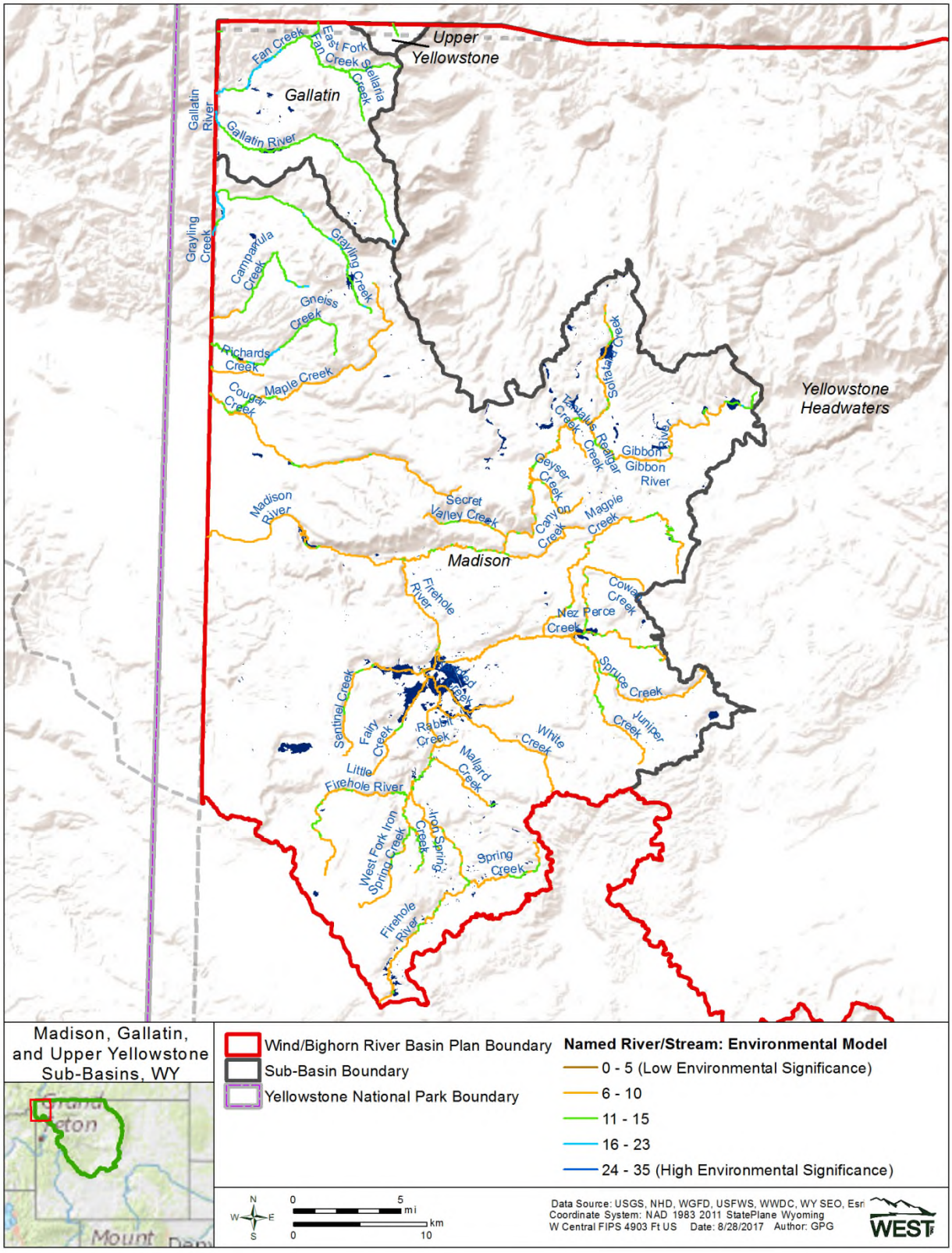

Figure B-2. Environmental model results for the Yellowstone Headwaters & Upper Yellowstone sub-basins in Wyoming.

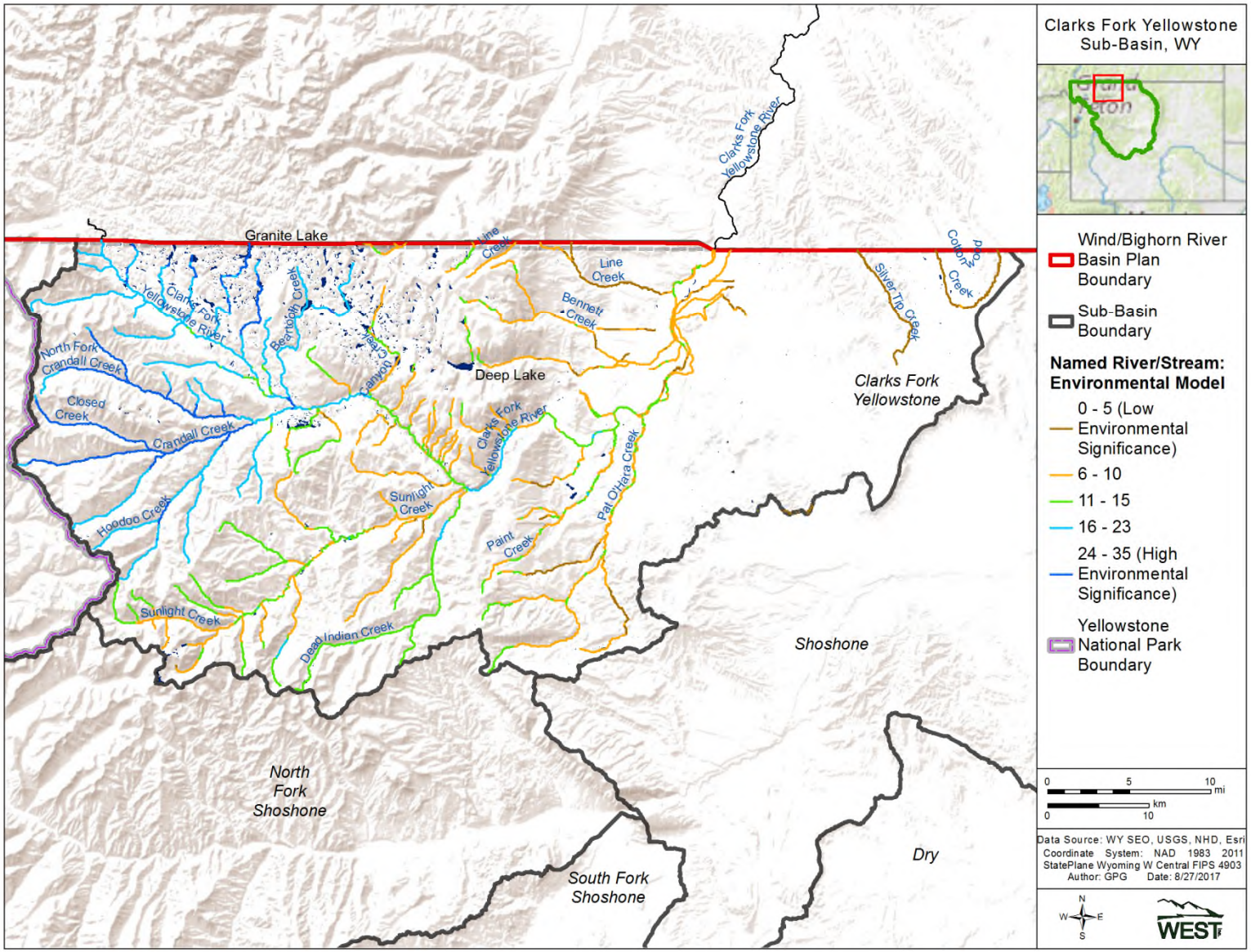

Figure B-3. Environmental Model Results for the Clarks Fork-Yellowstone Sub-basin in Wyoming.

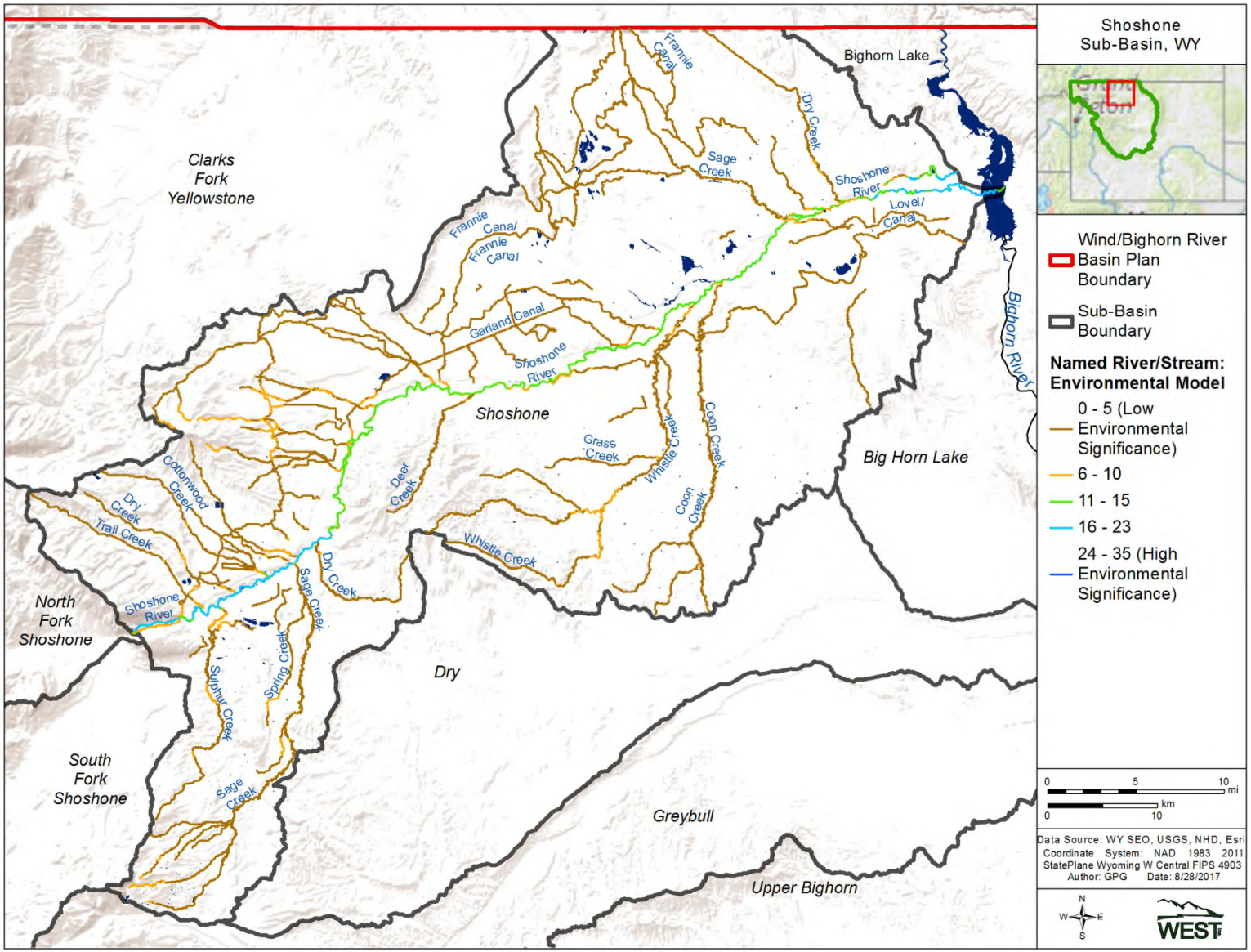

Figure B-4. Environmental Model Results for the Shoshone Sub-basin in Wyoming.

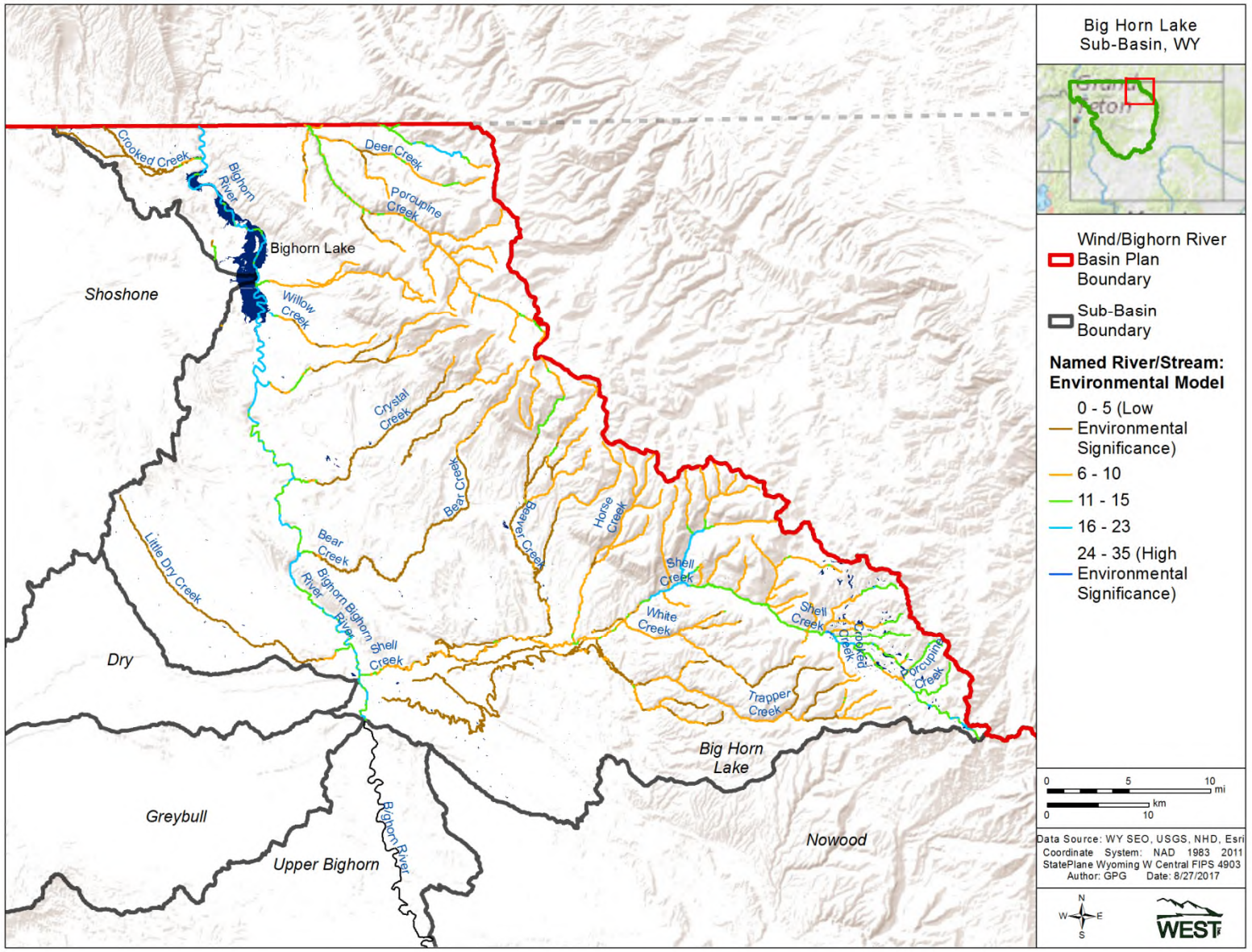

Figure B-5. Environmental model results for the Big Horn Lake sub-basin in Wyoming.

