Lower John Day Basin *State of the Basin Report*

Prepared by:

Lower John Day Basin Working Group

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2 CONTRIBUTORS

This report was developed by the Lower John Day Basin Working Group and its Data Committee. Members of the Lower John Day Working Group include the following organizations:

- Confederated Tribes of the Warm Springs Reservation of Oregon
- Gilliam County Soil & Water Conservation District
- Gilliam-East John Day Watershed Council
- Mid John Day-Bridge Creek Watershed Council
- Gilliam County Cattlemen's Association
- Oregon Department of Environmental Quality
- Oregon Water Resources Department
- Oregon Department of Agriculture
- Oregon Natural Desert Association
- Sherman County Area Watershed Council
- Sherman County Soil & Water Conservation District
- Sustainable Northwest
- The Freshwater Trust
- U.S. Department of Agriculture, Natural Resource Conservation Service
- WaterWatch of Oregon
- Wheeler Soil & Water Conservation District

Members of the Lower John Day Working Group Data Committee:

- Damon Brosnan, Natural Resources Conservation Service
- Allen Gillette, Warm Springs Tribe
- Christina Kirwan, Gilliam SWCD
- Brian Posewitz, WaterWatch
- Margaret Matter, Oregon Department of Agriculture
- Ken Thiemann, Oregon Water Resources Department
- Spencer Sawaske, The Freshwater Trust
- Herb Winters, Gilliam Soil & Water Conservation District
- Shreejita Basu, Sustainable Northwest

Members of the Lower John Day Working Group Outreach Committee:

- Debra Bunch, Mid John Day-Bridge Creek Watershed Council
- Hannah Fatland, Gilliam-East John Day Watershed Council
- Ben Gordon, Oregon Natural Desert Association
- Christina Kirwan, Gilliam SWCD
- Brian Posewitz, WaterWatch
- Amanda Whitnan, Sherman County Soil & Water Conservation
- Ken Thiemann, Oregon Water Resources Department

Consultants:

- Mike Gerel, Sustainable Northwest
- Peter Mitchell, Port of Arlington

Facilitator:

- Lee Rahr, Sustainable Northwest

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6 DEFINITIONS AND ABBREVIATIONS

Common Resource Area (CRA): A geographical area where resource concerns, problems, or treatment needs are similar; defined and utilized by the NRCS.

Consumptive water rights: Those water rights whose use removes water from a source that is not then returned to that source (e.g., crop consumption of water).

Non-consumptive water rights: Those water rights whose use does not remove water from a source (e.g., hydropower).

Water Availability Basin (WAB): Sub-basins delineated by the Oregon Water Resources Department (OWRD) for the purpose of computing available water.

Water Availability Reporting System (WARS): Water availability is the amount of water that can be appropriated from a given point on a given stream for new out-of-stream consumptive uses. It is obtained from the natural stream flow by subtracting existing in-stream water rights and out-of-stream consumptive uses.

Columbia River Basalt Group (CRBG): a regional province of igneous basalts that cover much of NE Oregon.

Porosity: The measure of the voids in a rock or soil that are capable of holding groundwater. It is typically understood in relationship to volume of solids and void space within the total volume of material.

Hydraulic conductivity (permeability to water): The ability of a rock or soil to transmit water, vertically or horizontally, computed typically as a rate (e.g. inches per day)

Specific yield: The ability of a rock or soil to drain water (under gravity). It is typically computed at the ratio of the volume of water that can be drained from a saturated soil under gravity to the volume of the rock or soil.

Recharge (groundwater): The surface water that moves through the unsaturated zone and enters aquifers. Recharge to the water table can be diffuse (precipitation over the land surface) or localized (streams losing water to groundwater within reaches of the stream). Recharge is one of the most difficult quantities to estimate in hydrology,

Sustainable Yield (groundwater): The theoretical balance between groundwater recharge, groundwater discharge to streams, and ground water storage with pumping for consumptive uses whereby impacts to groundwater storage and groundwater discharge to streams is minimally impacted. Realistically, any pumping will decrease groundwater storage and/or groundwater discharge to streams over time, though a level of equilibrium may be reached on human time scales that allows for sustainable groundwater diversion. Comparing recharge rates to pumping rates can provide a high-level estimate of whether pumping rates are sustainable.

Instream Water Right (ISWR): Water rights, held in trust by the Oregon Water Resources Department, for instream beneficial uses for fish and wildlife, water quality, and/or recreation.

Evapotranspiration (ET): A combination of evaporation – liquid water on a surface changing to water vapor – and transpiration – water lost through plant stomata. The two terms are lumped into ET because it is difficult or often impossible to measure the two sources of water separately.

1. INTRODUCTION

Water is important to all Oregonians. It is vital to community well-being, economic development, and a healthy environment. Across Oregon, every place has its unique water challenges that if left unaddressed, may worsen in the future, degrading the health of people, fish, and wildlife. The most common problem is there is simply not enough clean water for all needs at all times of the year; and supplies continue to dwindle with the impacts of new water resource development, climate change, over-allocation, and resource management stressing already limited supplies.

Oregon's first *Integrated Water Resources Strategy* ("IWRS") was adopted by the Oregon Water Resources Commission ("Commission") on August 2, 2012 (OWRD, 2012). The Strategy provides a blueprint to help the state better understand and meet its instream and out-of-stream needs, taking into account water quantity, water quality, and ecosystem needs. The Strategy was subsequently updated and adopted by the Commission on December 7, 2017.

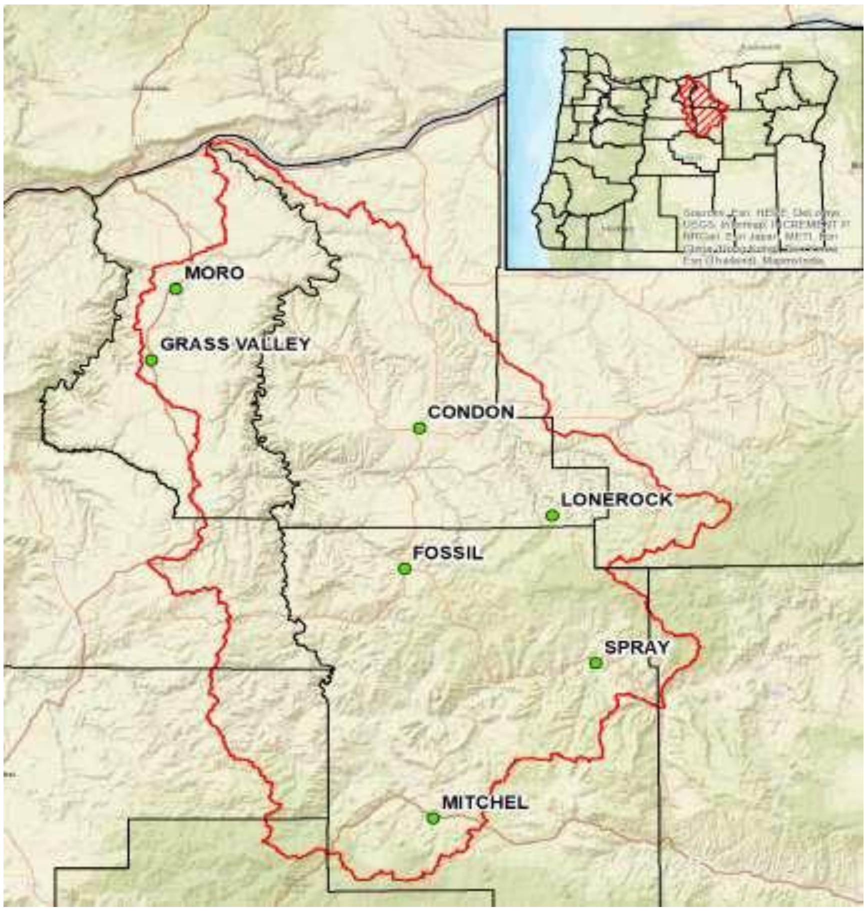
The IWRS recommended that the Oregon Water Resource Department ("OWRD") help communities undertake a place-based approach to integrated water planning. Place-based integrated water resources planning ("PBP") is a voluntary, locally initiated and led effort in which a balanced representation of water interests in a basin, watershed, or groundwater area work in partnership with the state to:

1. Build a collaborative and inclusive process;
2. Gather information to understand current water resources (looking at quantity, quality, ecosystem health) and identify knowledge gaps;
3. Examine current and future instream and out-of-stream water needs (water for people, the economy, and the environment);
4. Identify and prioritize strategic, integrated solutions to meet current and future water needs; and
5. Develop a place-based integrated water resources plan that serves as a roadmap for meeting water needs and informs future updates to the statewide IWRS.

In 2015, OWRD released *DRAFT Place-Based Planning Guidelines* that lays out a 5-step process for pursuing PBP efforts (OWRD, 2015). These guidelines were developed following extensive research and outreach efforts. In 2016 OWRD awarded grants to four communities to pilot the PBP process. The Lower John Day Basin Working Group ("Working Group") applied and was officially awarded funding on February 25, 2016 to be one of four pilots to pursue PBP from 2016 to 2019 for Lower John Day River Basin ("basin." "Lower John Day") in northcentral Oregon. See Figure 1 for a map of the rough planning area (USDA, 2005).

Planning Step #2 ("Step #2") of PBP is to characterize water resources, water quality, and ecological issues. The purpose of this *Lower John Day Basin State of the Water Resources Report* ("Report") is to summarize the data collection and analysis that occurred as part of Step #2. This report is needed to help the Working Group members develop a shared understanding of the water quantity, water quality, ecological health, and other conditions in the planning area. This area, like many in Oregon, experience water supply shortages for instream uses and out-of-stream uses and these are expected to intensify in the future. Note that this report also includes initial information regarding existing water demands, which will be required for the forthcoming Step #3. The Working Group's Data Committee recommended and the Working Group agreed that including both water supply and elements of demand in this report was the most efficient pathway toward creating a final Integrated Place-Based Water Resource Plan for the region by the close of the OWRD grant in 2019.

Figure 1: Lower John Day Planning Area



2. Lower John Day Working Group

A. Lower John Day Working Group

The Lower John Day Working Group's efforts to collaboratively address water resource issues in the region date to 2007. It was formed to include local governments, ranchers, environmental interest groups and others to identify develop a science-based approach to addressing the water resources of the Lower John Day Basin. The entire John Day River Basin community and its restoration practitioners are quite tightknit and most partners have worked together before.

The Working Group was expanded to include a more diverse mix of partners (with the departure of Morrow and Wasco SWCD that include small portions of the Lower John Day) and was reinvigorated by the formation of the basinwide John Day Basin Partnership. This occurred as a result of basin practitioners desire to pursue Oregon Watershed Enhancement Board ("OWEB") Focused Investment Program ("FIP") funding in July 2014 and application for PBP funding in December 2015. The Lower John Day Working Group approaches natural resource planning in a ridge-top-to-ridge-top landscape scale. The diversity in spatial structure of the basin's wildlife and habitats are both affected by a variety of local historic and ongoing influences that cross land use, watershed, and political boundaries (NPCC, 2005; CTWSRO, 2015). Thus, a wide focus is needed to prioritize areas for projects that pose the greatest need and potential for ecological and community lift. Further, studies show that landscape-scale plans can be more readily designed to address future change and related stressors, including climate change, urbanization, fire, habitat fragmentation, and pests (Forest Service, 2009; P. Tilman, 2012). Finally, this method is very much in line with recent work of river ecosystem academia and large landscape restoration funders who are increasingly calling for restoration practitioners to undertake a more holistic and coordinated approach to ensure work is carried out as effectively and cost-effectively as possible (Palmer, 2006).

The Working Group considers the FIP and PBP "projects," and will likely pursue other projects in the future. The pilot is discussed in Subsection B below.