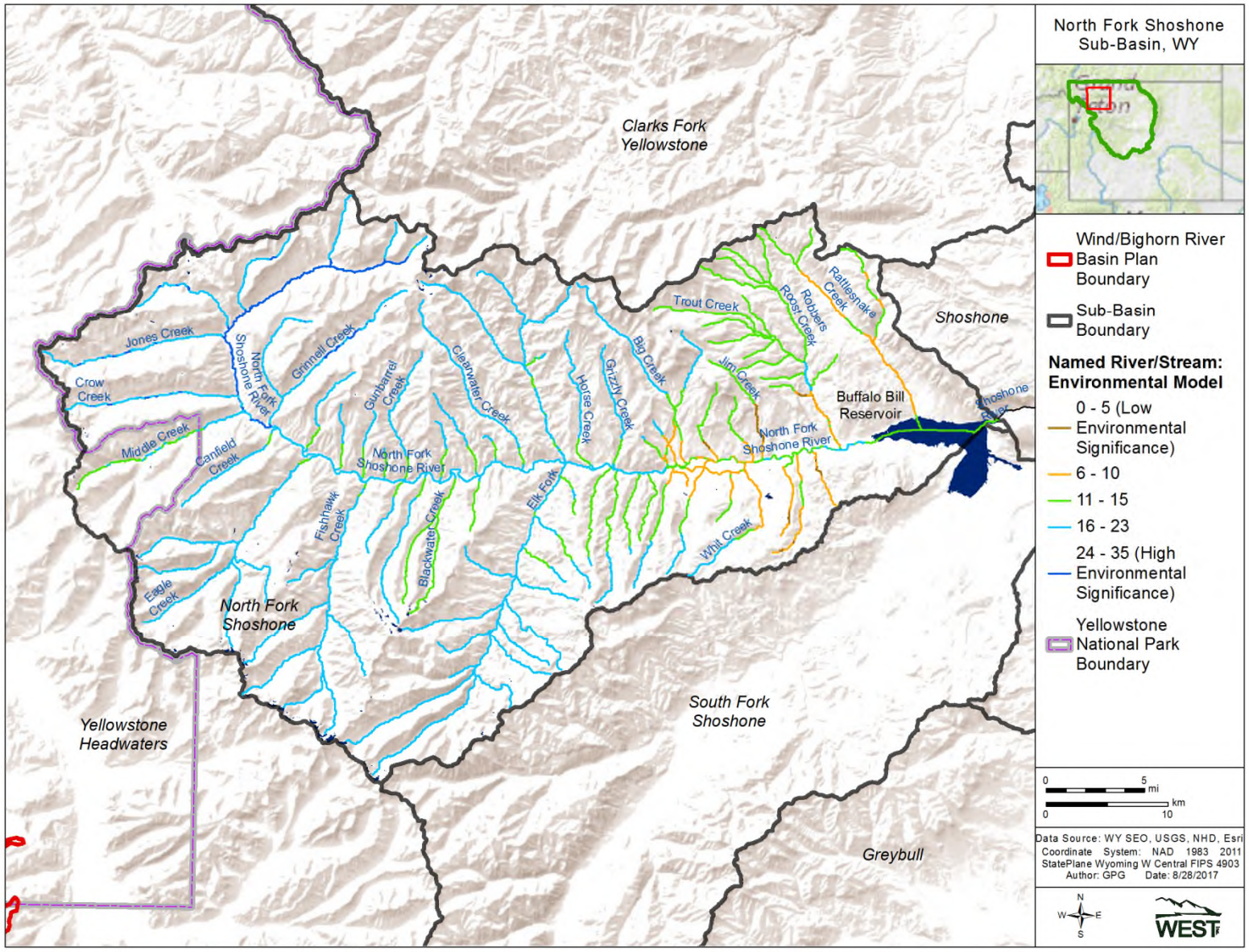

Figure B-6. Environmental model results for the North Fork Shoshone sub-basin in Wyoming.

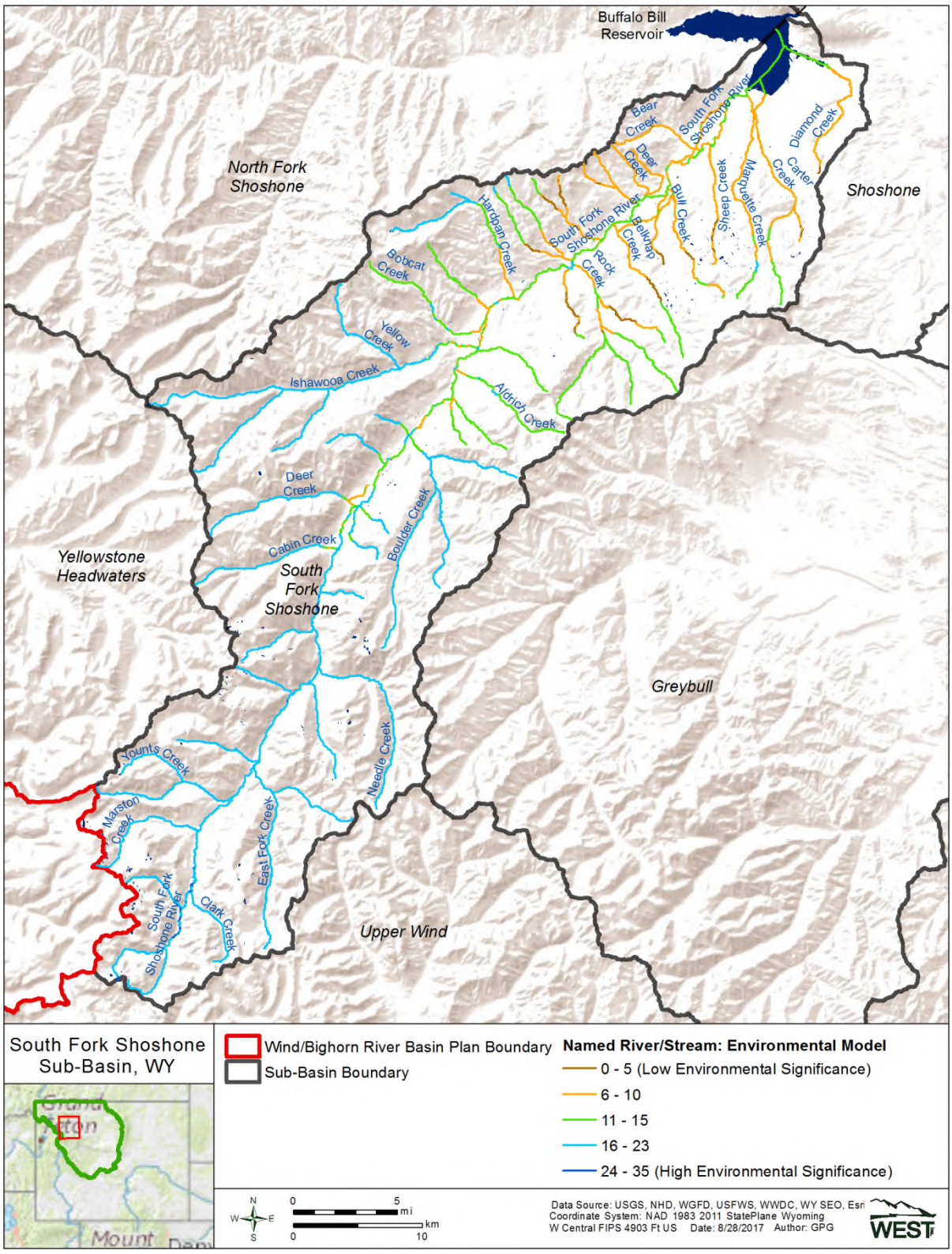

Figure B-7. Environmental model results for the South Fork Shoshone sub-basin in Wyoming.

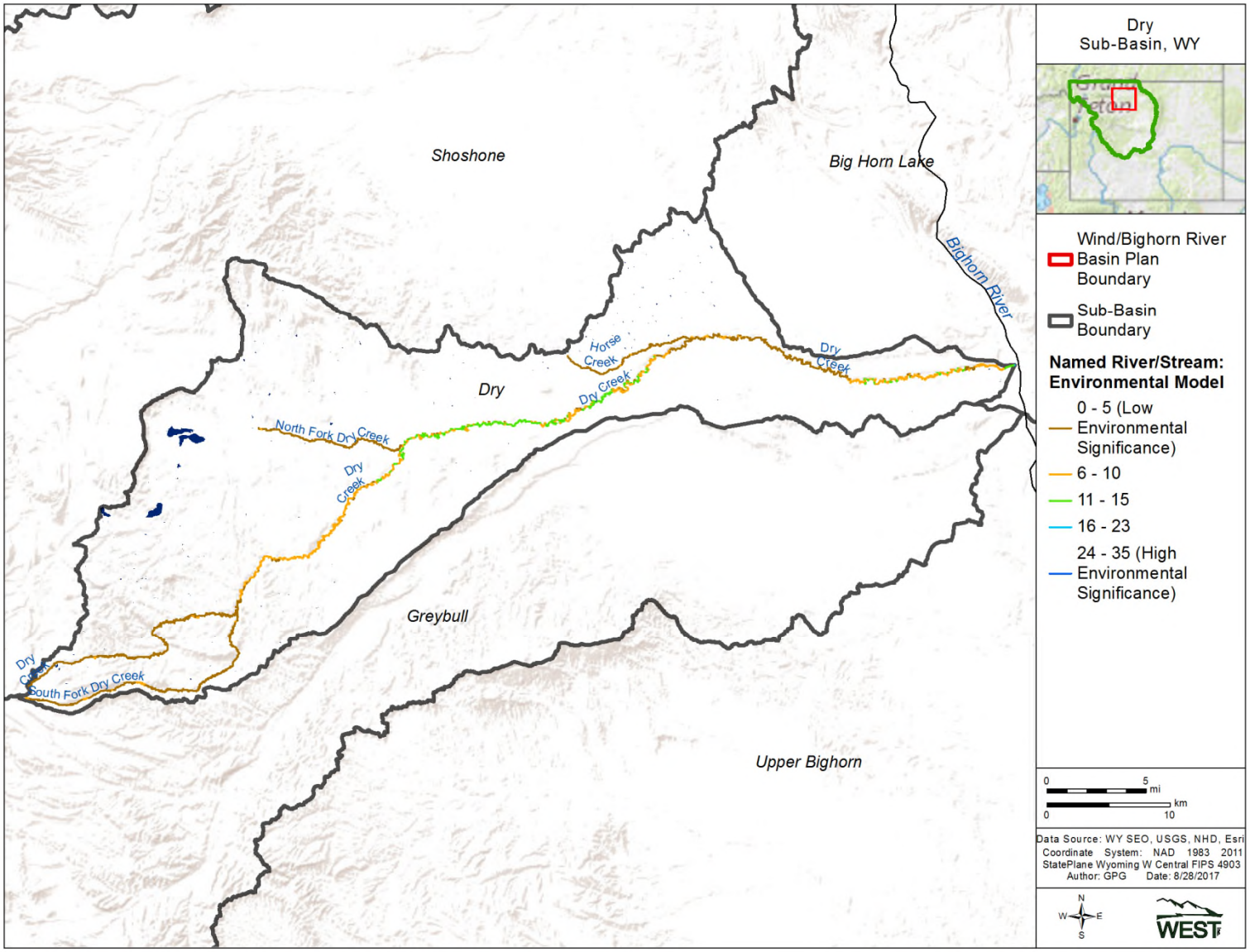

Figure B-8. Environmental model results for the Dry sub-basin in Wyoming.

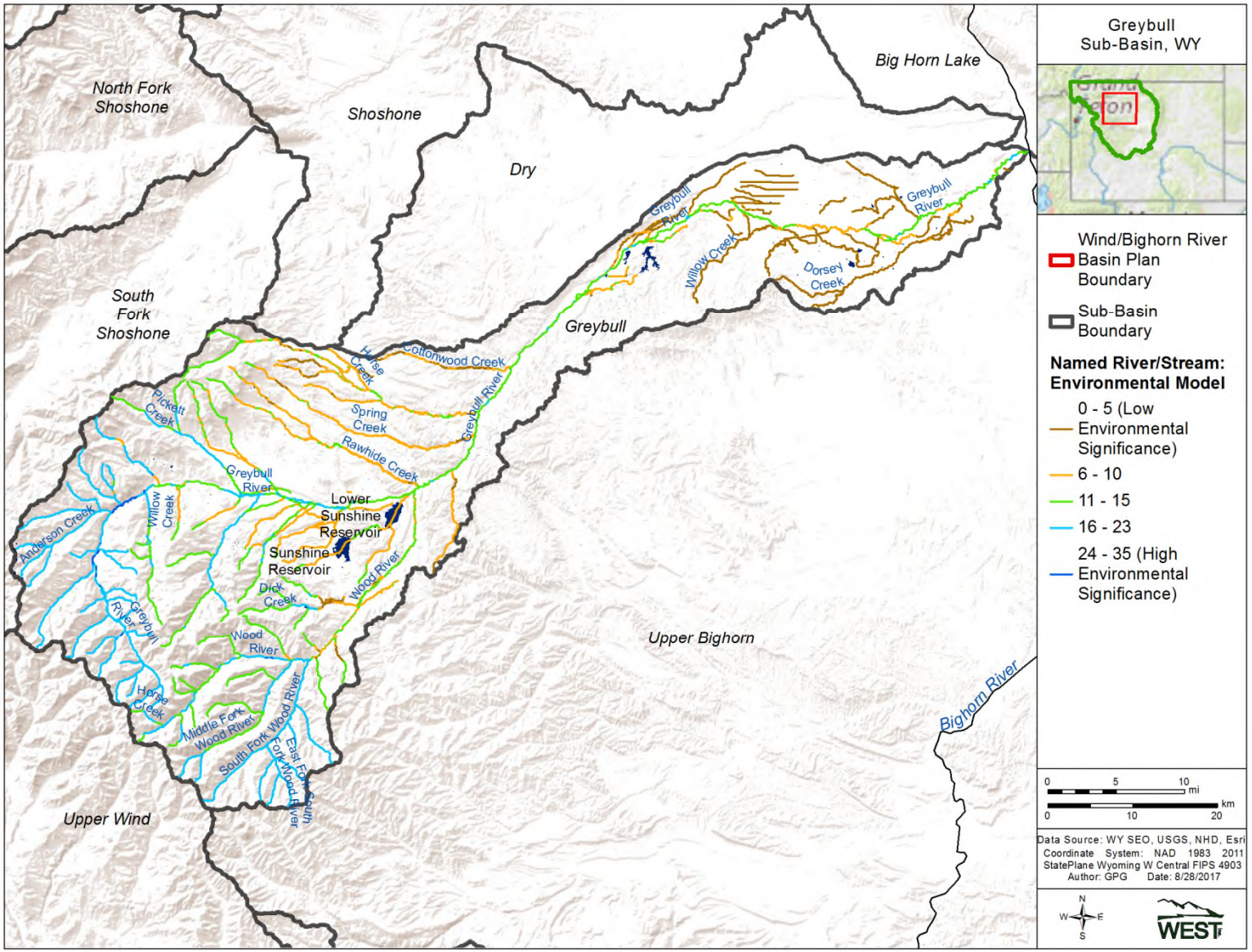

Figure B-9. Environmental model results for the Greybull sub-basin in Wyoming.

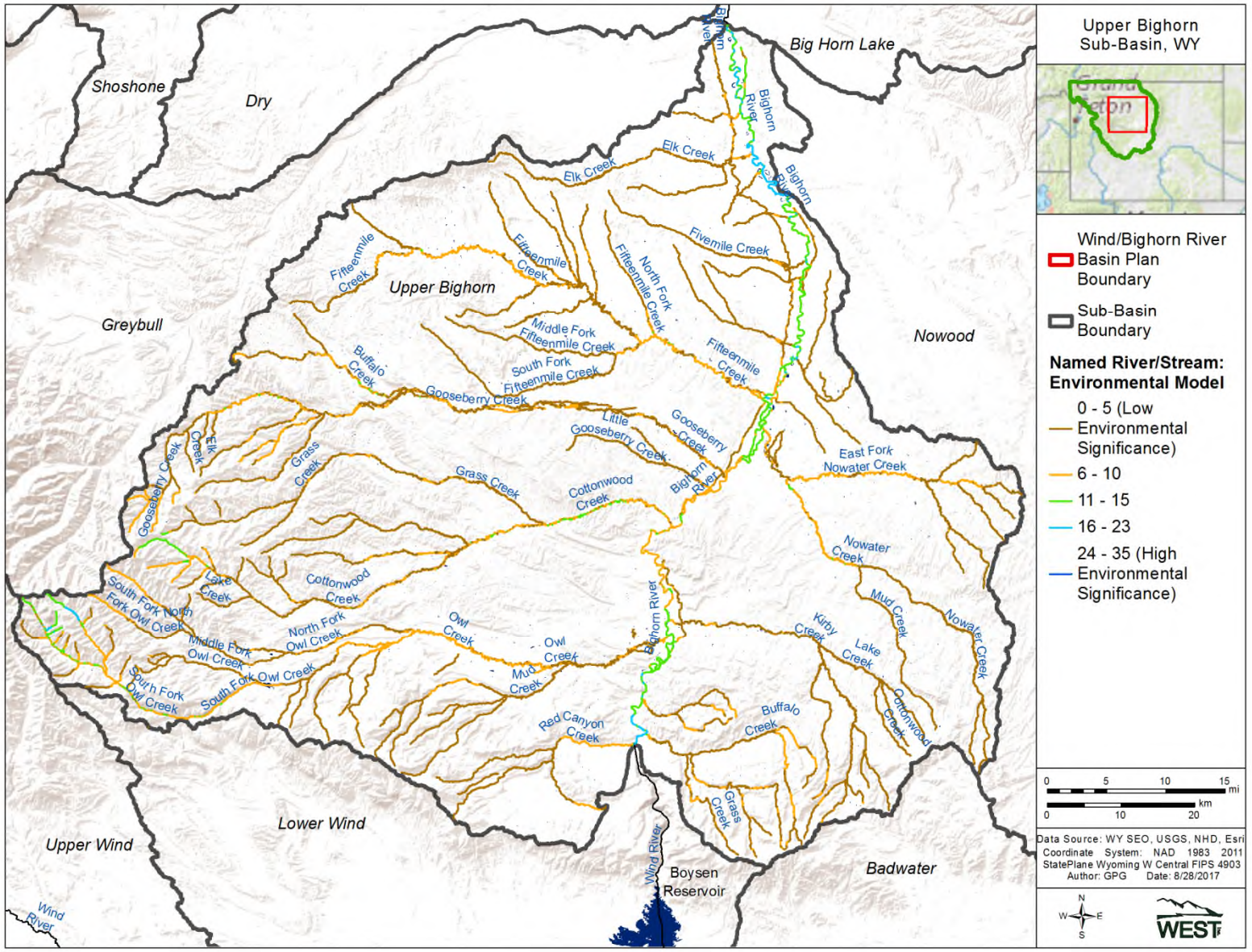

Figure B-10. Environmental model results for the Upper Bighorn sub-basin in Wyoming.

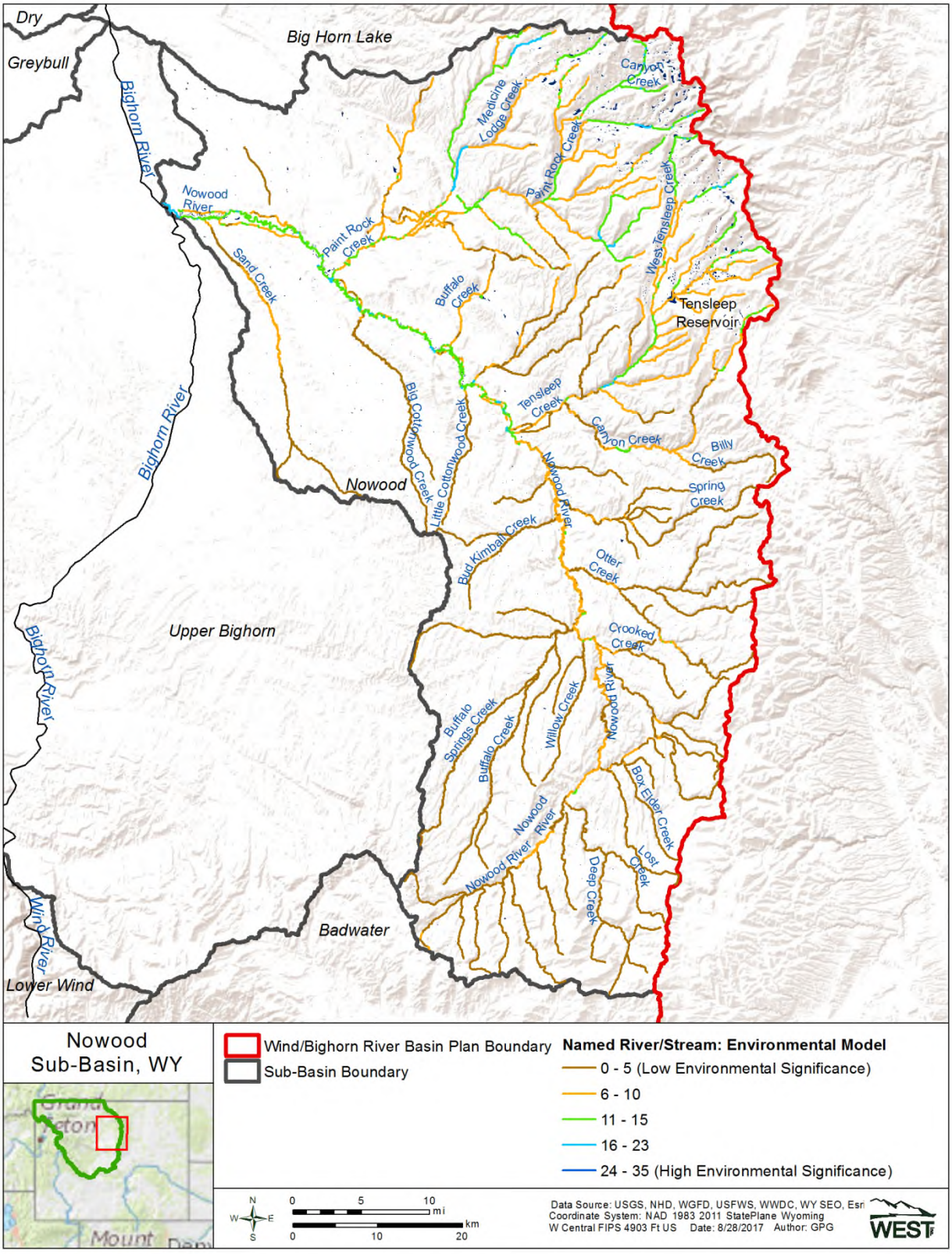

Figure B-11. Environmental model results for the Nowood sub-basin in Wyoming.

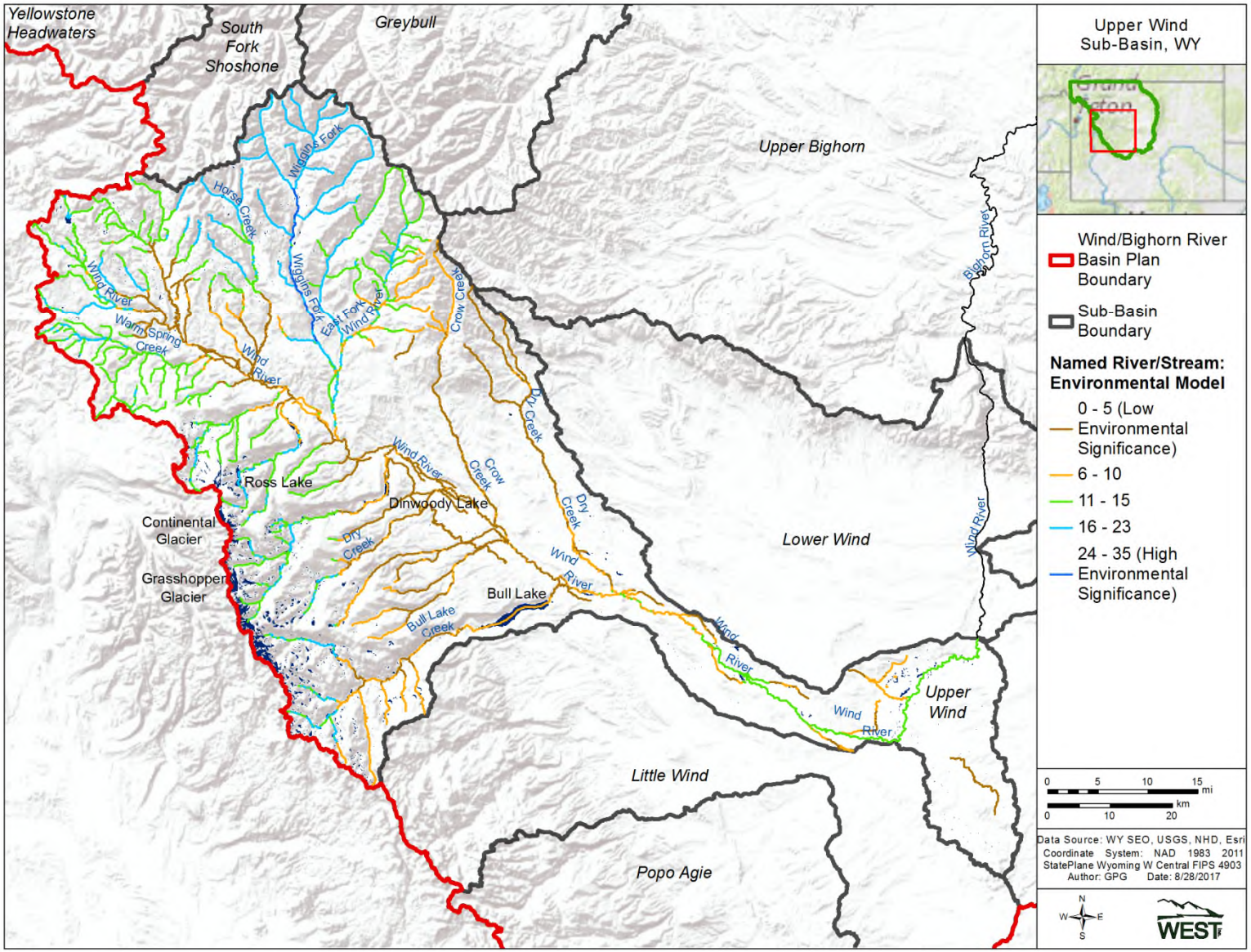

Figure B-12. Environmental model results for the Upper Wind sub-basin in Wyoming.

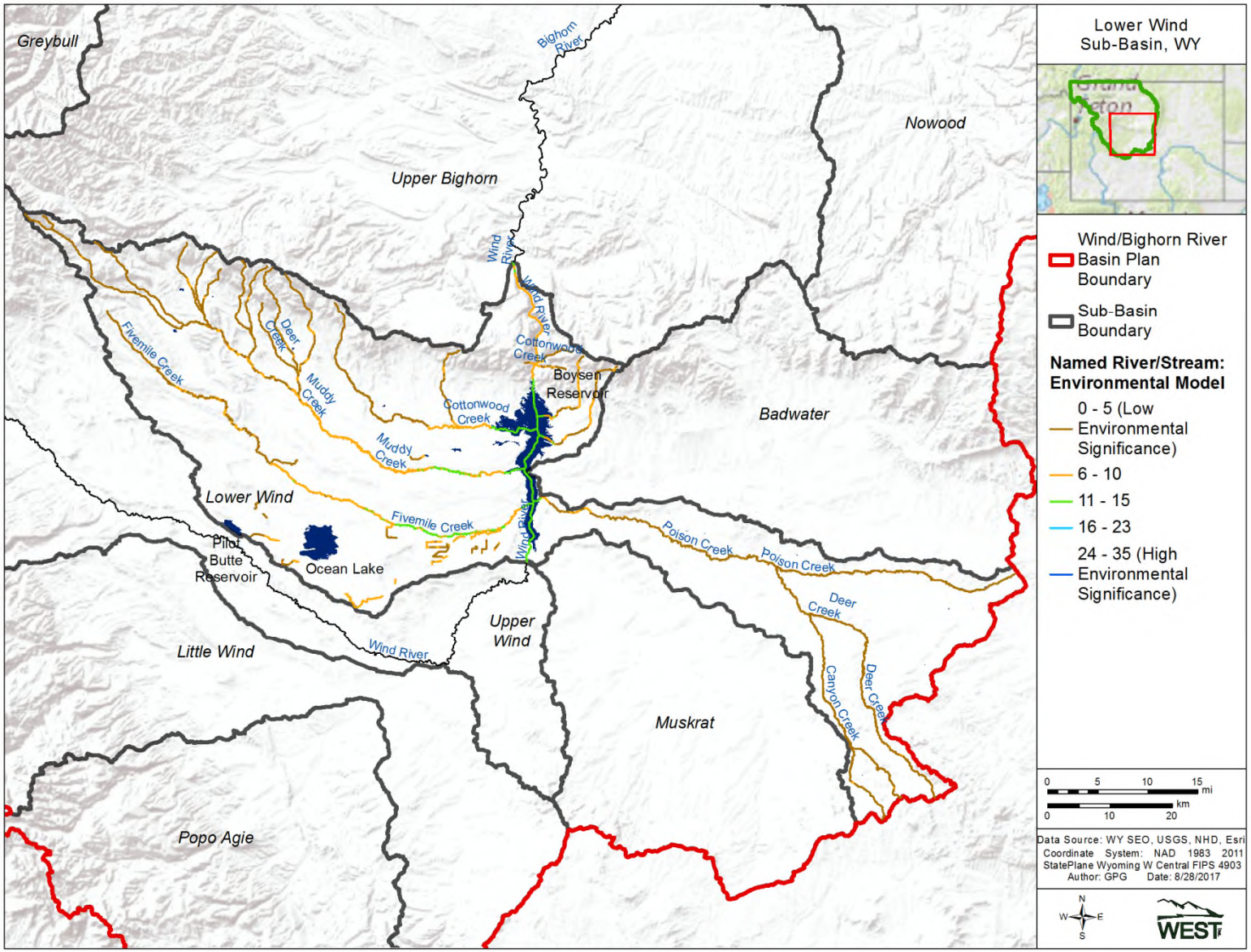

Figure B-13. Environmental model results for the Lower Wind sub-basin in Wyoming.