The **vision** of the Working Group is a Lower John Day Basin with the clean water and healthy watersheds necessary to provide for local ecosystems, economies, and communities.

The **mission** of the Working group is to restore and maintain the Lower John Day for the ecological, economic, social, and cultural well-being of local communities. We apply deep knowledge of the region, best available science, and cooperative planning and fundraising to empower more actions that establish healthy and resilient native habitats, balanced water use, and working landscapes for future generations.

B. Lower John Day Place-Based Planning Pilot

Upon signing of a grant agreement (Grant #G-0601-LJD) for use of PBP funds on June 30, 2016, the Lower John Day Place-Based Planning Pilot officially became a project of the Lower John Day Working Group. Gilliam Soil & Water Conservation District ("SWCD") is the official convener and fiscal agent of the PBP pilot. A Declaration of Cooperation for the group was signed by 14 partners in April 2017. An ongoing work plan, budget, and request for proposal, contracting, and invoice processes with partners were also created to further govern the efforts of the group through completion of the pilot in 2019.

The partners of the PBP pilot are as follows:

Confederated Tribes of the Warm Springs Reservation of Oregon (CTWS)

Gilliam County Soil & Water Conservation District

Gilliam-East John Day Watershed Council

Mid John Day-Bridge Creek Watershed Council

Gilliam County Cattlemen's Association

Oregon Department of Environmental Quality (DEQ)

Oregon Water Resources Department (OWRD)

Oregon Natural Desert Association

Sherman County Area Watershed Council

Sherman County Soil & Water Conservation District

The Freshwater Trust (TFT)

U.S. Department of Agriculture, Natural Resource Conservation Service (NRCS)

WaterWatch of Oregon

Wheeler County Soil & Water Conservation District

Further, the Oregon Department of Fish & Wildlife have also designated themselves a partner to the effort by letter. Overall, private, public, and non-government organization (NGO) interests are well represented by the Working Group. Efforts are underway via public outreach to increase the participation of local landowners and recreational businesses.

The **purpose** of the PBP pilot is for water interests to collaboratively create an Integrated Place-Based Water Resource Plan for the Lower John Day River Basin.

Water interests were defined as local governments, tribal governments, utilities, major industries or employers, agriculture and forestry groups, conservation groups, special districts, and state and federal agencies that are located within, serve, or whose members have interest in the planning area.

Planning principles adapted from the IWRS to fit the unique circumstances of the Lower John Day Basin include the following:

- Maintain a locally-initiated and led collaborative process.
- Employ a voluntary, non-regulatory approach in the planning process.
- Use an inclusive process that strives for a balanced representation of basin water interests.
- Utilize an outside facilitator and facilitated processes.
- Conduct planning in close partnership with OWRD.
- Include the most current water resource data and scientific concepts.
- Address both instream and out-of-stream needs.
- Cover water quantity, quality, and ecosystem health.
- Builds on and integrates existing studies and plans.
- Strive for consensus in decision-making.
- Utilize an open and transparent process that fosters public participation.
- Adhere to IWRS principles, Place-Based Planning Guidelines, and federal, state, and local laws.

To date, the Working Group and its committees have met regarding the pilot project twelve times, completing Step #1, and pursuing Step #2 and part of Step #3 via this report. Public participation to date is discussed in Section 9 of this report.

3. Basin Overview

The Lower John Day Basin in northcentral Oregon supports native aquatic fish species and habitat, small rural communities whose economy is centered on agriculture and energy development, and exceptional recreational, historical, and cultural riches. This section compiles and summarizes existing plans, assessments, and other available information to describe the basin setting. Note that no new data were collected for this section.

A. Location

The Lower John Day Basin planning area encompasses all of the John Day River Basin downstream of the confluence of the Upper and North Fork John Day Rivers near Kimberly, Oregon (Figure 1).. It covers 8-digit hydrologic unit code 1707024, a drainage area of 3,149 square miles (over 2 million acres) The majority of the Lower John Day falls within Gilliam, Wheeler, and Sherman Counties, with smaller portions in Morrow, Wasco, Jefferson, Crook, and Grant Counties.

B. Topography

The Lower John Day Basin is located in the southern section of the Columbia Plateau Ecological Province in northcentral Oregon. It is situated in the interior plateau between the Blue Mountains to the east and the Cascades Range to the west. Elevations tend to increase from north to south in the basin. The John Day River flow originates in the Strawberry Mountains (9,000 ft.) and flow generally westward and then northward for approximately 284 miles, discharging into the Columbia River east of Rufus (200 ft.). Figure 2: Lower John Day Elevations

C. Physical Geography and Geology

The John Day main stem and tributaries are generally low in gradient through much of their length. Valleys tend to be trough-shaped, with steep slopes separating narrow riparian areas from uplands. The narrow and sometimes meandering valleys often limit channel migration and sinuosity (ODEQ, 2010). Specifically, the Lower River Basin has a plateau form, broken by the sinuous valley of the mainstem and its steep-walled tributaries (ODEQ, 2010). The Lower John Day is characterized by loess-covered plateaus. Figure 3**.** shows a relief map developed using LiDAR data which highlights the features mentioned here.

Figure 2: Lower John Day Elevations

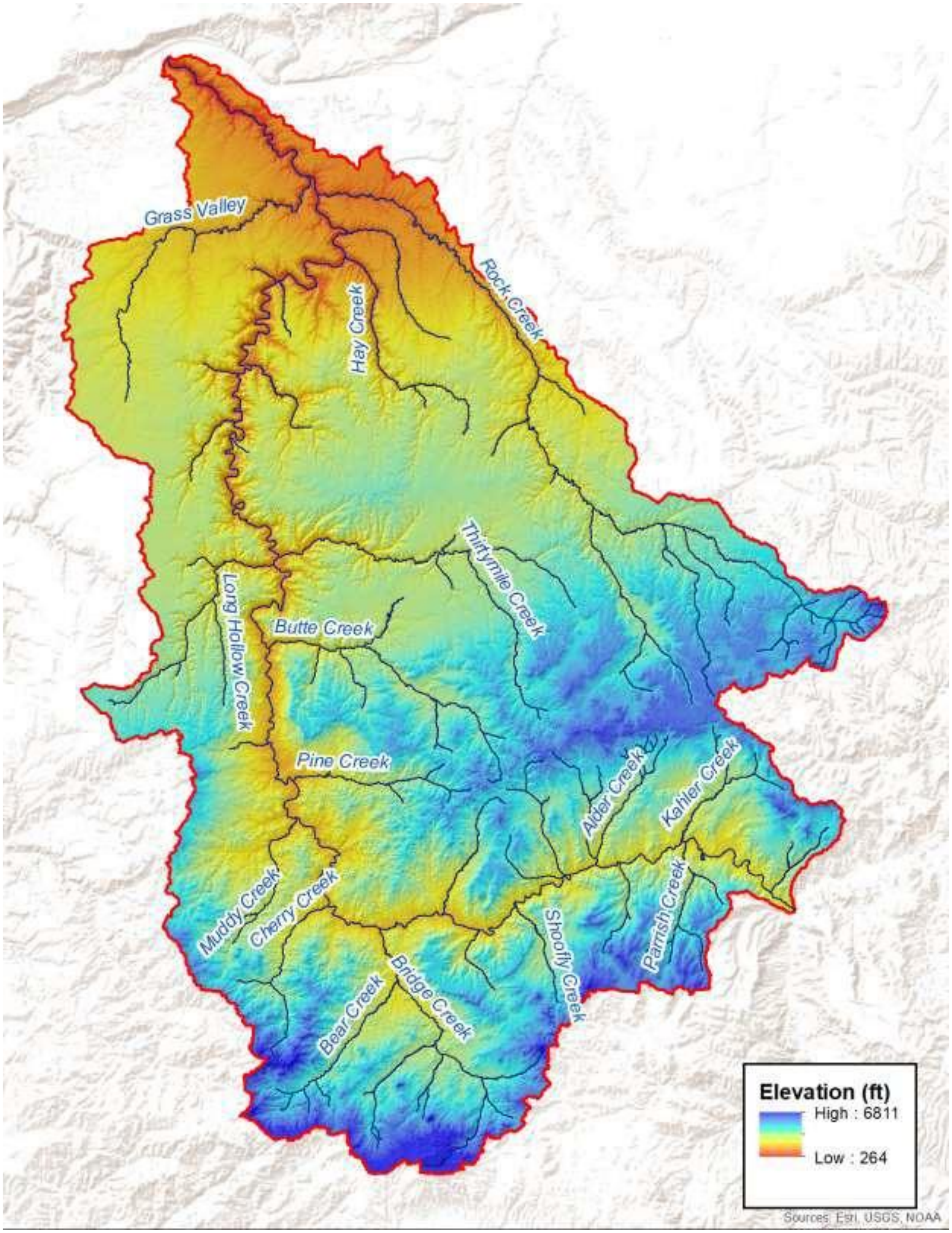
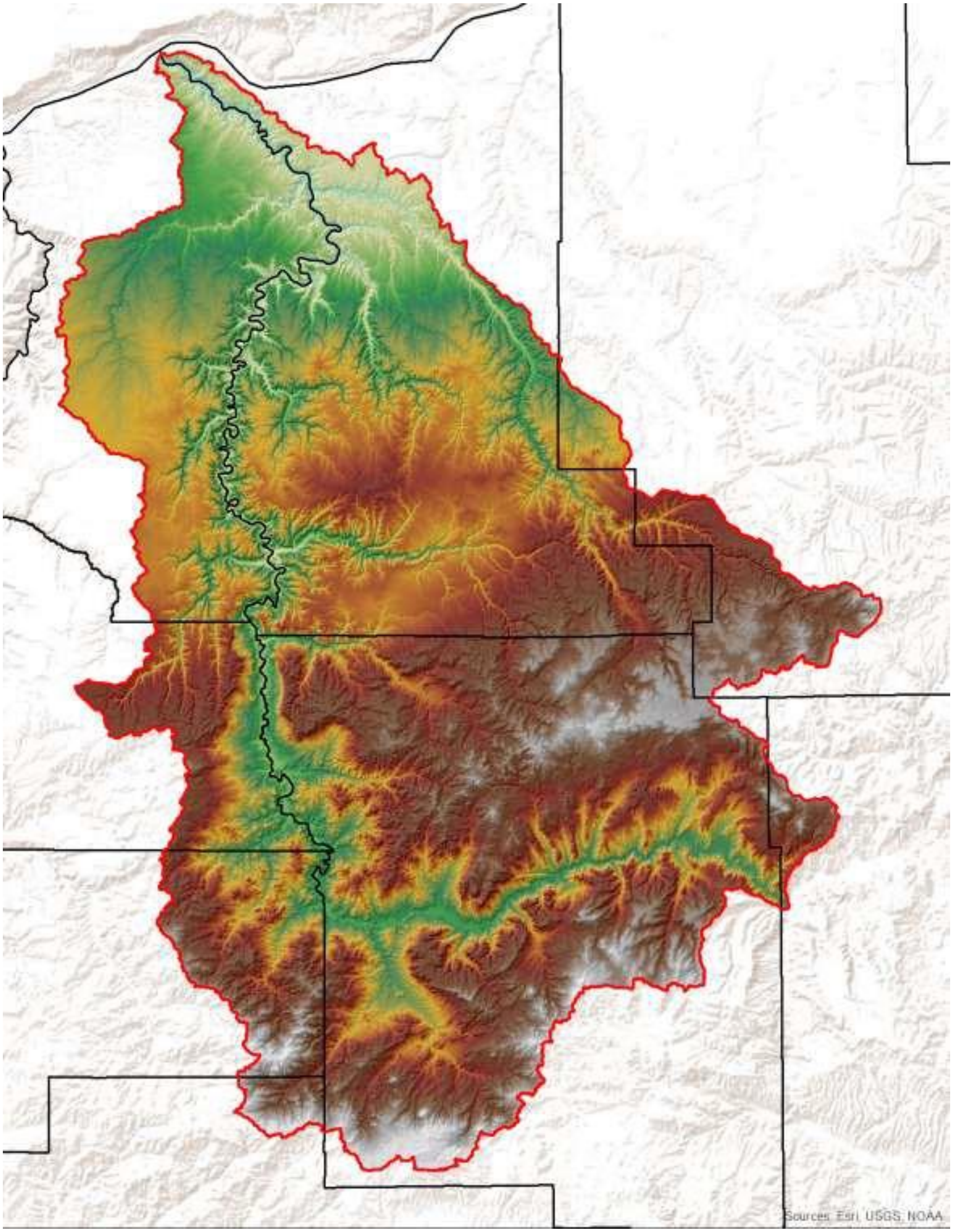


Figure 3: Lower John Day Relief Map



Rock assemblages include masses of oceanic crust, marine sediments, volcanic materials, ancient river and lake deposits, and recent river and landslide deposits (NPCC, 2005). Major geologic events included lava flows, mudflows, and ash fall that formed and stratified key formations. The Lower John Day Basin is comprised of 5 primary geologic units: (1) Columbia River Basalt Group (CRBG), (2) John Day/Clarno Group, (3) Quaternary surficial deposits (Alluvium), (4) Mitchell Group, and the (5) Dalles Group. These units are shown in Figure 4 (Marcy, 2017). Typical stratigraphy for the John Day River Basin is provided in Figure 5 (Gannet, 1984).