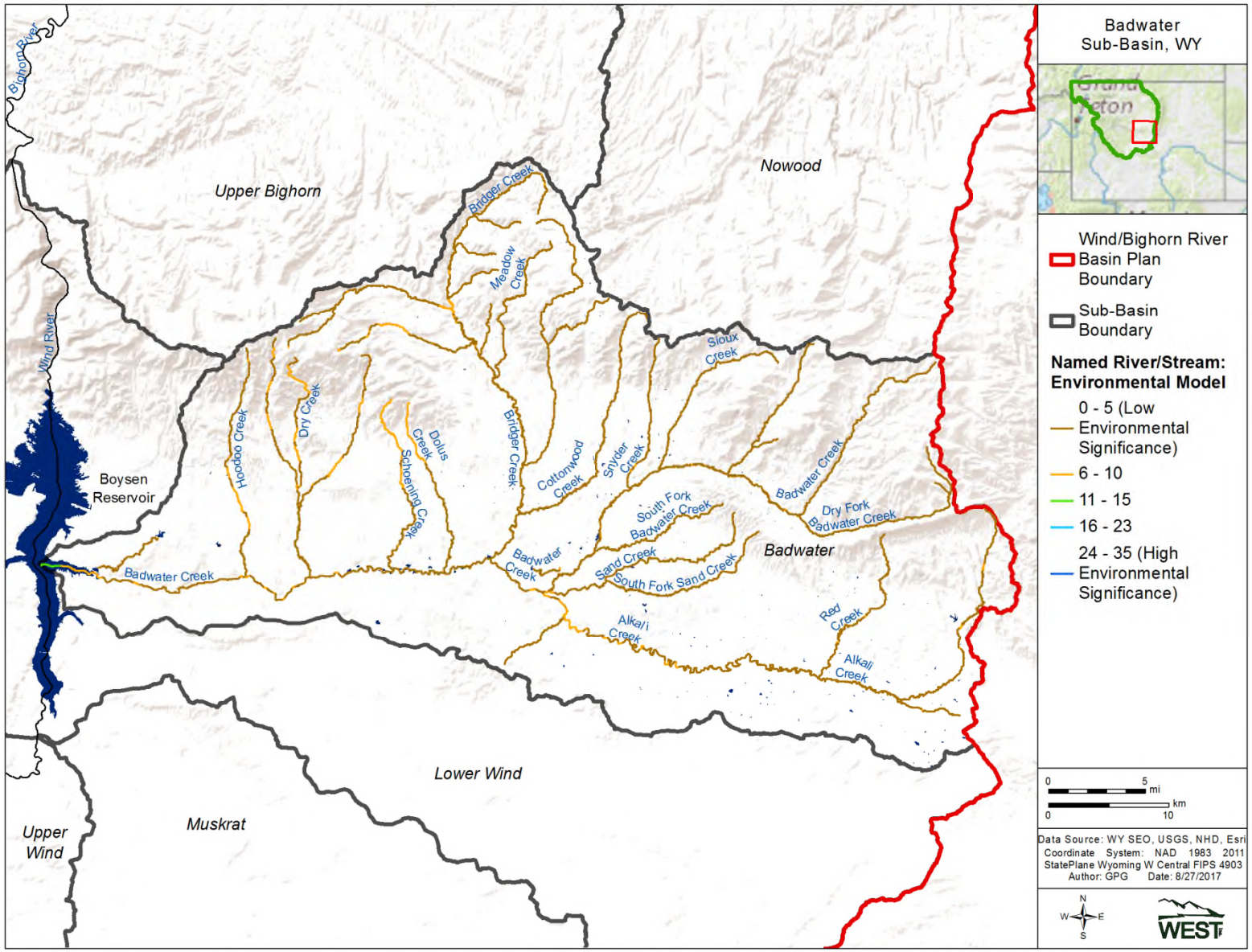

Figure B-14. Environmental model results for the Badwater sub-basin in Wyoming.

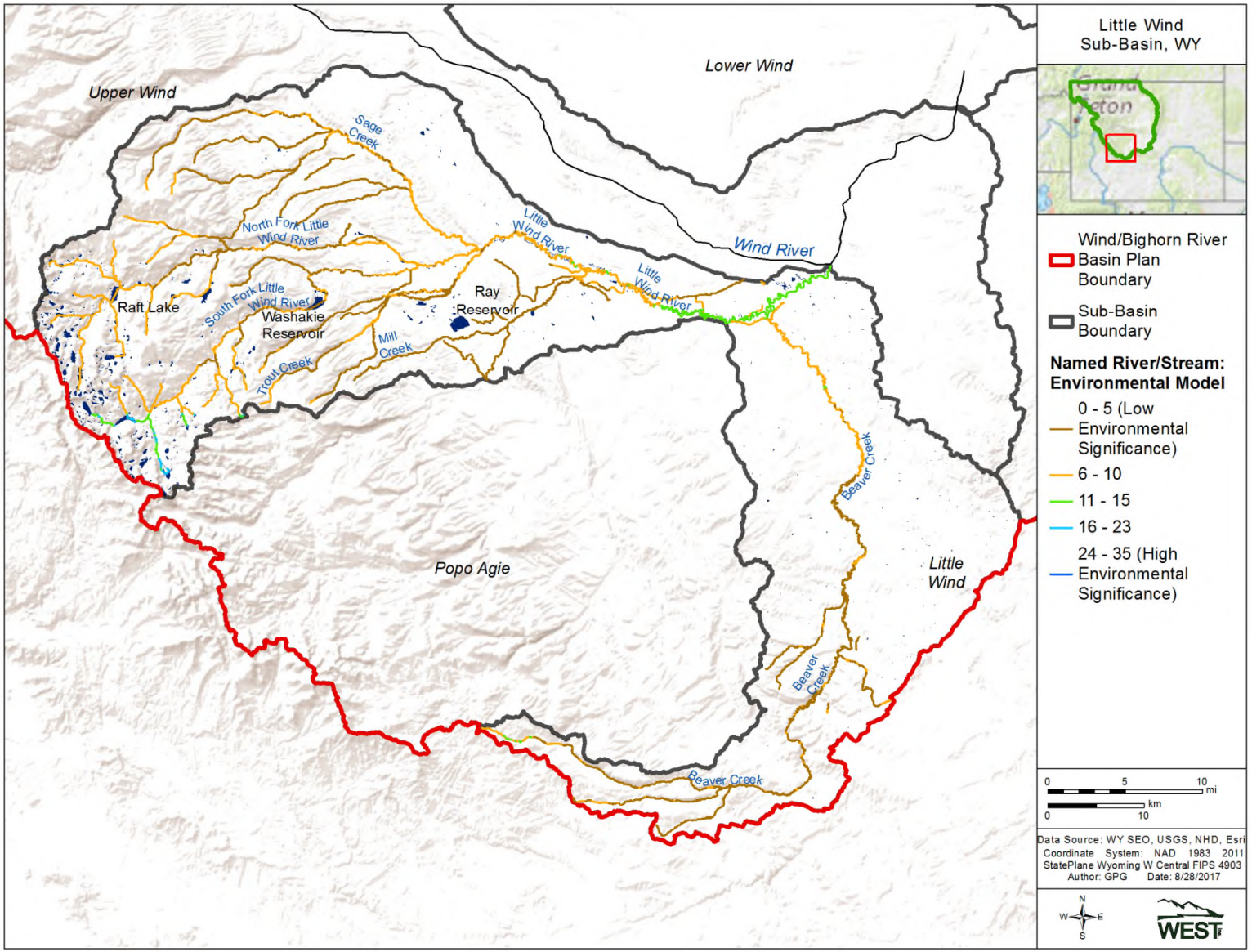

Figure B-15. Environmental model results for the Little Wind sub-basin in Wyoming.

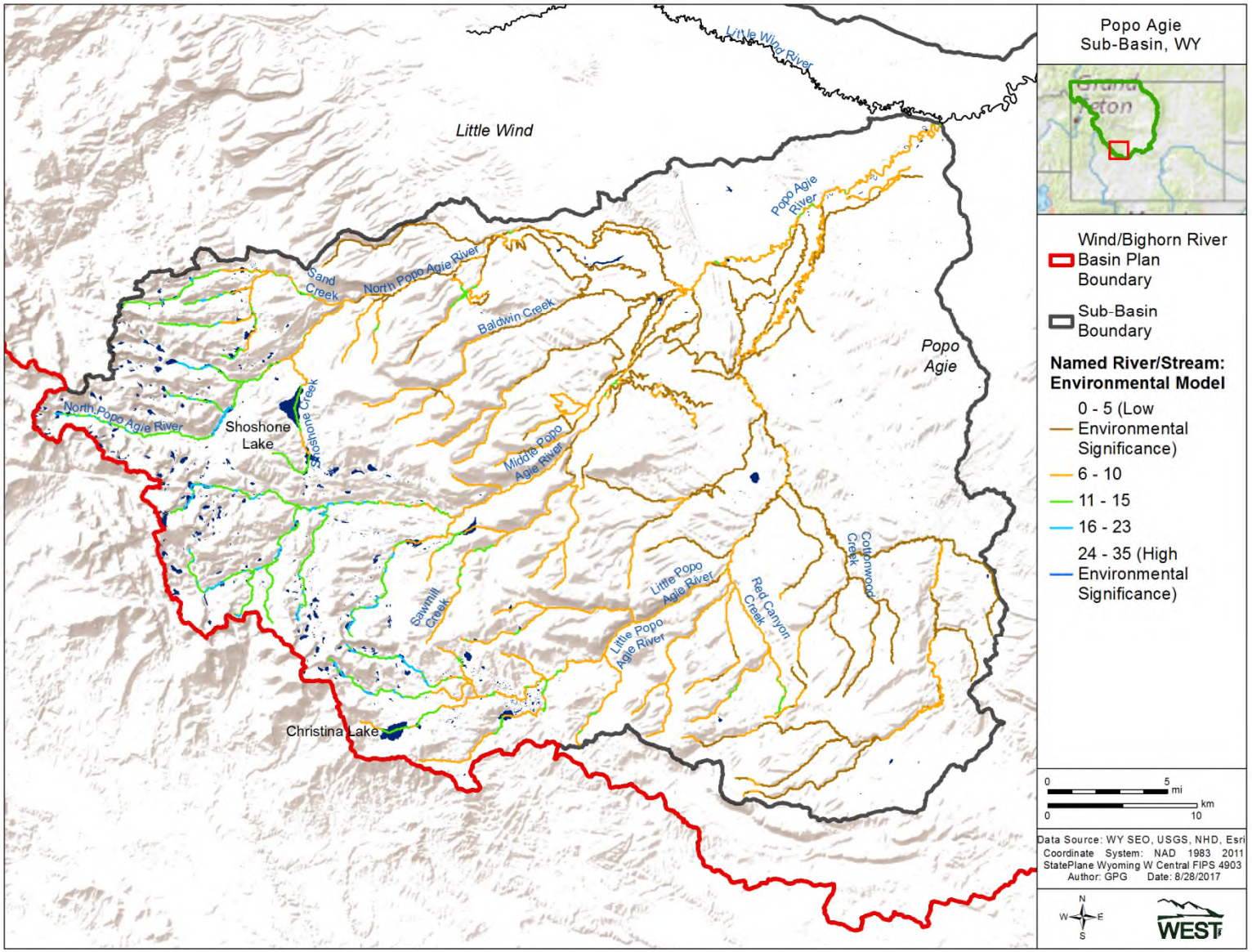

Figure B-16. Environmental model results for the Popo Agie sub-basin in Wyoming.

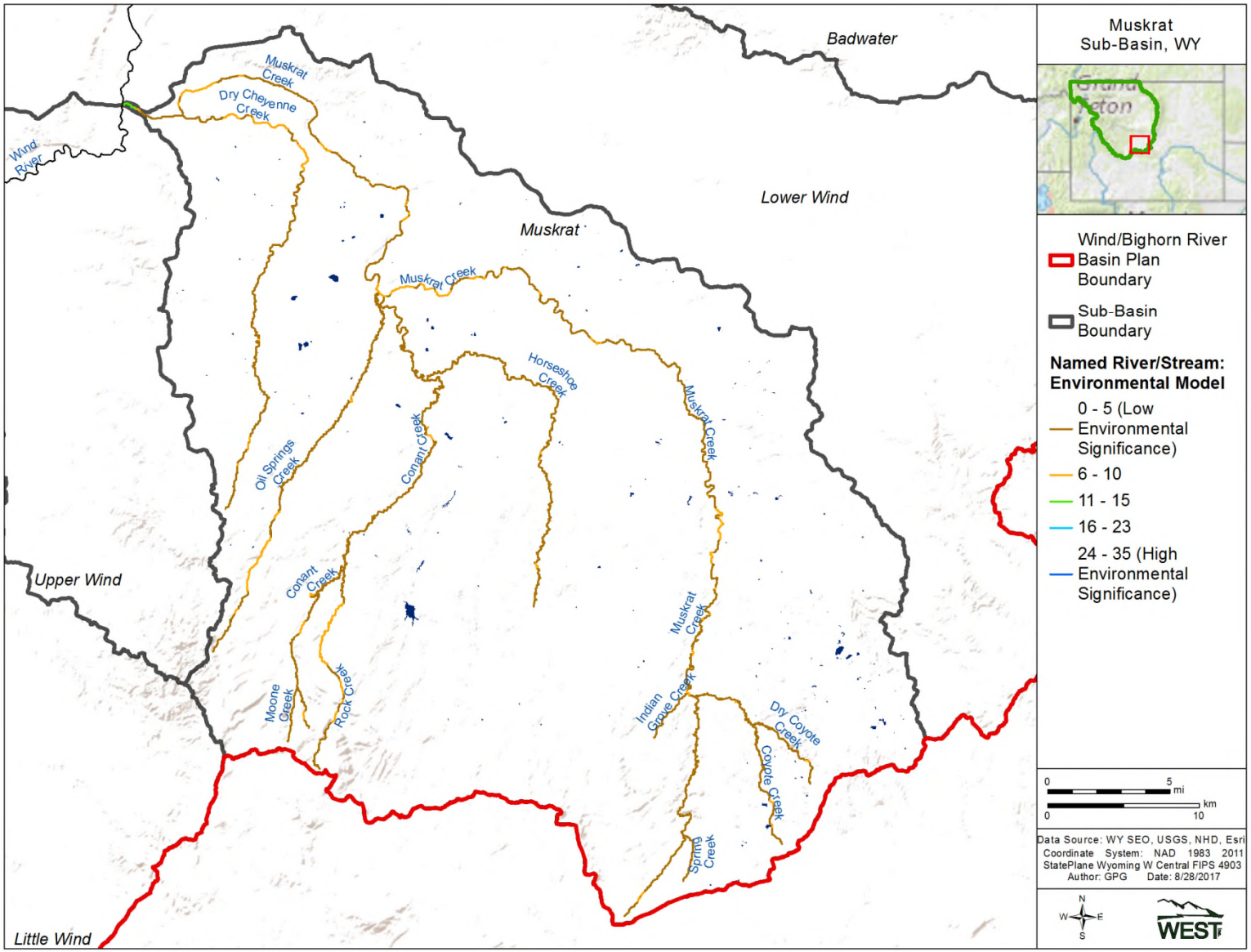

Figure B-17. Environmental model results for the Muskrat sub-basin in Wyoming.

Appendix C. Recreation Model for the Wind – Bighorn River Basin

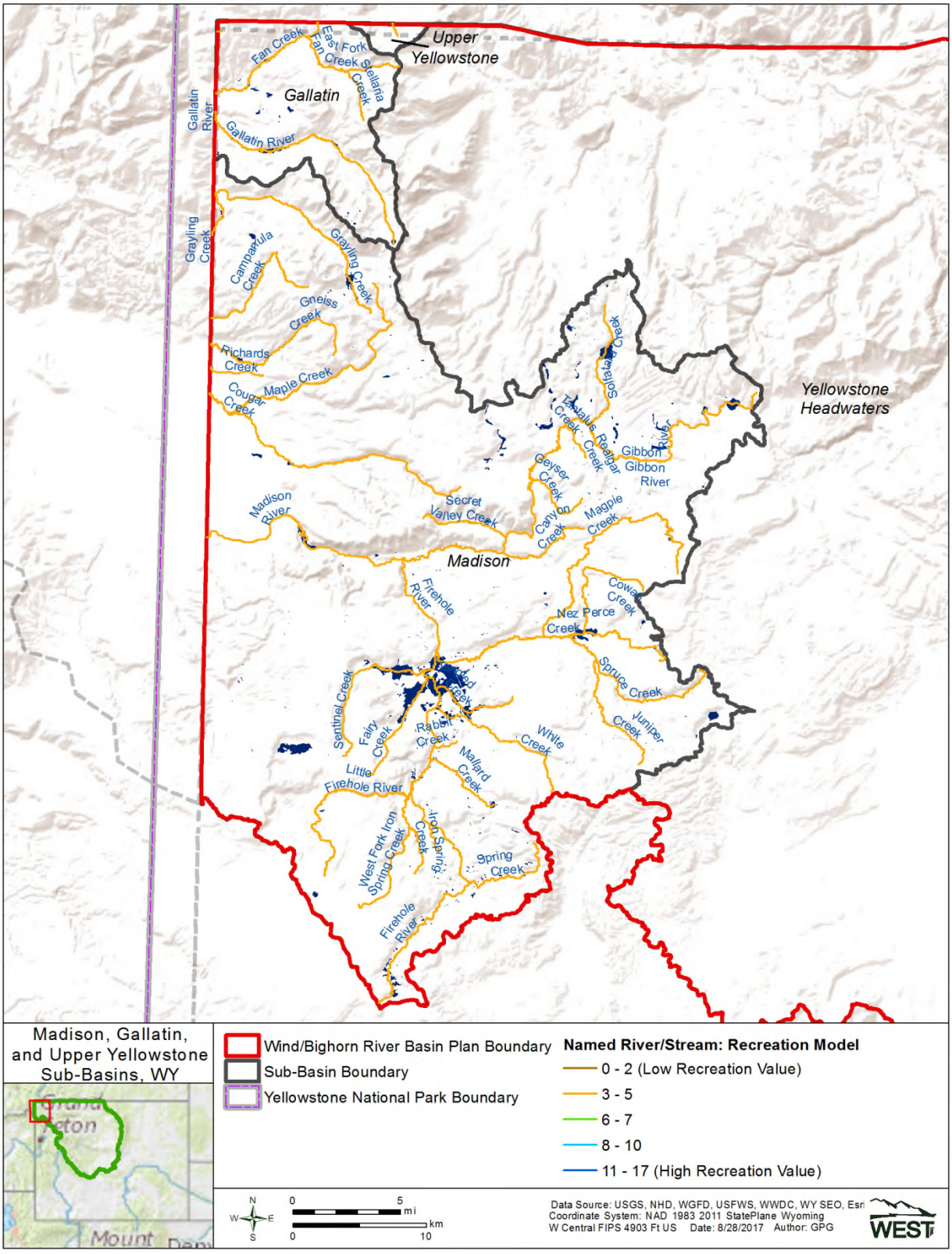

Figure C-1. Recreation model results for the Madison & Gallatin sub-basins in Wyoming.

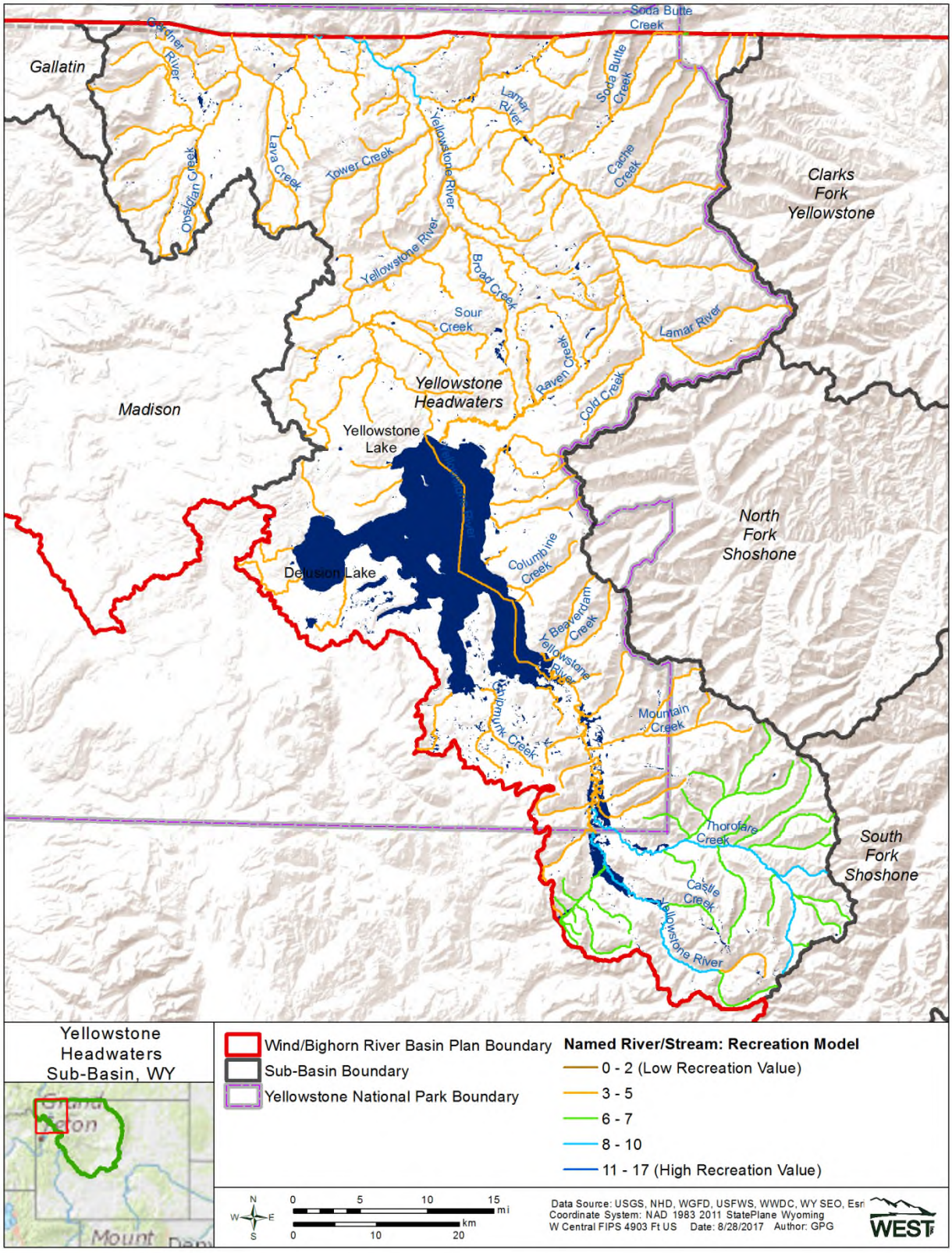

Figure C-2. Recreation model results for the Yellowstone Headwaters & Upper Yellowstone sub-basins in Wyoming.

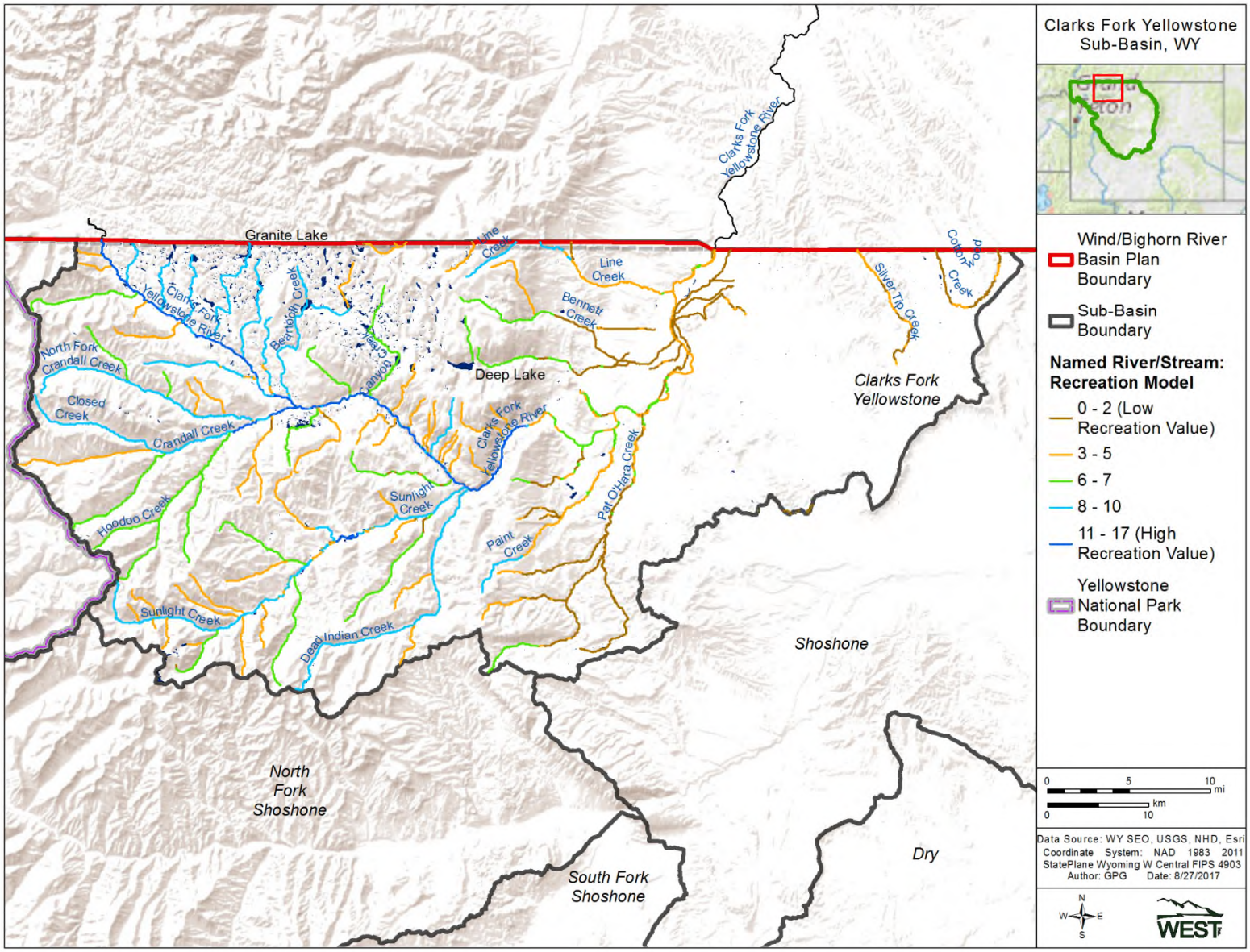

Figure C-3. Recreation model results for the Clarks Fork-Yellowstone sub-basin in Wyoming.

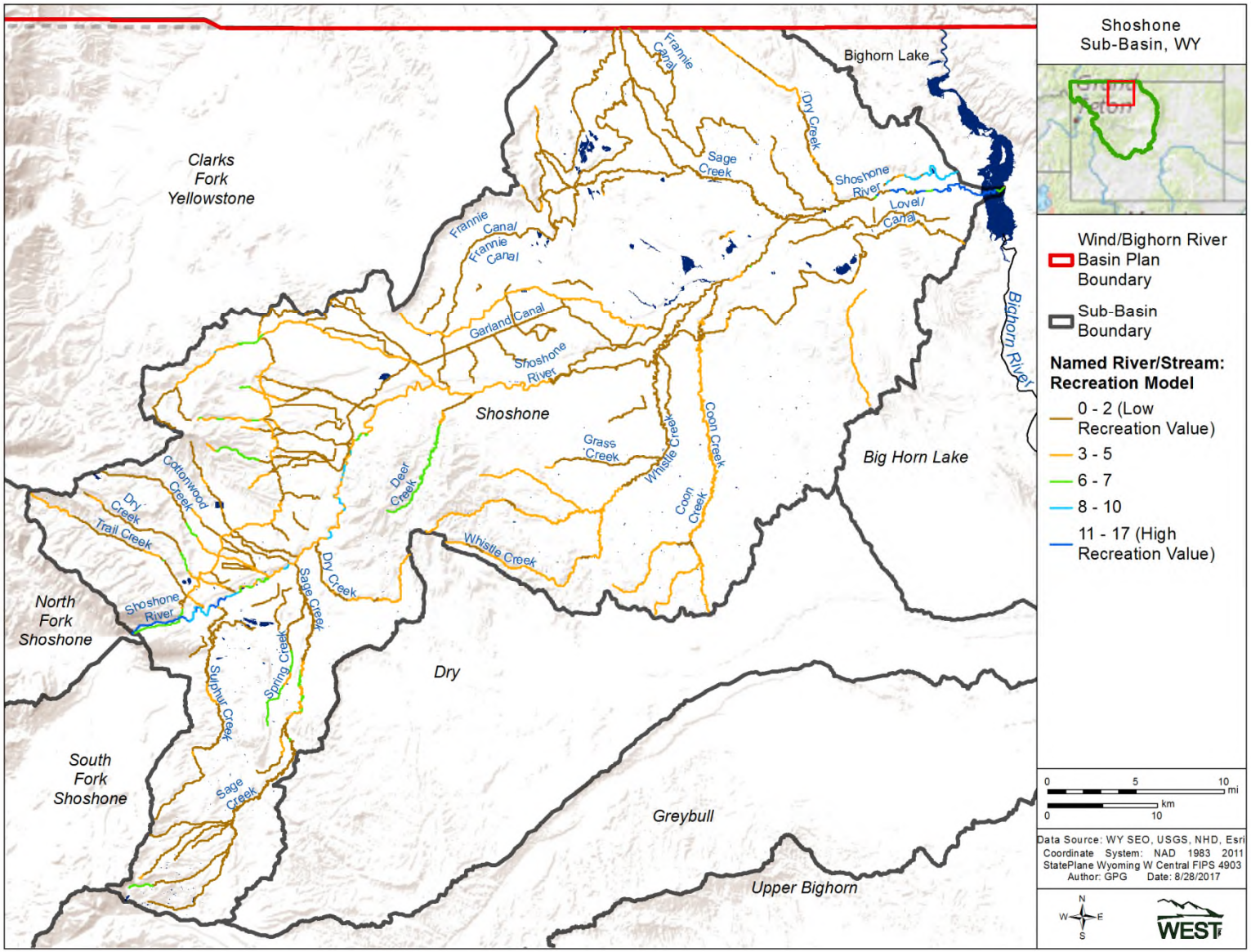

Figure C-4. Recreation model results for the Shoshone sub-basin in Wyoming.

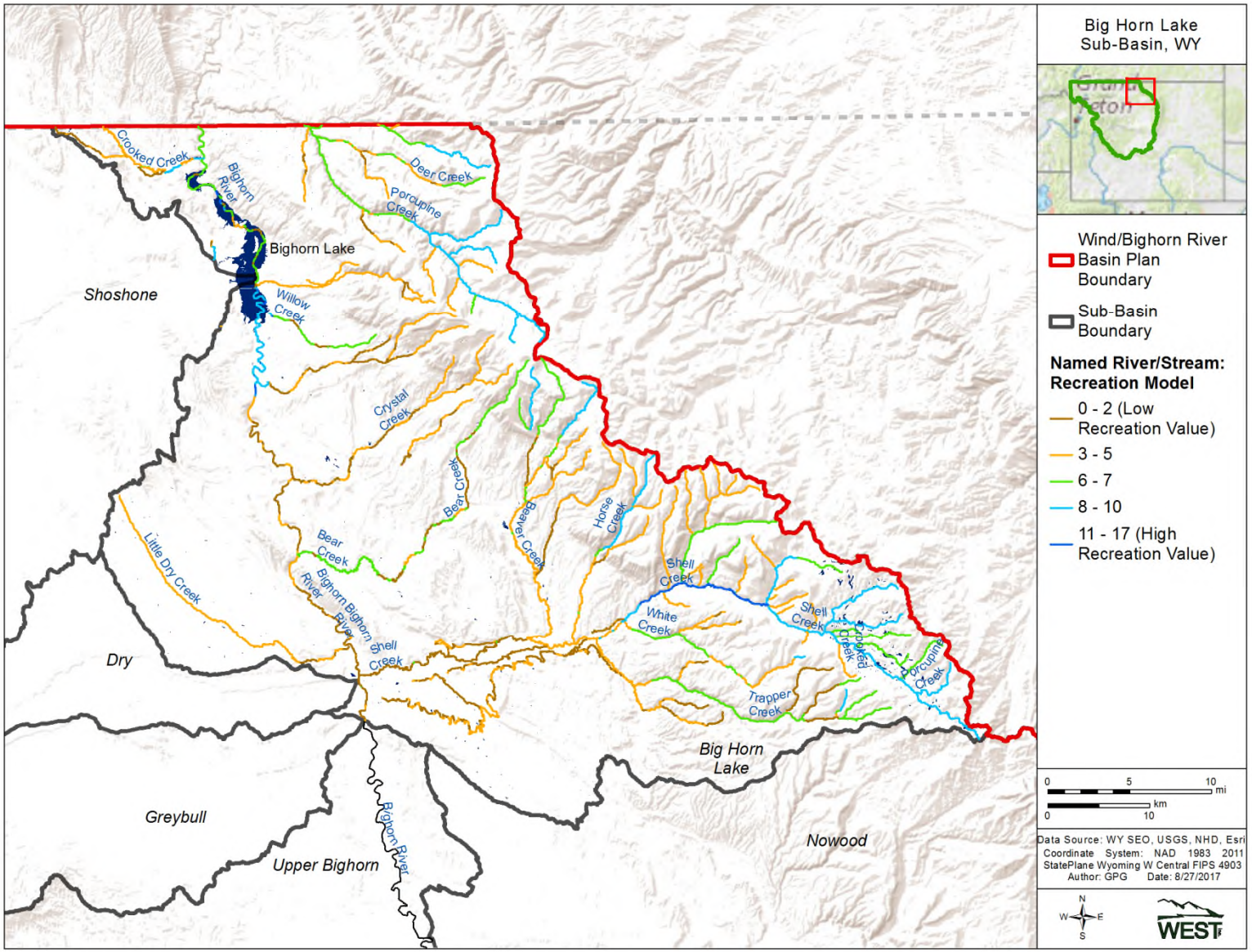

Figure C-5. Recreation model results for the Big Horn Lake sub-basin in Wyoming.