Of these groups, the CRBG dominates in terms of total coverage area. The CRBG, a less erodible formation, resulted from a series of flood basalt 12 to 19 million years ago (ODA, 2017). CRBG are the dominant rocks at elevations below 4000 feet. Igneous rocks are exposed in the higher reaches of the basin, while the Lower River subbasin exposures are primarily extrusive rocks, ash, and wind-blown loess. (NPCC, 2005) After volcanic activity ceased (10 million years ago), erosion and faulting continued to alter the landscape (ODA, 2017).

Figure 4: Lower John Day Key Geologic Units

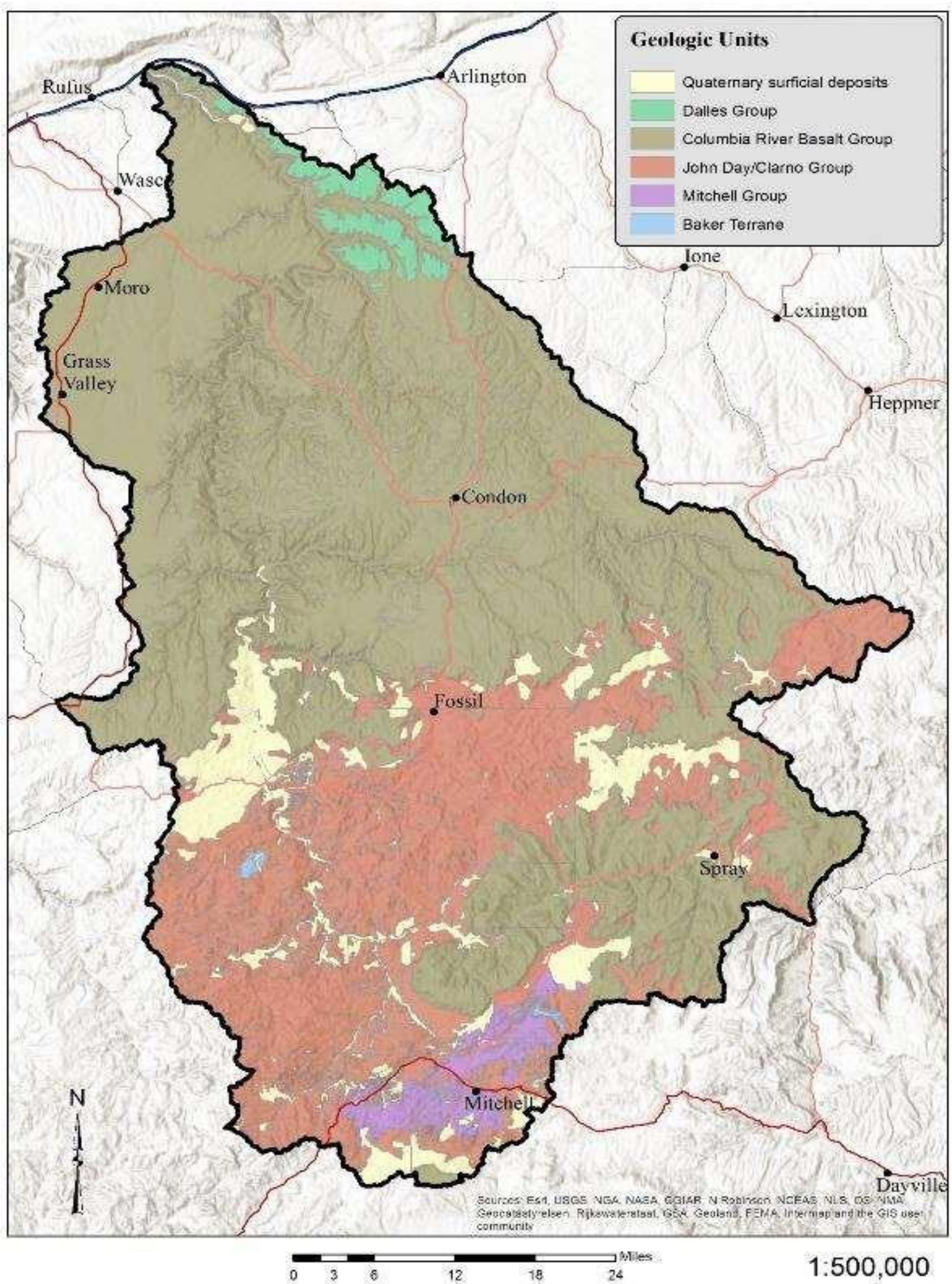


Figure 5: Typical Stratigraphy in the John Day River Basin

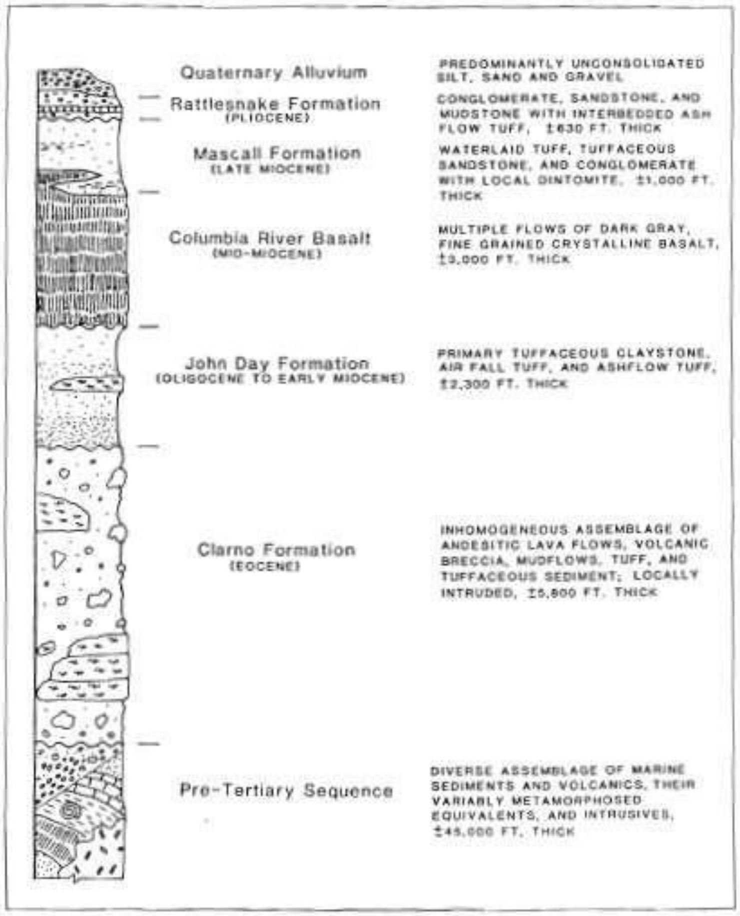
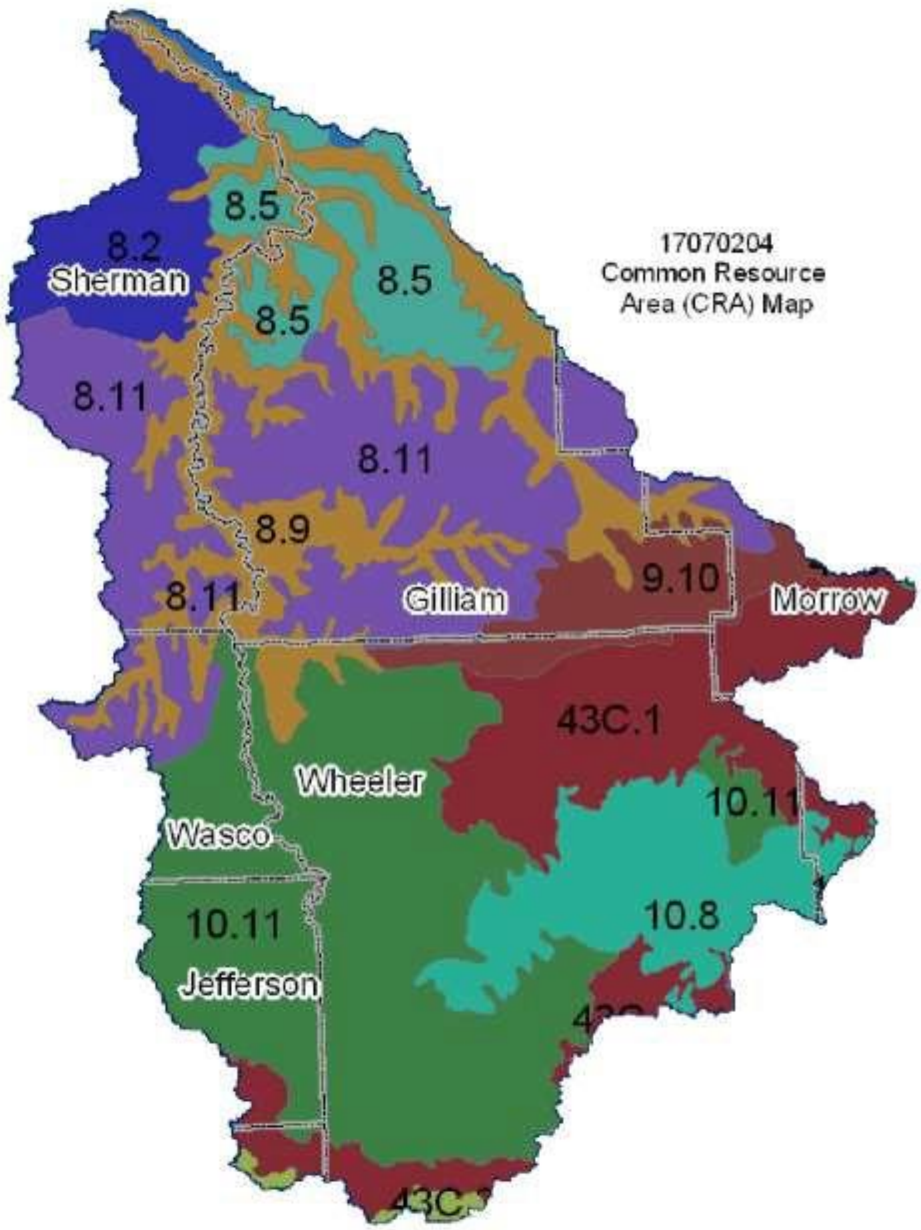


Figure 2. GENERALIZED STRATIGRAPHIC SEQUENCE OF MAJOR UNITS IN THE JOHN DAY BASIN

The major Common Resource Areas in the basin include Columbia-Plateau-Umatilla Plateau, Central Rocky and Blue Mountains Foothills-John Day Clarno Moist Uplands, Central Rocky and Blue Mountain Foothills-John Day Clarno Uplands, and Blue and Seven Devils Mountain-John Day Clarno Highlands. The Columbia-Plateau-Umatilla Plateau is made up by loess-mantled basalt plateaus and consists of the moderately deep silt loam soils of the Condon and Morrow series n (USDA, 2005). The temperature regime is mesic, and the moisture regime is xeric. Precipitation is about 12 to 15 inches. The Central Rocky and Blue Mountains Foothills - John Day-Clarno Moist Uplands unit is characterized by rangeland soils on hills or mountains associated with basalt, the dominant soils being those of the Waterbury, Gwin, and Rockley series. The temperature regime is mesic, and the moisture regime is xeric. Central Rocky and Blue Mountains Foothills - John Day-Clarno Uplands consist of rangeland soils on hills or mountains associated with the John Day/Clarno Formation n (USDA, 2005). The dominant soils are those of the Simas and Tub series. The temperature regime is mesic, and the moisture regime is aridic and xeric. Finally, the Blue and Seven Devils Mountains - John Day-Clarno Highlands is characterized by forestland that is underlain by the John Day/Clarno Formation. The temperature regime is frigid, and the moisture regime is xeric. The amount of volcanic ash on the soils is minimal. The soils are typically clayey textured with a strongly expressed argillic horizon. Figure 6 depicts the major Common Resource Areas in the basin (USDA, 2005).

Figure 6: Common Resource Areas



Note: numbers refer to CRA descriptions developed by the NRCS.

D. <u>The Climate</u>

The climate in the Lower John Day is semi-arid. This large area is highly variable in terms of precipitation, land cover, elevation, and evapotranspiration (ET). The area has a continental climate, characterized by low winter and high summer temperatures, low average annual precipitation and dry summers. The low annual rainfall on the majority of the landscape is characteristic of the Intermountain Region, which receives most precipitation (70-80 percent) between November and March. Less than 10 percent of the annual precipitation falls as rain during July and August, usually from sporadic, but violent thunderstorms (ODA, 2017).

Annual rainfall varies from about 8 inches in the northeast part of the basin to about 28 inches in the extreme southeast, higher elevation, forested areas. Most of the agricultural areas receive between 10 and 14 inches of precipitation per year (ODA, 2017). In general, precipitation and ET patterns are highly correlated with elevation. Consequently, there is a general decrease in precipitation input from the southern border of the basin in the Ochoco Mountains towards the Columbia River. Maximum precipitation totals are as much as three times greater in the highest elevations of the Ochocos relative to areas adjacent to the Columbia River in the north. See Figure 7 for 30-year average annual precipitation (1980-2010)(Prisim Climate Group, 2018), and Figure 8 for average annual ET(2010-2014)(NASA, University of Montana, 2018). Mean annual temperatures vary inversely with elevation. Mean annual temperature is 58° F. Throughout the region actual temperatures vary from sub-zero during the winter months to over 100° F during the summer (ODA, 2017). Inflows of moist Pacific air moderate extreme winter temperatures. The average frost-free period is 200 days.

Figure 7: Lower John Day 30-year Average Annual Precipitation (1980-2010)

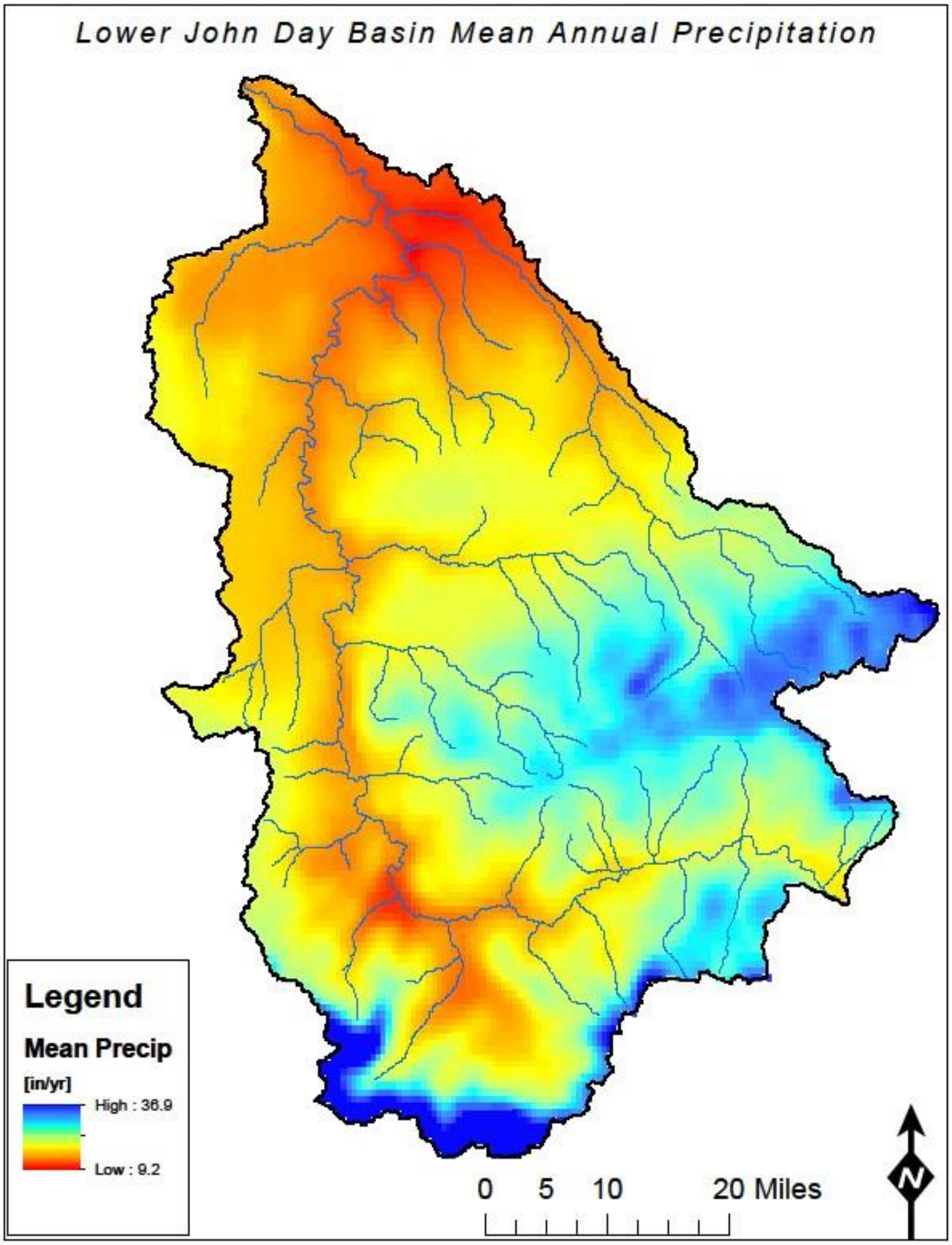
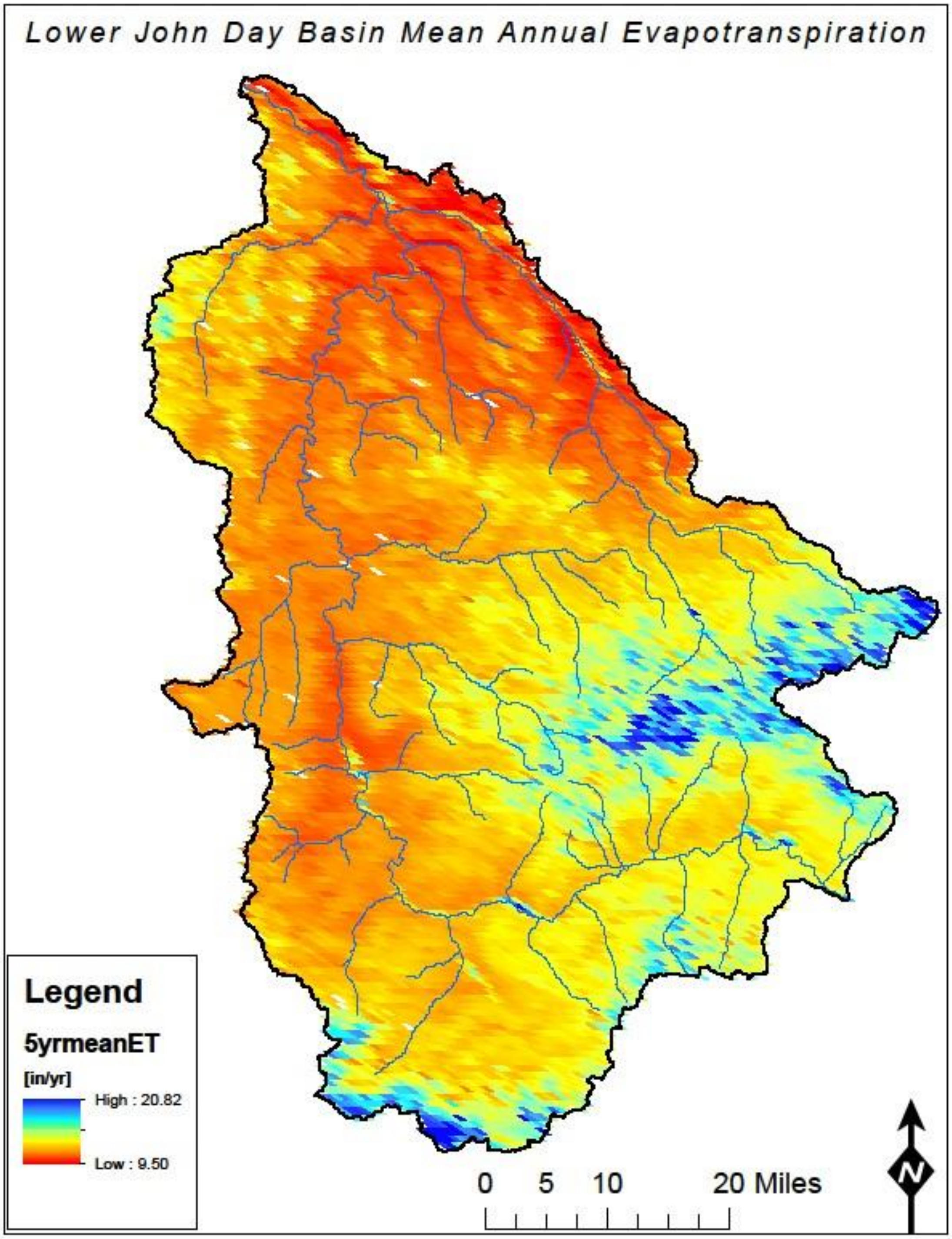


Figure 8: Lower John Day Mean Annual Evapotranspiration 2010-2014



E. Water Resources

The John Day and Columbia rivers are the largest watercourses within the basin. Most water is derived from the upper watersheds of the John Day River Basin, primarily in the form of melting snow. The North and Middle Forks provide 60% of the flow to the main stem (NPCC, 2005). Major tributaries of the Lower John Day include Wallace Canyon, Bridge Creek, Thirtymile Creek, Butte Creek, Rock Creek, Grass Valley Canyon, Pine Hollow, Bear Creek, Dry Creek, Blalock Canyon and Juniper Creek (ODA, 2017). There are 981 stream miles in the basin. Section 5 of this report provides further detail on surface flows.