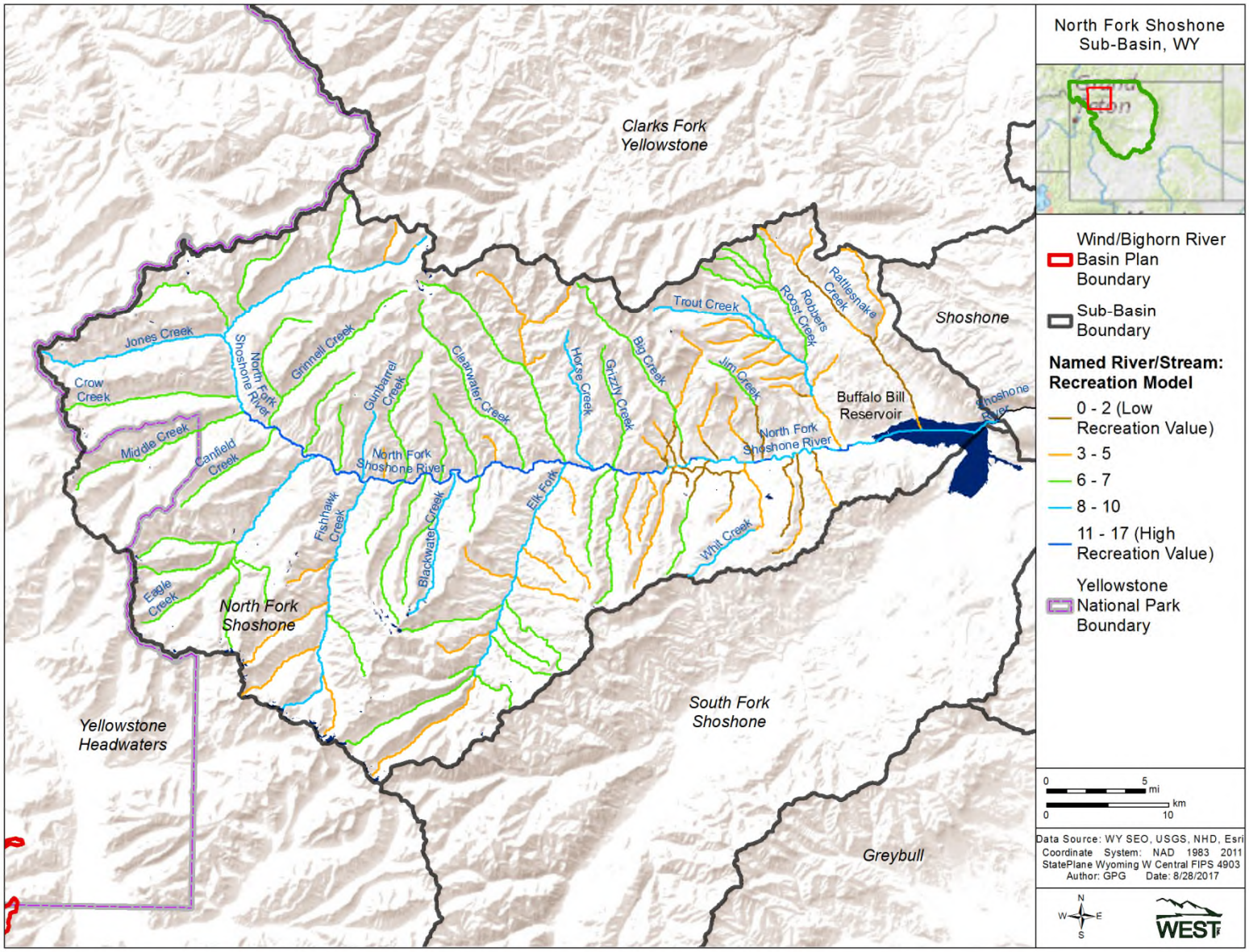

Figure C-6. Recreation model results for the North Fork Shoshone sub-basin in Wyoming.

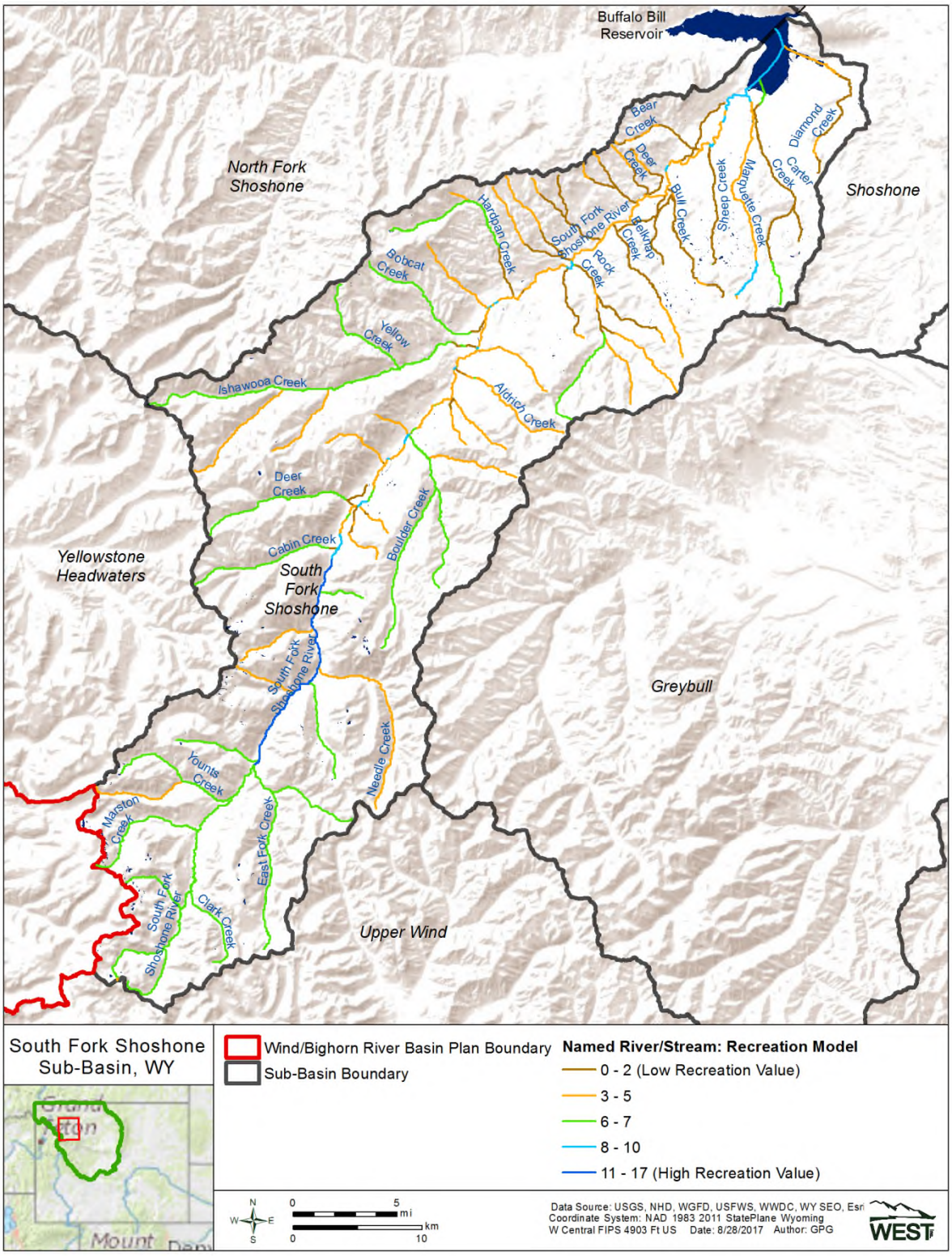

Figure C-7. Recreation model results for the South Fork Shoshone sub-basin in Wyoming.

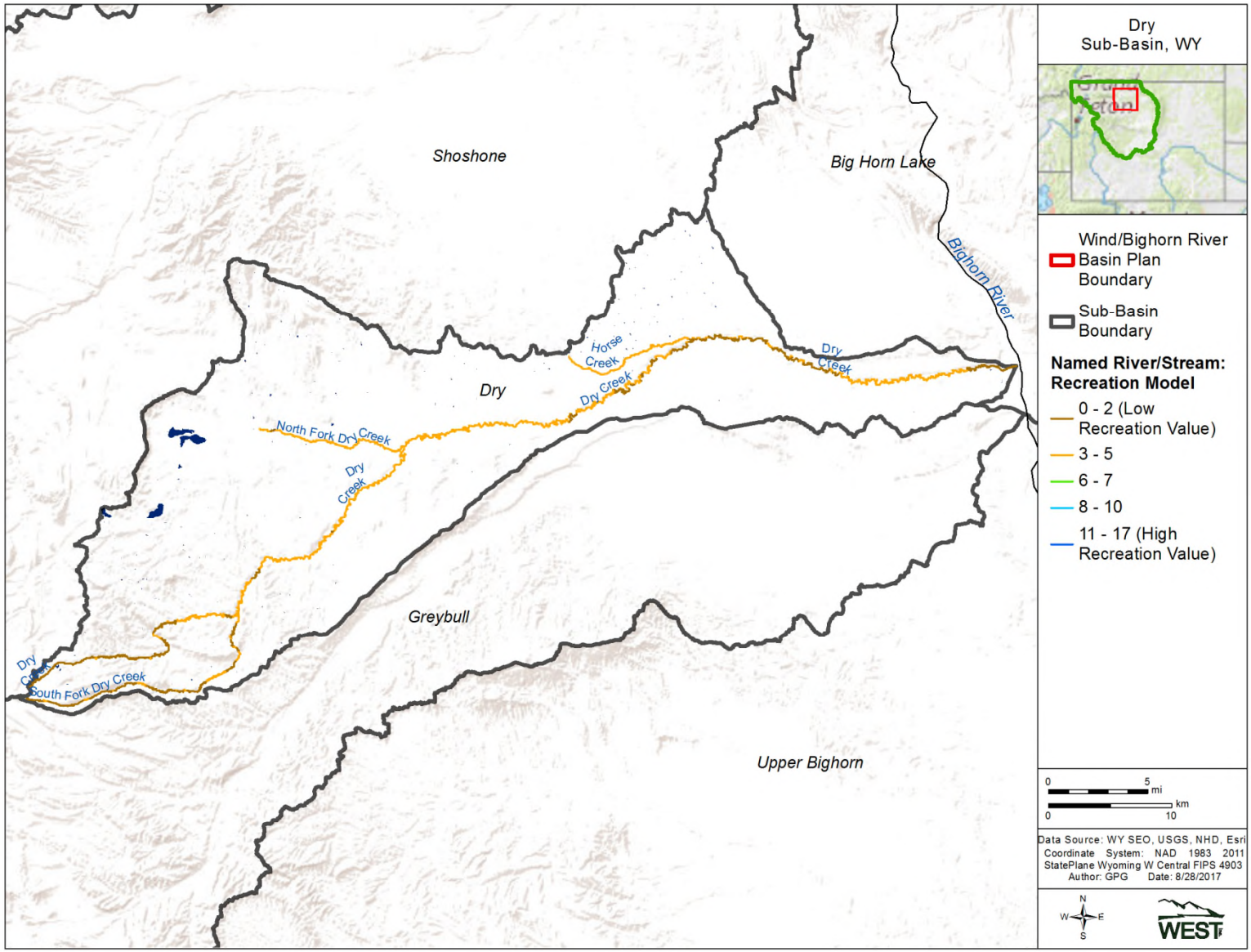

Figure C-8. Recreation model results for the Dry sub-basin in Wyoming.

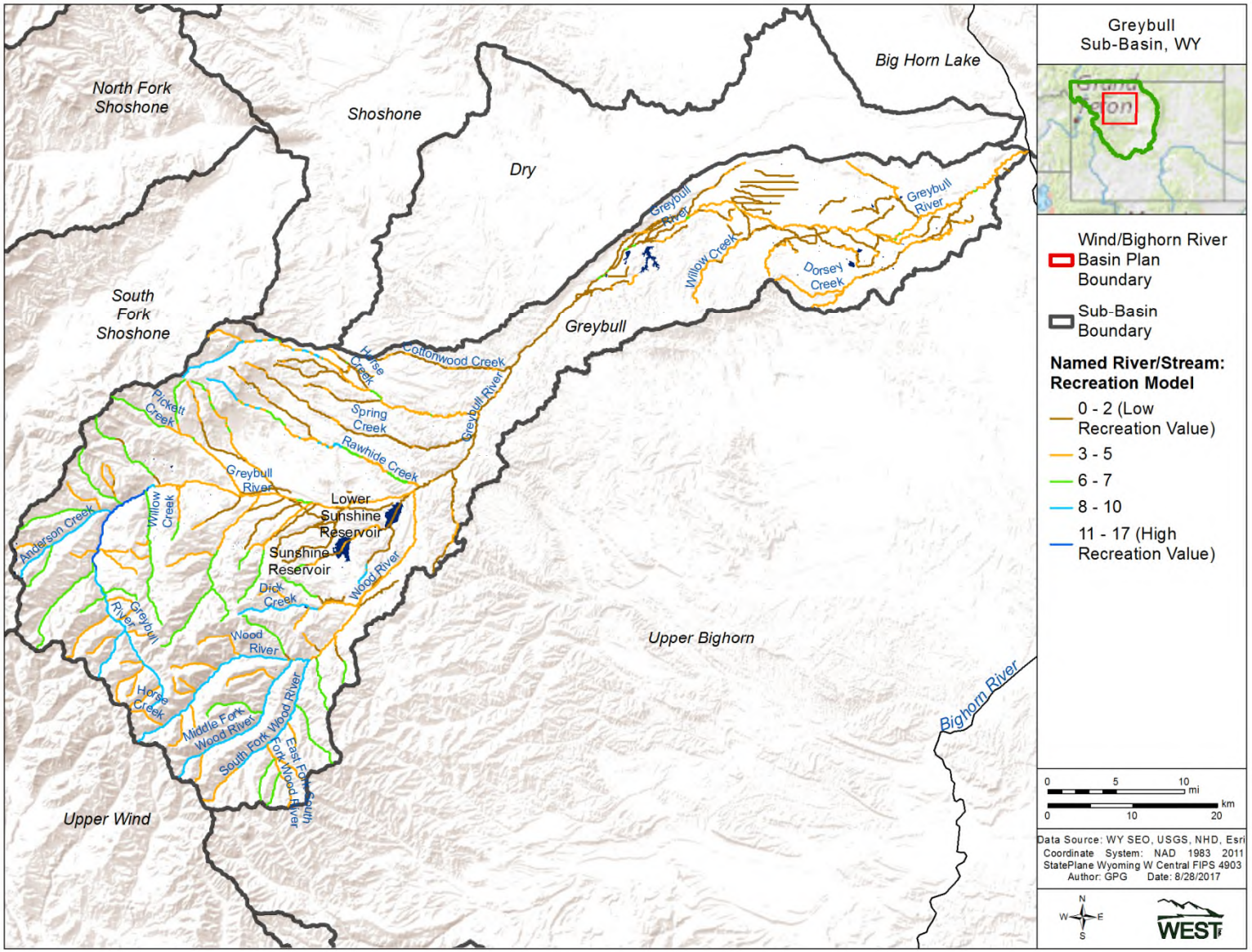

Figure C-9. Recreation model results for the Greybull sub-basin in Wyoming.