Major aquifers are found in areas of CRBG and alluvial deposits geologic units shown in Figure 4. Significant alluvial deposits are located in the vicinity of Spray, Twickenham, and Clarno. Upper Rock, Muddy, Lower Bridge, and Rowe Creek tributary basins account for over 85% of all storage. More information on groundwater, aquifers, and storage is provided in Sections 6 and 7 of this report. There are 12 reservoirs in the region with dams over 10 feet, with four on Muddy Creek. More detail is provided in Section 7.

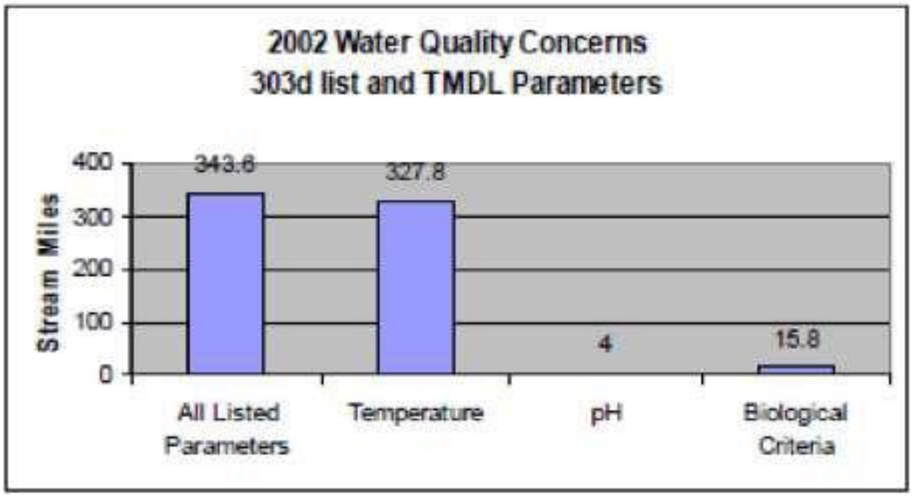
The John Day is a primarily free-flowing system (no large-scale dams) with highly variable discharge from peak to low flows (ODA, 2017). Discharge usually peaks from March through June and seasonal low flows typically occur from August to October. The John Day River tends to experience flood events in December and January when warm temperatures and high precipitation results in rain on snow events, which lead to extreme runoff (ODA, 2017). Peak flows can account for 70% of the annual discharge. Flood events occur in December and January which can result in extreme runoff (ODA, 2017). From year to year peak flows can vary from 300 to 700%. The hydrologic curve has shifted from historic times, with peak flow higher than the past and late season flows more diminished. It is suspected that these effects are due to greatly reduced rates of soil infiltration, reduced capacity for groundwater/riparian storage, and diminished in channel storage in beaver ponds (NPCC, 2005).

Flow data are available beginning in 1904, with a mean annual discharge into the Columbia River of 2000 cubic feet per second (NPCC, 2005). Average annual discharge of the John Day River into the Columbia River is approximately 1.5 million acre feet (or 2,103 cfs), with a range of 1 million to 2.25 million acre feet. Peak flow at the McDonald Ferry gauging station (River Mile 21) is typically over 100 times greater than the lowest flows the same year. Groundwater provides much of the base flow for the Lower River in the summer (NPPC, 2005). In much of the basin, channel morphology is strongly influenced by valley form, alluvial fans, and large terraces (ODEQ, 2010). The vast majority of the irrigation comes from surface waters of the main stem and its tributaries, so agriculture can play a major role in modifying local and regional hydrology (ODEQ, 2010).

Historical descriptions indicate that the John Day River was once a relatively stable and healthy river with natural riverine processes and habitats. However, watershed conditions in the John Day Basin have changed significantly over the past 150 years (NPCC, 2005). A myriad of water and land use practices, from mining to livestock grazing to riverine habitat degradation to invasive species, have contributed to these changes. These disturbances have impaired water quality in hundreds of stream miles, degraded riparian corridors and disconnected floodplains, reduced biodiversity, and fish populations, and changed the structure and function of upland habitats (NPCC, 2005; ODEQ, 2010).

The John Day River and some tributaries are impaired for several beneficial uses including salmon and trout rearing and migration and aquatic life. Fish and aquatic life require dissolved oxygen concentrations, stream temperatures, and biological criteria, and other water quality characteristics to be within certain limits. Currently, these limits are not being met and therefore fish and aquatic life uses are not being adequately supported in the John Day River and some tributaries. Further discussion of water quality is provided in Section 6 of this report.

Figure 9: Summary of 303(d) Listings

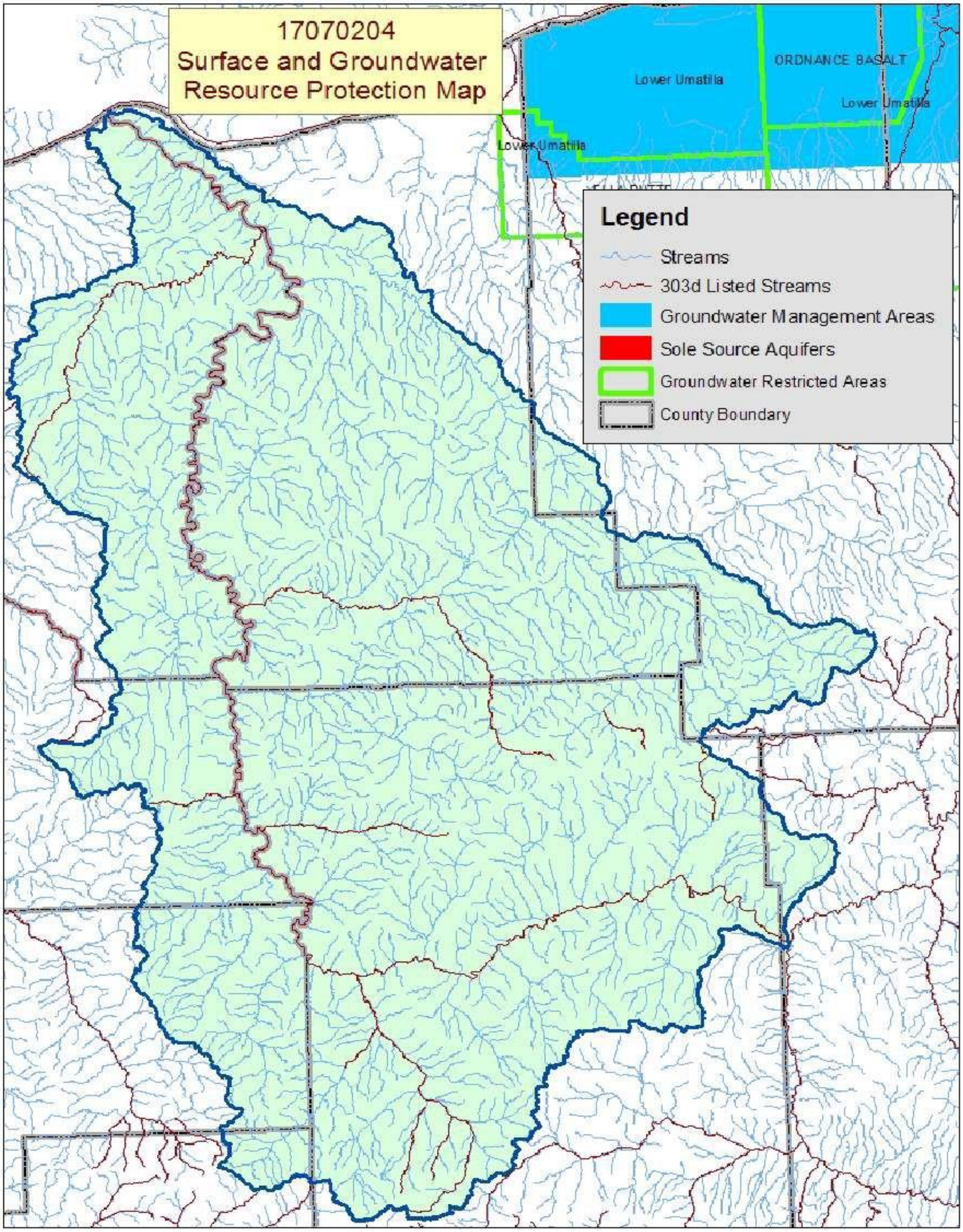


A detailed John Day Basin-wide evaluation for groundwater resources was completed by OWRD in 1984 (Gannett, 1984). Some key findings of the report related specifically to the Lower John Day Basin include that groundwater movement is generally northward toward the Columbia River, however it is locally structurally controlled. Average annual groundwater recharge rates over the basin were estimated at 0.4-0.6 in/yr. The high transmissivity and relatively shallow static water levels make yields adequate for domestic and stock use in most areas, yet overall there is regional low recharge and significant depth of wells necessary to extract water. (Gannett, 1984).

Beneficial uses in the John Day that water quality standards are seeking to protect include domestic water supply, industrial water supply, irrigation, livestock watering, fish and aquatic life, wildlife and hunting, fishing, boating, water contact recreation, and aesthetic. Standards are set based on the most sensitive beneficial use. In this case, temperature and dissolved oxygen standards are based on salmon and trout, and the bacteria standard is based on water contact recreation (ODEQ, 2010). TMDL implementation for these standards is underway.

In spite of past human disturbances, the basin continues to support wild runs of anadromous salmonids and a wide assemblage of resident wildlife. In addition, public and private landowners have increased awareness of the negative impacts of some land management practices. Current practices have been, and continue to be, improved to minimize these impacts while at the same time furthering the long-term interests of natural resource industries in the subbasin. (NPCC,2005).

Figure 10: Lower John Day Surface and Groundwater Protection Map



F. Biotic Systems

The John River Day Basin supports unique and rich biodiversity. The variety of landform, elevation, and climate in the Blue Mountains and adjacent private lands result in a unique diversity of plants and animals (Forest Service, 2014).

The present plant communities differ from the original flora or pre-European settlement in the Lower John Day subbasin as a result of intensive grazing, fire suppression, and introduction of exotic plants. Native bunchgrasses have been largely replaced by western juniper, sagebrush, and exotic plants (e.g. cheatgrass). Land cover is predominantly rangeland and cropland (ODA, 2017). The dominant vegetation depends on topographic position and precipitation, ranging from coniferous forest (ponderosa pine, lodgepole pine, Douglas fir, white fir) at higher elevations of the Ochocos and western edge of the Blue Mountains, to grass, shrub, and juniper communicates at middle elevation and desert shrub-steppe at lower elevations (ODA, 2017). The basin supports a wide variety of threatened and endangered plants (NPCC, 2005). Riparian corridors are largely degraded and a moderate number of wetlands have been lost (NPCC, 2005). These areas are usually flooded during part of the growing season and completely dry during mid to late summer. Land has been converted to grazing and dry-land wheat at mid-elevation and irrigated agriculture in the floodplain (NPCC, 2005).

Exotic plants (noxious weeds) and uncontrolled growth of some native species (e.g. juniper) is a growing problem within the region. One great threat to native rangeland biodiversity and recovery of less than healthy watersheds is the rapidly expanding invasion of noxious weeds.
Although many weeds occupy lands in the Lower John Day subbasin, those causing most concern are diffuse, spotted, and Russian knapweeds; Dalmation toadflax; yellow starthistle; Scotch thistle; purple loosestrife; rush skeletonweed; leafy spurge; poison hemlock; Russian thistle; Canada thistle and medusahead rye (ODA, 2017).

Central to the entire John River Day Basin's aquatic ecosystem are the anadromous salmonids (CTWSRO, 2015). The river system supports one of the most significant anadromous fish runs in the Columbia Basin (NPCC, 2005). The John Day still supports the strongest wild runs of spring Chinook and summer steelhead in the Columbia River drainage and fall Chinook salmon and anadromous Pacific lamprey are present in the basin (Forest Service, 2014; CTWSRO, 2015). Other important fish species include resident populations of bull trout, westslope cutthroat trout, and interior redband trout. It is estimated that there are 27 species of fish, including 17 native species, in the basin (ODA, 2017). Overall, the Lower John Day provides a key transportation corridor for salmonids. Further details on the current abundance of summer steelhead, spring Chinook, and Pacific lamprey are offered below.

Presently, summer steelhead are the most widely distributed salmonid species, seasonally occupying most tributaries and mainstem habitats. Spawning and rearing distribution occurs in the mainstem, lower mainstem tributaries downstream of the North Fork confluence (CTWSRO, 2015). Spring Chinook distribution is slightly more confined to mainstem habitats and larger tributaries compared to steelhead, although juvenile Chinook migrate through the Lower John Day into cool-water tributaries during summer months (CTWSRO, 2015).

Many fish populations in the Lower John Day River have declined significantly from historic levels. Historic photographs taken by pioneers (on file at the Grant County Museum) show wagons stacked high with salmon taken from the John Day River before the 1900s. Numerical records of run sizes are not available, but one can speculate based on historic estimates for the Columbia River that the John Day River contributed several hundred thousand salmon and steelhead to the Columbia system. (ODFW, 1990). From 1958 through 2003, adult steelhead returns to the John Day Basin ranged from about 5,000 to 40,000 and showed a declining trend from an average of about 20,000 per year to about 10,000 per year. (NPCC, 2005). ODFW estimates since then range from about 5,000 in 2004 to 15,000 in 2012. (ODFW, 2012). From 1963 through 2003, estimated returns of adult spring chinook salmon ranged from about 350 to 6,350 per year and showed an upward trend from an average of about 2,000 per year to an average of about 2,850 per year. (NPCC, 2005).

"Although bull trout historically occurred throughout the John Day Subbasin, they are no longer present in the Lower John Day Basin except for some overwintering above Spray. Abundance and distribution of redband trout are not routinely indexed in the John Day Subbasin. At this time, abundance estimates of John Day trout populations are unknown. Summer distribution of redband trout is limited to headwater areas, similar to John Day cutthroat and bull trout, by a variety of land use impacts including stream dewatering from irrigation diversions and temperature barriers caused by stream alterations due to cattle grazing and timber harvest. (ODFW 1995)." (NPCC, 2005).

With populations below historic levels, many fish species are now listed at the federal or state level. Mid-Columbia summer steelhead and bull trout were listed as threatened in 1998 and 1999, respectively. Westslope cutthroat trout and interior redband trout are listed as a sensitive species by the State of Oregon (ODFW, 2008). Over the last century, the integrity and health of habitats in the John Day that support these species have been severely degraded. This is a cause of population declines for all native salmonids and the Pacific lamprey. Stream corridors have been simplified, fragmented, and disconnected from floodplain areas, creating poor habitat for native fish. "Some past and current landuse practices have degraded the aquatic resource. Water withdrawals have reduced stream flows, especially during summer, and contributed to higher water temperatures; poorly-managed grazing, mining, timber harvesting, and maintenance of push-up dams have reduced riparian vegetation and shade, also contributing to higher water temperatures and reducing habitat diversity overall; pushup dams and reduced flows have created physical and thermal obstacles to fish movement. Riparian road construction and use, agricultural and residential development, and recreational use of riparian areas have also contributed to compromised fish habitat." (NPCC, 2005.)

Nevertheless, certain aspects of watershed function have been restored through a combination of federal, state, tribal, local, and private efforts. Improved scientific understanding of species needs, watershed management, and conservation practice has delivered benefits (NPCC, 2005). Habitat quality is variable depending on the degree to which native habitats have been impacted—for the good or bad—by human activities. All told, the absence of dams, sparse population, high quality habitat in the headwaters, and greater participation in conservation programs by private landowners, has enabled large areas of the basin to retain excellent future restoration potential.

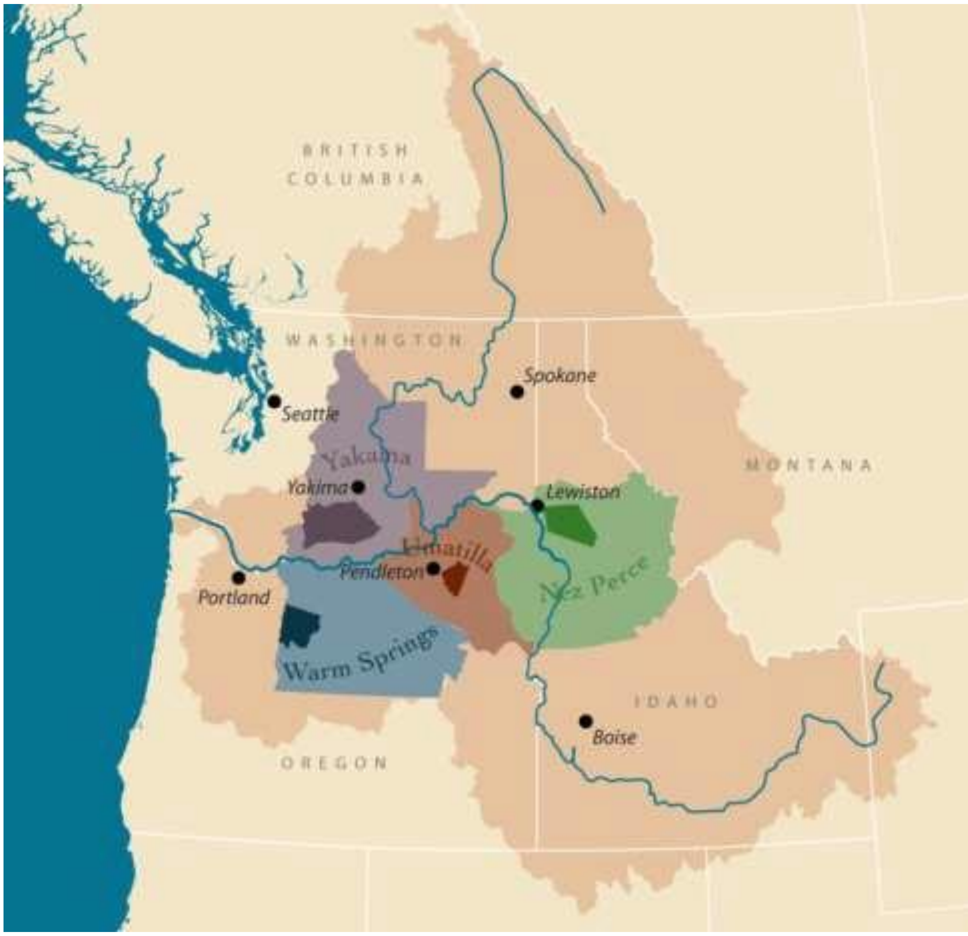
A variety of wildlife species, including large and small mammals, waterfowl, passerines, raptors, reptiles, and amphibians, are associated with the John Day Subbasin riverine, wetland, and upland habitats. Many wildlife species reside within the subbasin in association with Shrub-Steppe habitat. Certain populations of wildlife species are being managed by federal and state wildlife managers throughout the subbasin, including big game, fur bearer, upland birds, and waterfowl species. Many raptors inhabit the subbasin as well.

G. Population, Ownership, and Land Use

The Lower John Day Basin has been used by Native Americans for gathering and harvesting fish and game for thousands of years. In the mid-19th- century, homesteads and ranches were established along the fertile bottomlands of river corridors where water was available for agriculture (CTWSRO, 2015). Fur trading and gold mining stimulated early European settlement (BLM, 2006). Other early land uses included wheat farming in the Lower River Subbasin, ranching and haying throughout, and logging in the upper elevation forests. Small communities were established along the river to provide goods and services for mines, homesteads, and ranches (NPCC, 2005).

Today, the basin is overwhelmingly rural with a very small population. The basin boundary overlaps eight rural Counties. The total population of the three counties with the largest acreage in the basin, Gilliam, Wheeler, and Sherman Counties, is 4908 (US Bureau of the Census, 2016). Population density is roughly 0,9-2.2 people/square mile (ODA, 2017). This population is spread between scattered ranches and home sites, small towns of 100 to 500 people built around a school or post office, and larger towns of over 500 people that generally serve as county seats, are home to government offices, and/or sustain service-oriented businesses. Condon in Gilliam County is the largest town. Many of these towns were historically sawmill towns (NPCC, 2005). The declining timber industry, closure of saw mills, and the lack of new industrial opportunities have led to a declining and aging population (ODEQ, 2010; BLM, 2006). The basin is home to aboriginal territory of two Native American Tribes with treaty rights for fishing, hunting, and gathering. Figure 11 shows tribal aboriginal territory in the basin.

Figure 11: Tribal Aboriginal Use Areas



Private ownership is substantial in the basin. Land ownership in the basin is roughly 91% private, federal (approximately 8% BLM and 1% Forest Service) (ODA, 2017). Ownership has been relatively static for the last decade. The basin is 20% forested, 54% rangeland and 25% agriculture, <1% urban (USDA, 2005).

Much of the near-stream lands along the lower mainstem are managed by the Bureau of Land Management (BLM) for grazing and recreation (ODEQ, 2010). Riparian areas are typically managed as part of agricultural operations, and many have been altered by water diversions, channelization, and vegetation changes (ODEQ, 2010). An increasing number of riparian areas are being managed with an emphasis on protecting fish and wildlife values and water quality (ODEQ, 2010). The Forest Service managed the higher elevation lands in the Ochoco National Forest. The National Park Service oversees the John Day Fossil Beds National Monument the state operates Cottonwood Canyon State Park. The John Day River mainstem from Tumwater Falls upstream to Parrish Creek is designated as State Scenic Waterway and the Lower John Day River mainstem from Tumwater Falls upstream to Service Creek are designated Federal Wild and Scenic Rivers (ODEQ, 2010).

Private lands are mostly in agricultural use. There are about 327 farms and ranches in the Lower John Day. Most of these are grain crop operations in Gilliam and Sherman Counties that are more than 1,000 acres in size. Much of the forestland in Wheeler County consists of areas less than 1,000 acres in size. Much of this forestland is under private industrial ownership and is used for timber and grazing. Other private forestland and rangeland is used for fee hunting, which has become a significant source of income for area ranchers (USDA, 2005).

The primary agricultural products in the planning area are small grain, pasture and hay, and beef cattle production. Approximately, 135,000 acres are in small grain crops, 12,000 acres of pasture and hay, and 150,000 of fallow or idle cropland. Figure 14 describes crop types. The maximum allowable acreage (25% of total cropland) has been enrolled in the Conservation Reserve Program, removed from crop production and planted to perennial grasses (USDA, 2005). There is a trend toward fragmentation of large private land holdings. Historic and present mining, transportation, and recreation uses are dispersed across the region (ODEQ, 2010). Figure 13 provides a map of land ownership and Figure 12 depicts land use.

Western Juniper has expanded vigorously throughout the Lower John Day. Fire suppression has resulted in juniper encroachment into native grasslands. These juniper forests increase water usage through increased evapo-transpiration, thus leading to reduced streamflows (NPCC 2005). The Oregon Natural Heritage Program's Historic Vegetation dataset identifies approximately 50,000 acres of pre-European Settlement Western Juniper presence. The Institute for Natural Resource's 2013 Juniper Presence dataset identifies over 675,000 acres of Wester Juniper presence. Figure 17 shows the 2013 Western Juniper presence and Figure 18 shows the pre-settlement Western Juniper presence. Briefly stated, juniper encroachment and eventual dominance alter the hydrologic cycle, which is the ability of the soil to capture, store, and safely release water and alters nutrient cycling and energy flow, reducing a site's productive potential, biological diversity, wildlife habitat quality, and forage value (Barret 2007). Figure 15 shows the land cover and Figure 16 provides the juniper densities. The mean max age identified by the Institute of Natural Resources for the basin is 123 years and can be seen in Figure 19. Figure 20 shows the mean Western Juniper canopy cover by Water Availability Basin (WAB) with the high percent cover being in the southwestern portion of the basin.