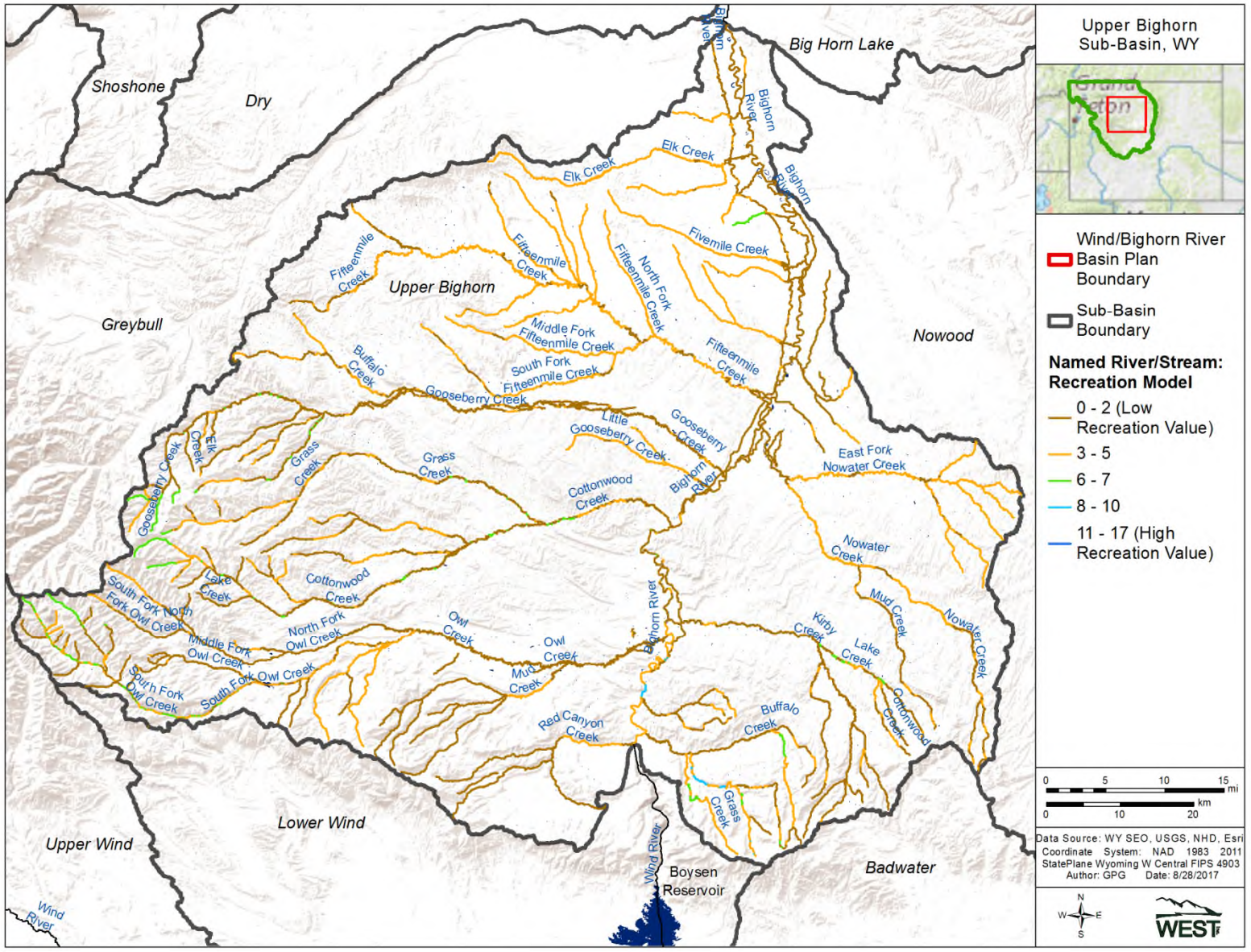

Figure C-10. Recreation model results for the Upper Bighorn sub-basin in Wyoming.

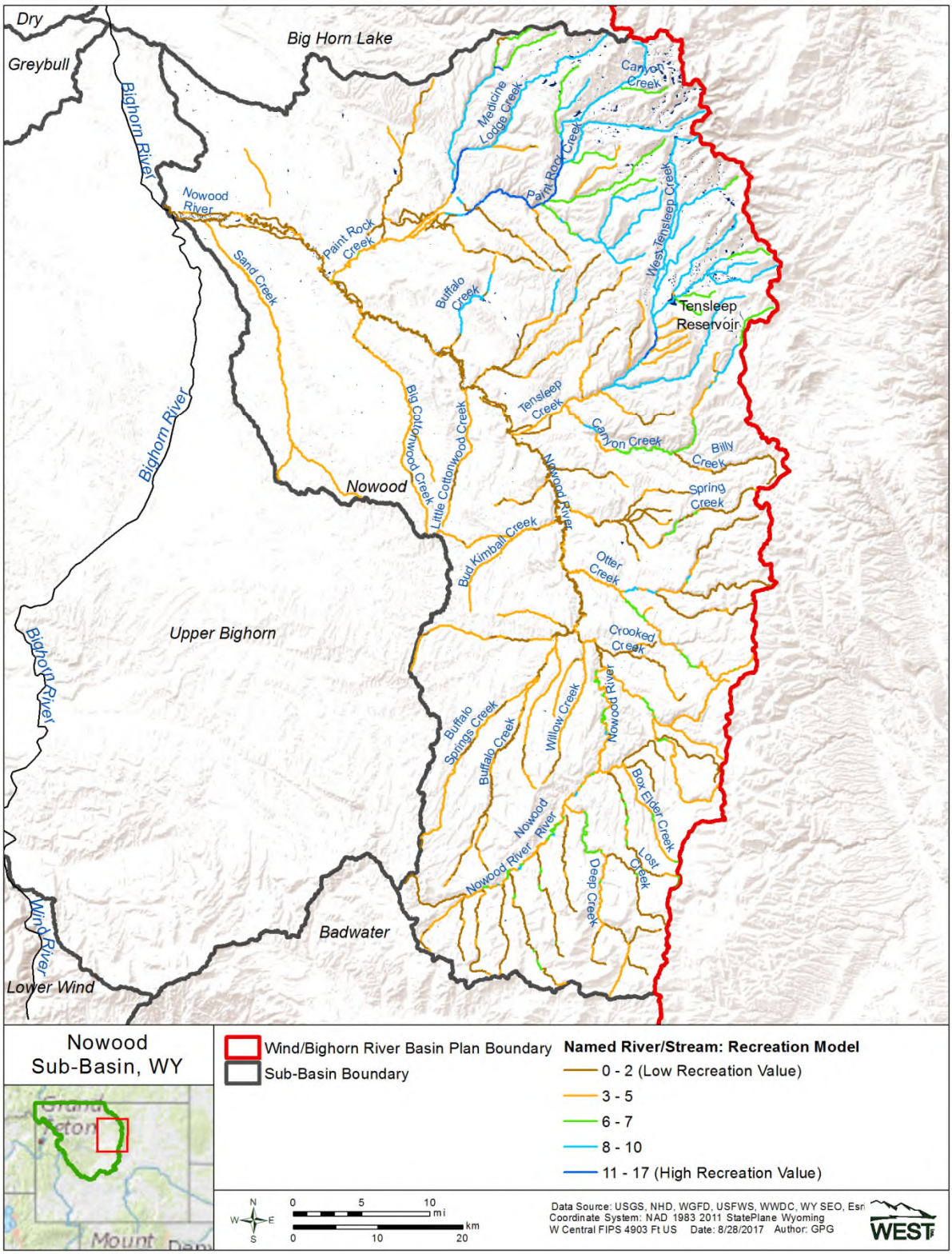

Figure C-11. Recreation model results for the Nowood sub-basin in Wyoming.

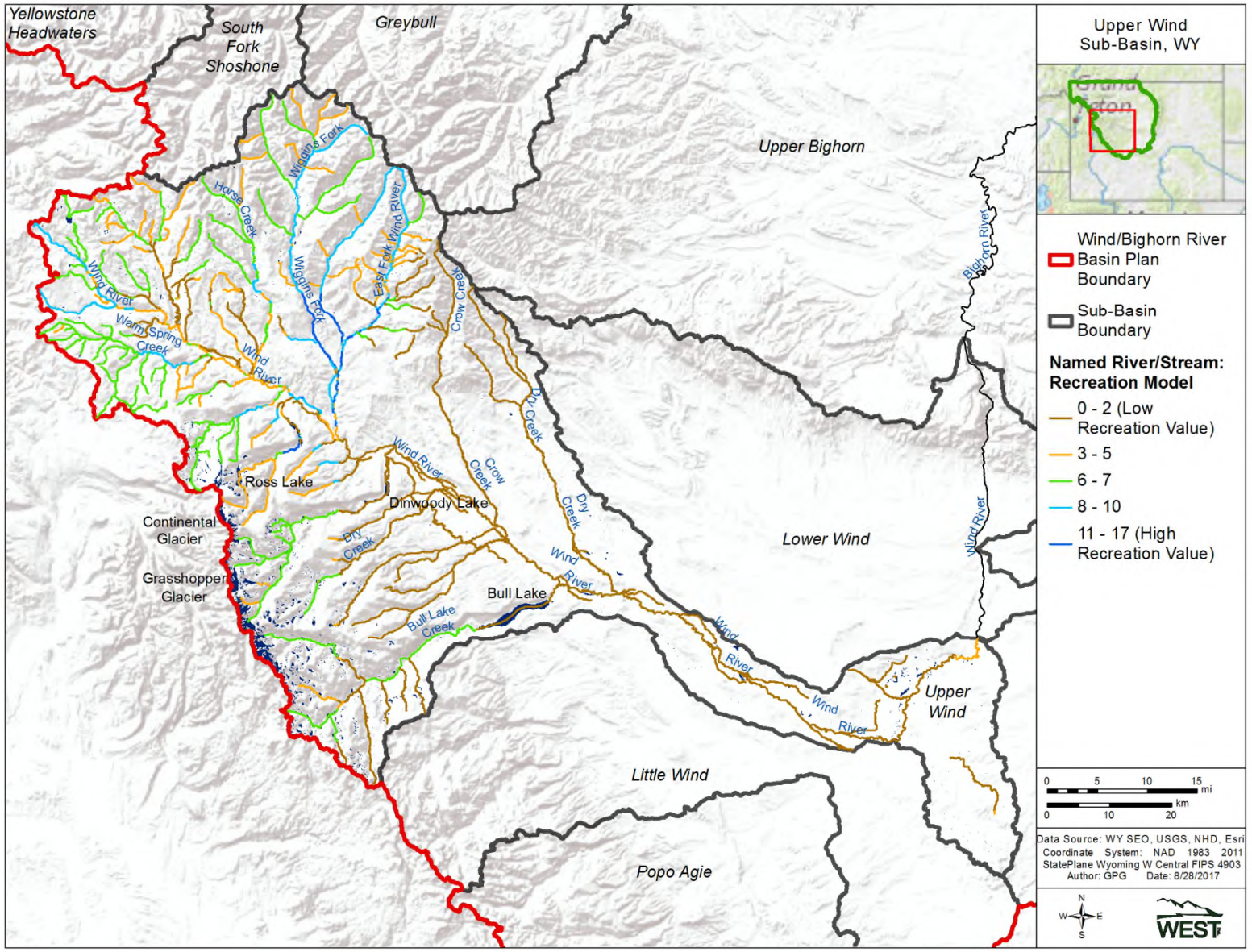

Figure C-12. Recreation model results for the Upper Wind sub-basin in Wyoming.

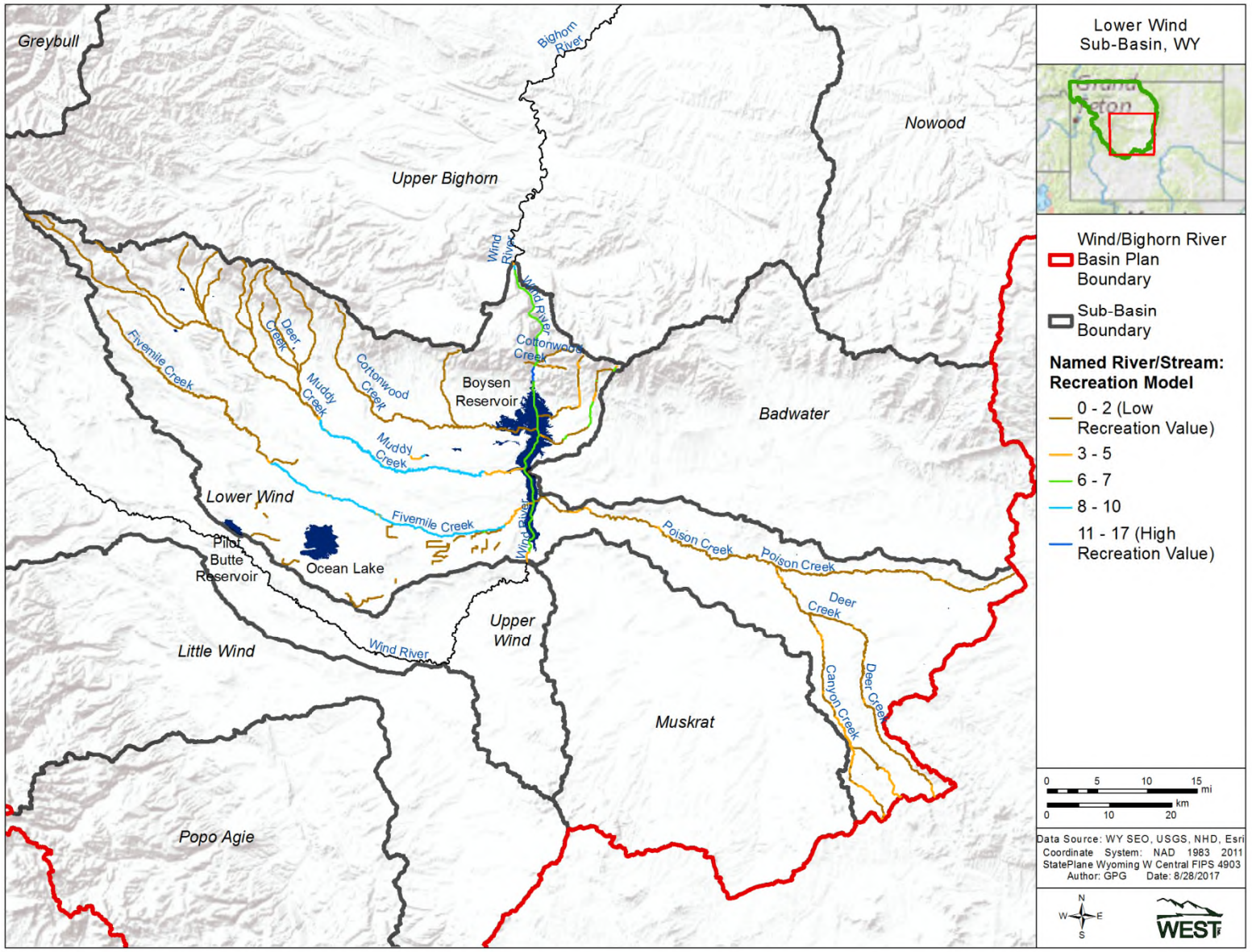

Figure C-13. Recreation model results for the Lower Wind sub-basin in Wyoming.