Spring seeps in the basin can be seen in Figure 21 and was created using the digital USGS 7.5 quadrangle maps. The John Day Subbasin plan list spring reconnection with strategy C: flow restoration. Springs in headwater areas provide much of the flow in area streams in late summer and fall. In some areas, poorly designed road networks, small impoundments and other disturbances have redirected spring flows away from downstream drainages and into areas where they do not contribute to sustaining streamflow. Reconnecting these springs John Day Subbasin Revised Draft Plan March 15, 2005 258 to downstream drainages can contribute to increased base flows and reduced water temperatures (NPCC 2005). Figure 21 also show the spring densities in spring per mile by WAB. The highest densities are in Kahler and Rowe Creek watersheds and the lowest in Scotts Canyon.

Figure 12: Land Ownership. Source: NRCS.

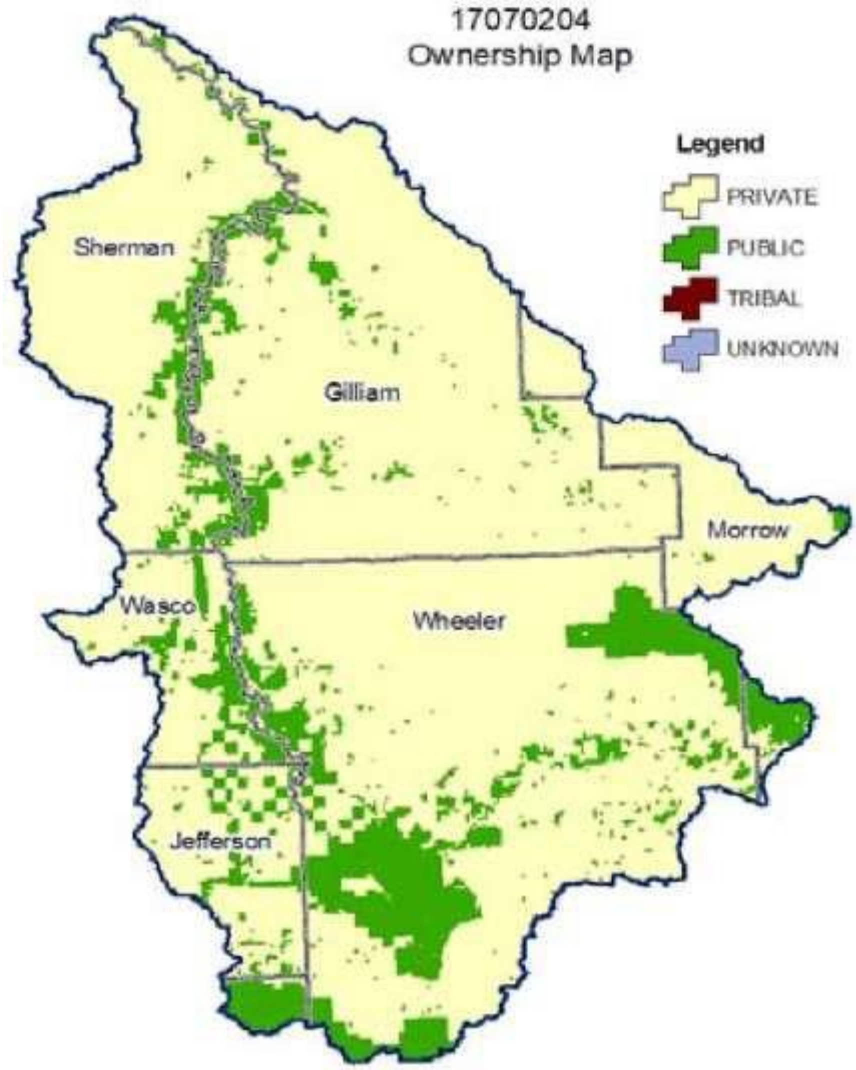


Figure 13: Land Use. Source: NRCS.

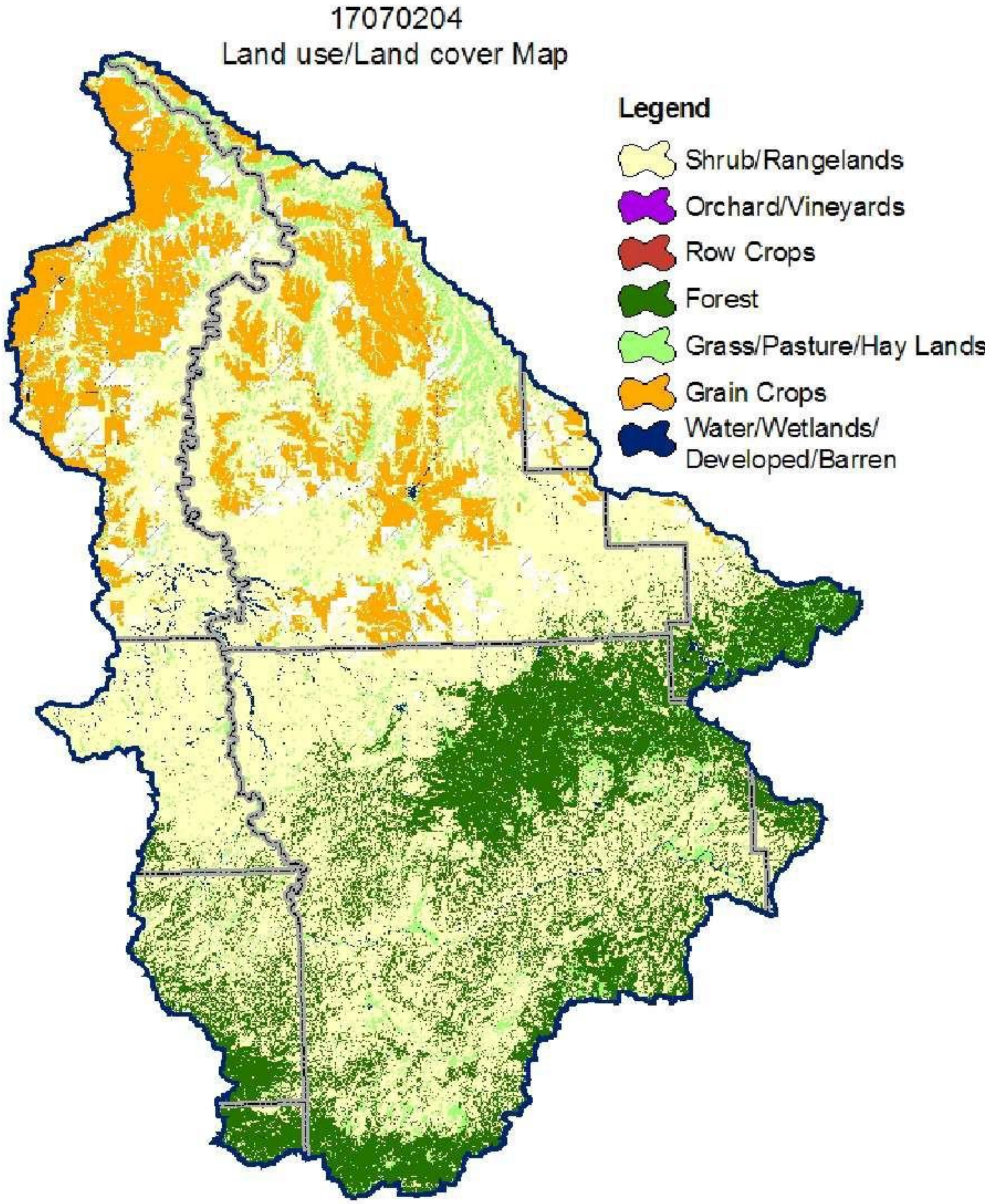


Figure 14: Crop Types. Source: Gilliam SWCD.

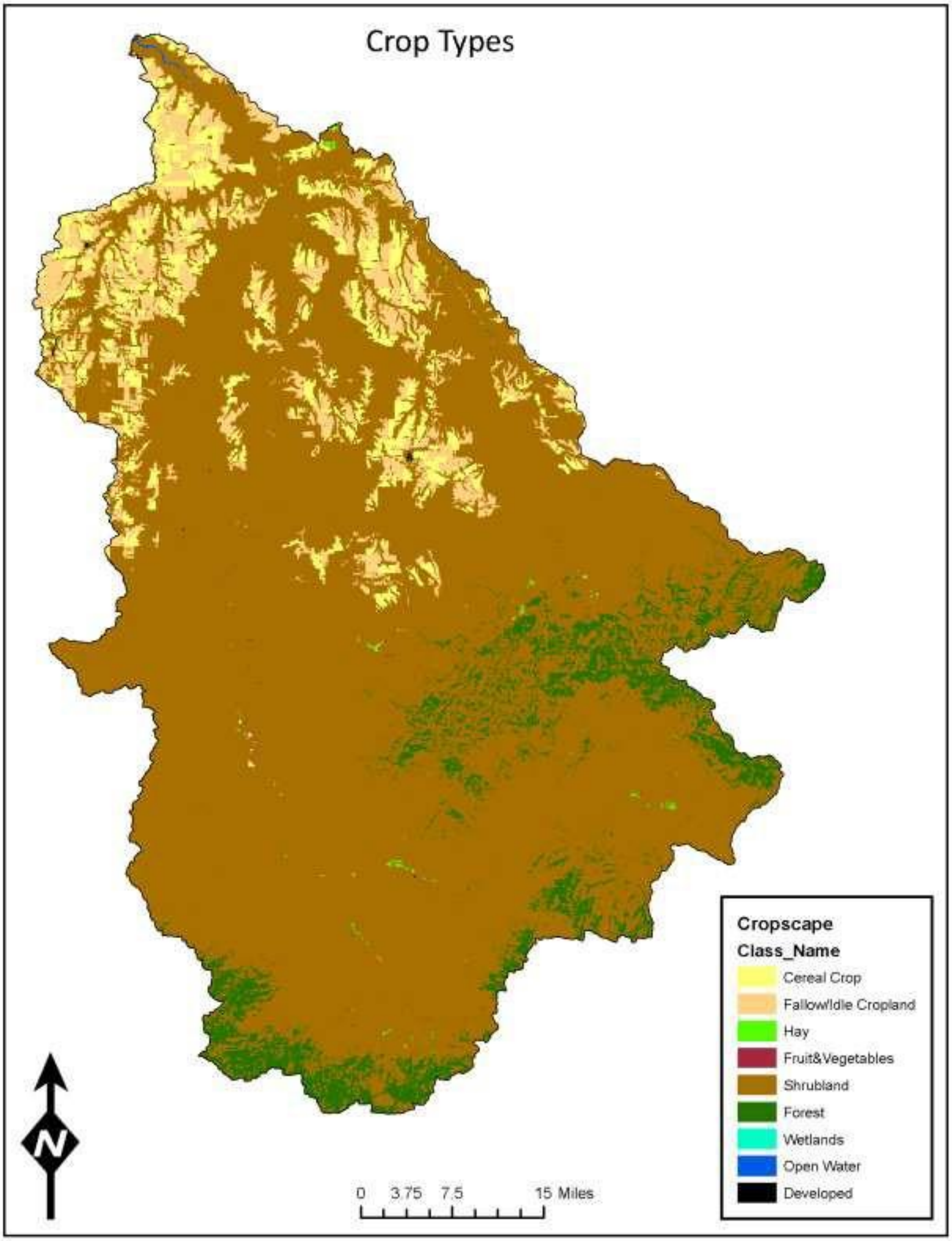


Figure 15: Land Cover. Source: The Freshwater Trust.