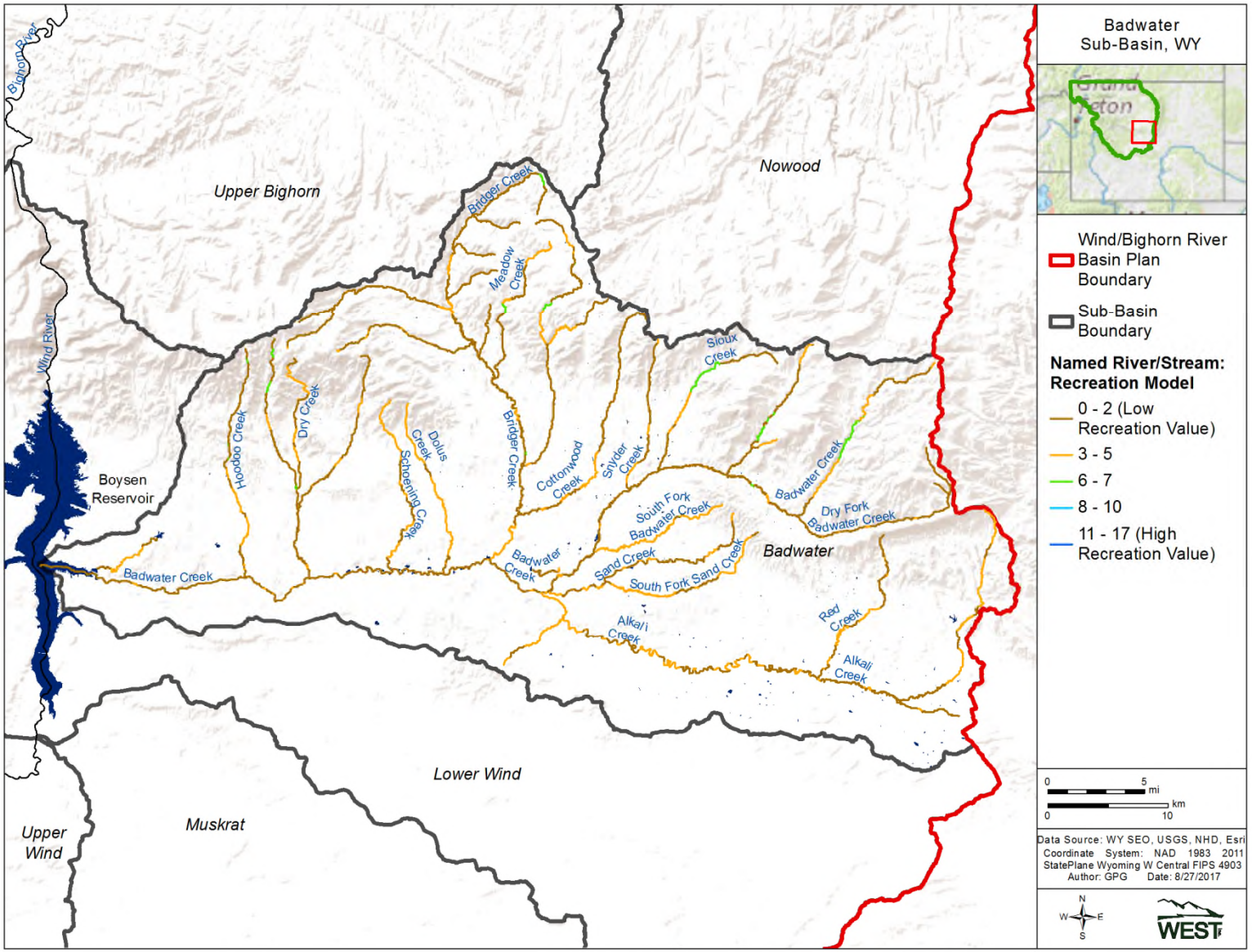

Figure C-14. Recreation model results for the Badwater sub-basin in Wyoming.

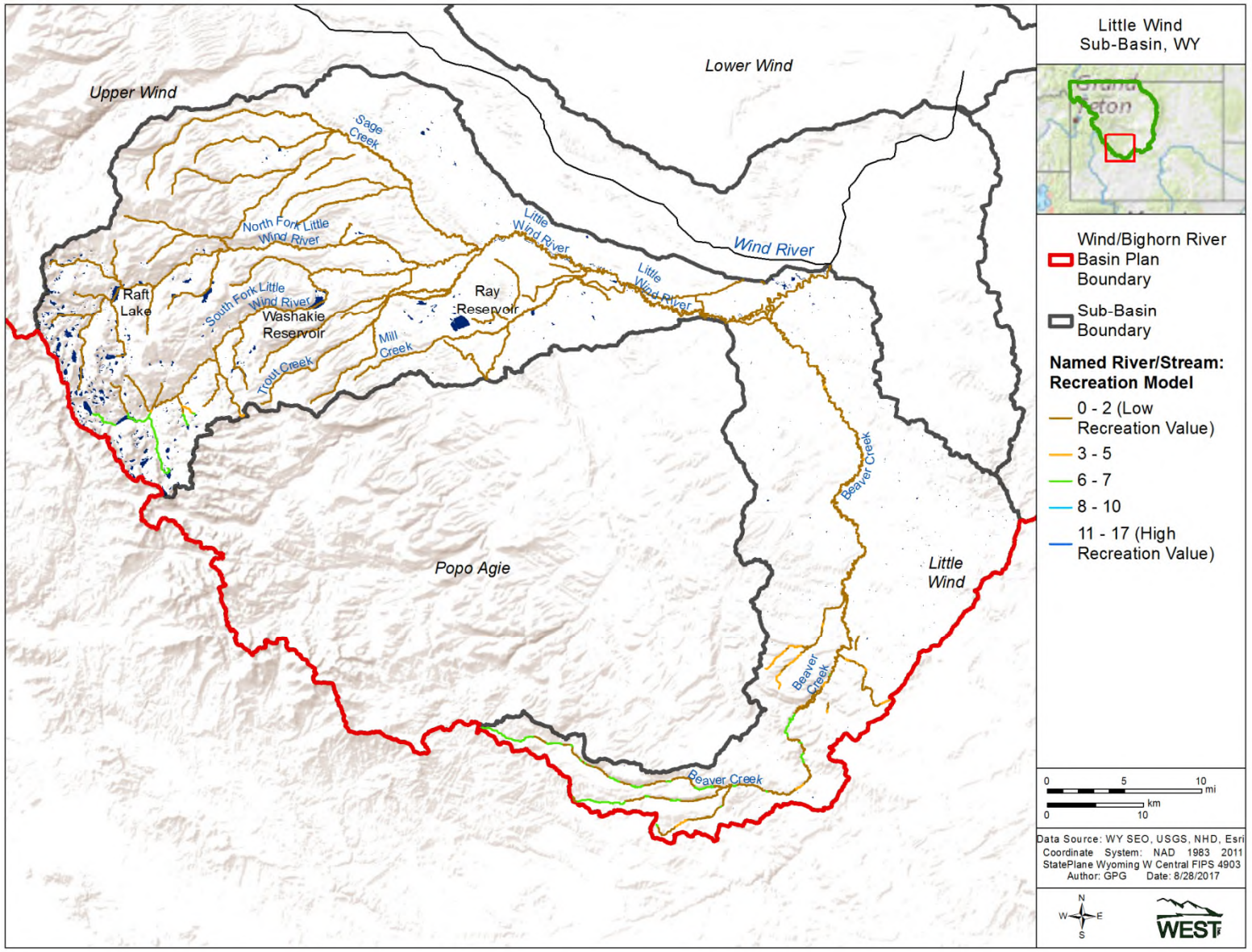

Figure C-15. Recreation model results for the Little Wind sub-basin in Wyoming.

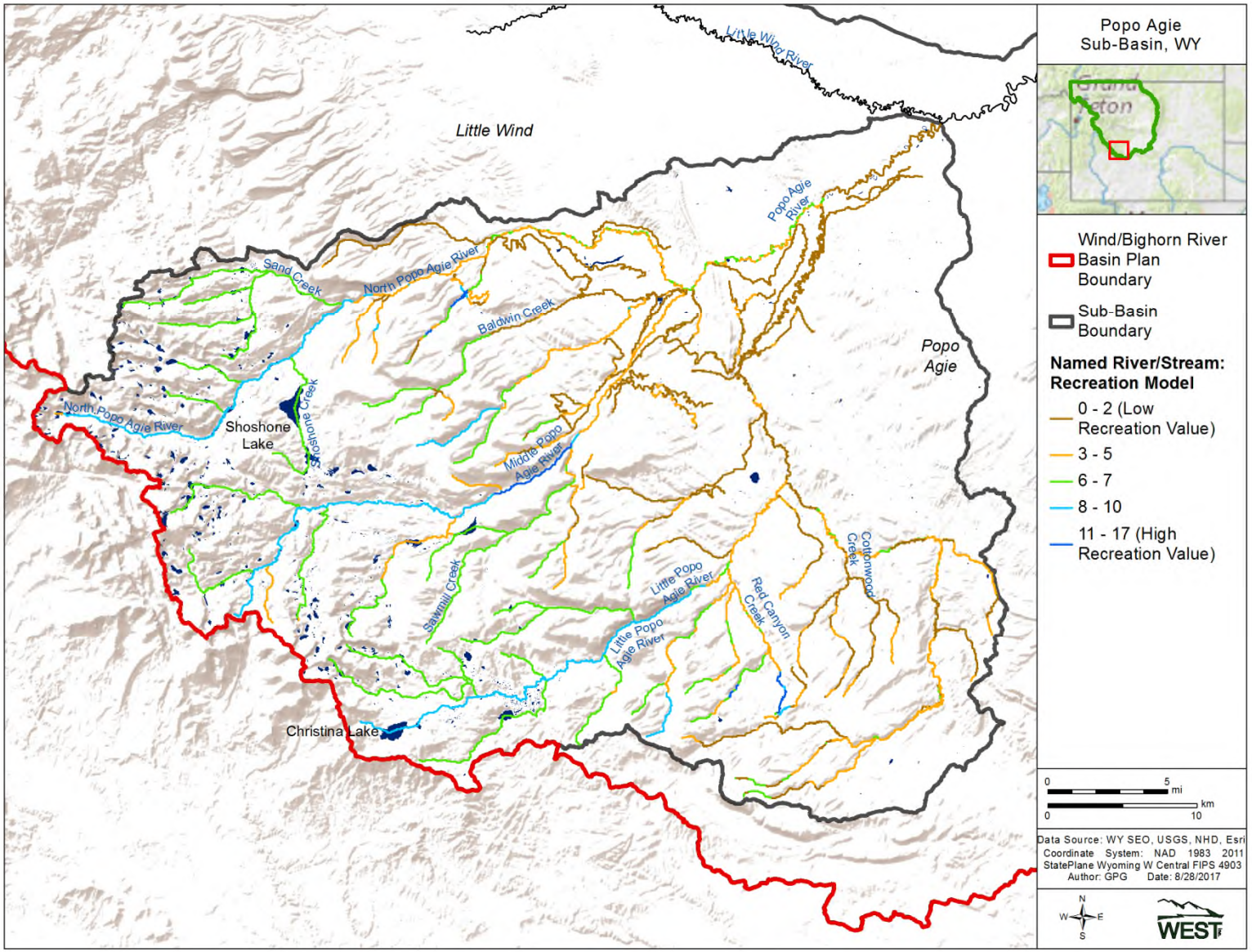

Figure C-16. Recreation model results for the Popo Agie sub-basin in Wyoming.

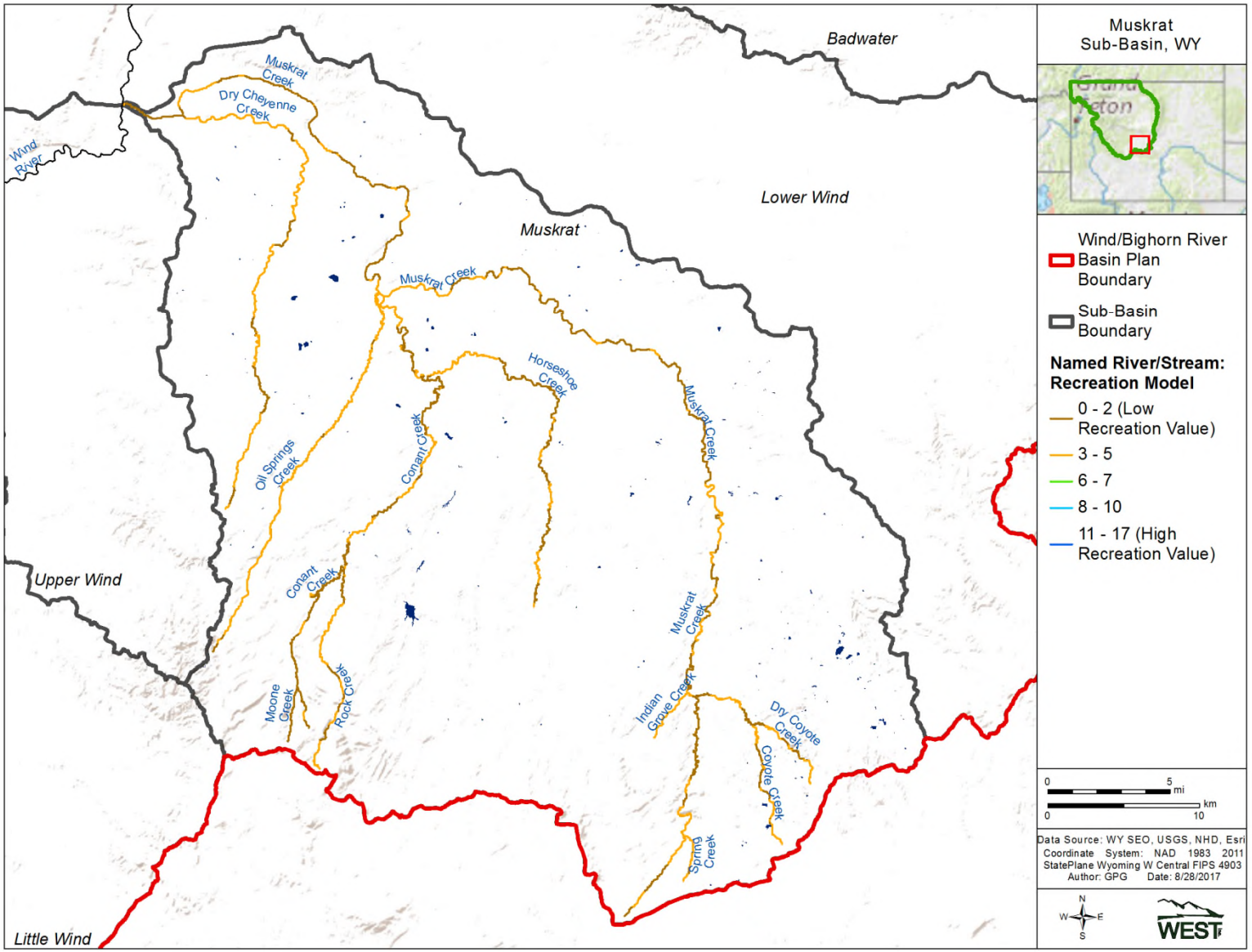

Figure C-17. Recreation model results for the Muskrat sub-basin in Wyoming.