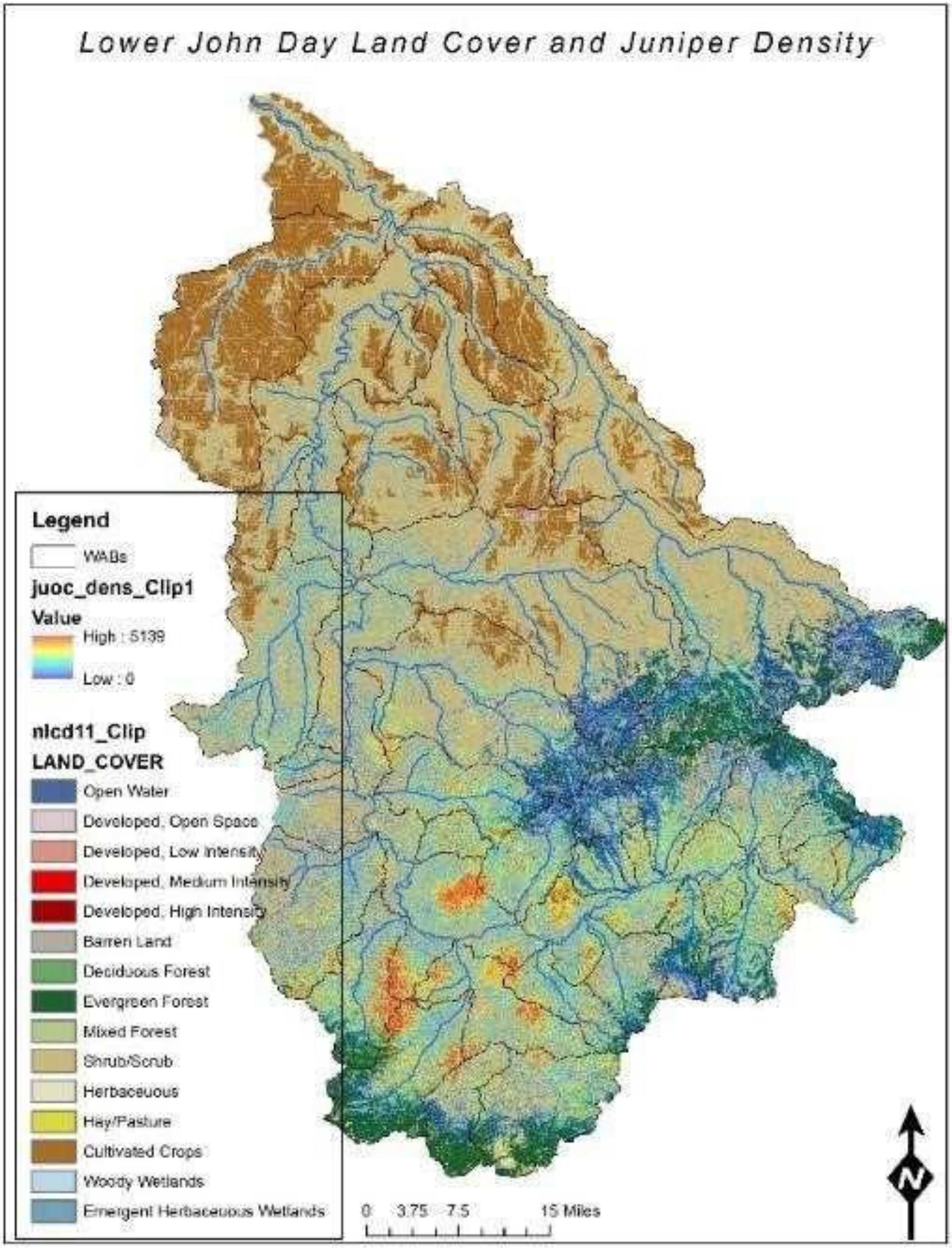


Figure 16: Juniper Density

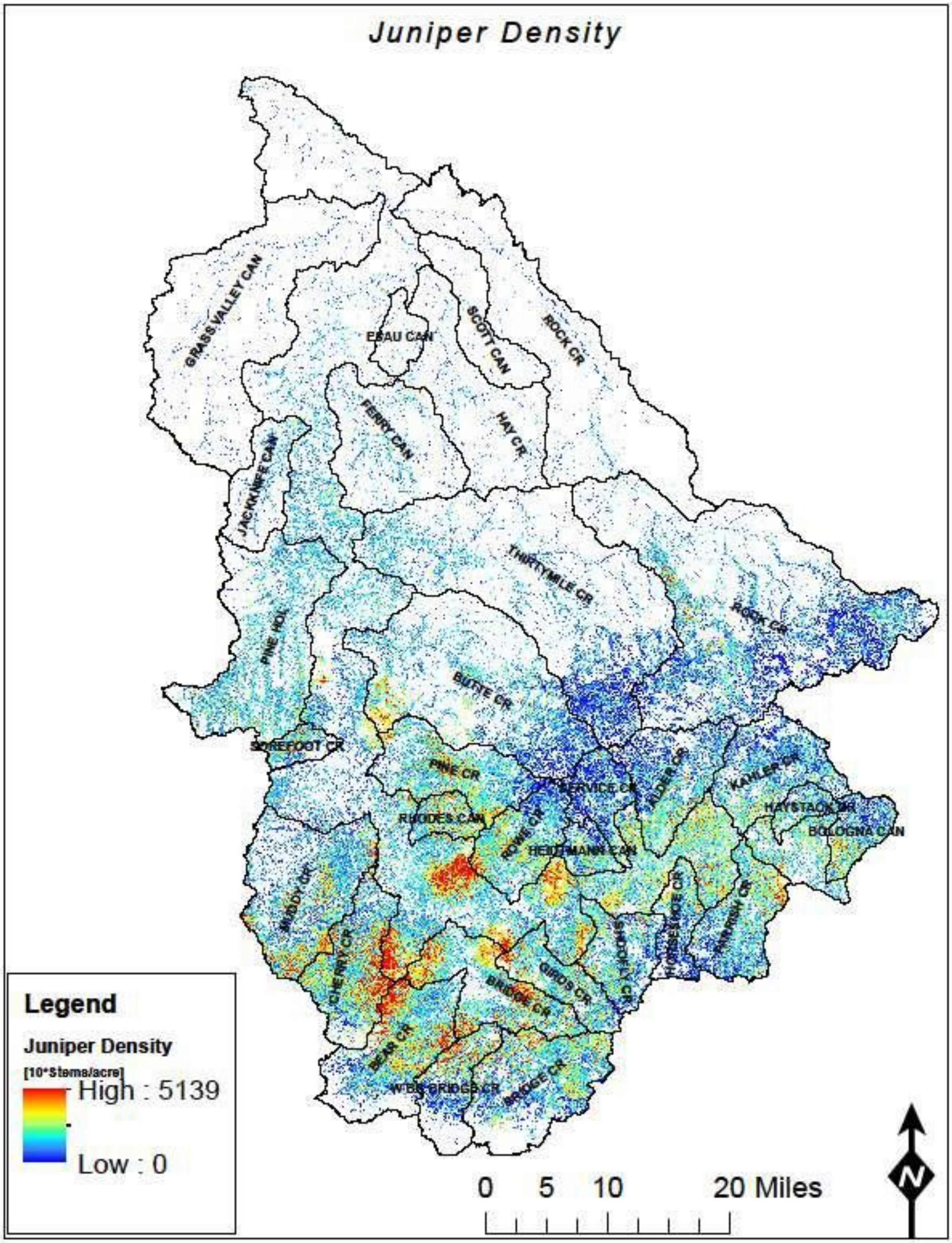


Figure 17: Western Juniper Presence

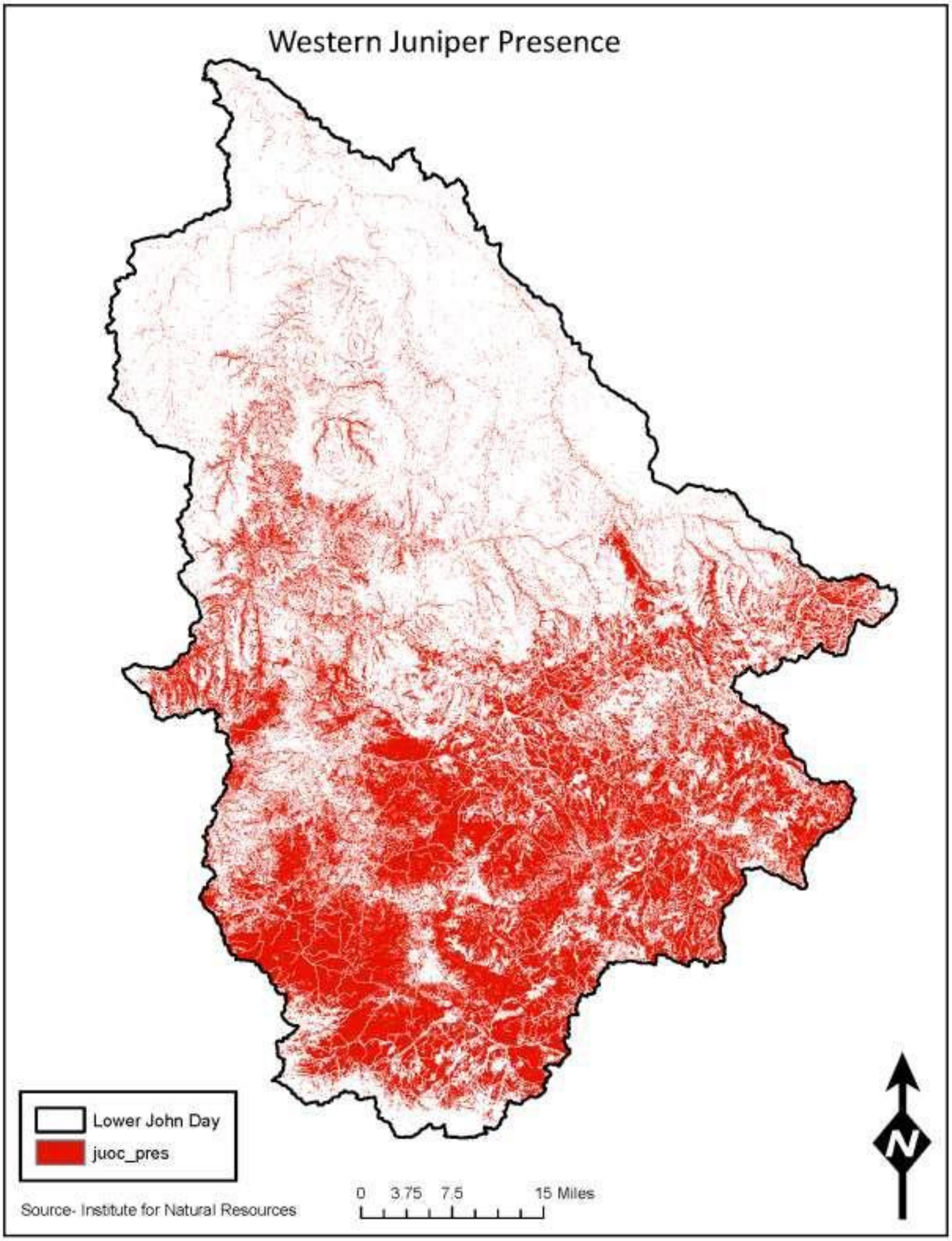


Figure 18: Presettlement Western Juniper Presence. Source: Gilliam SWCD.

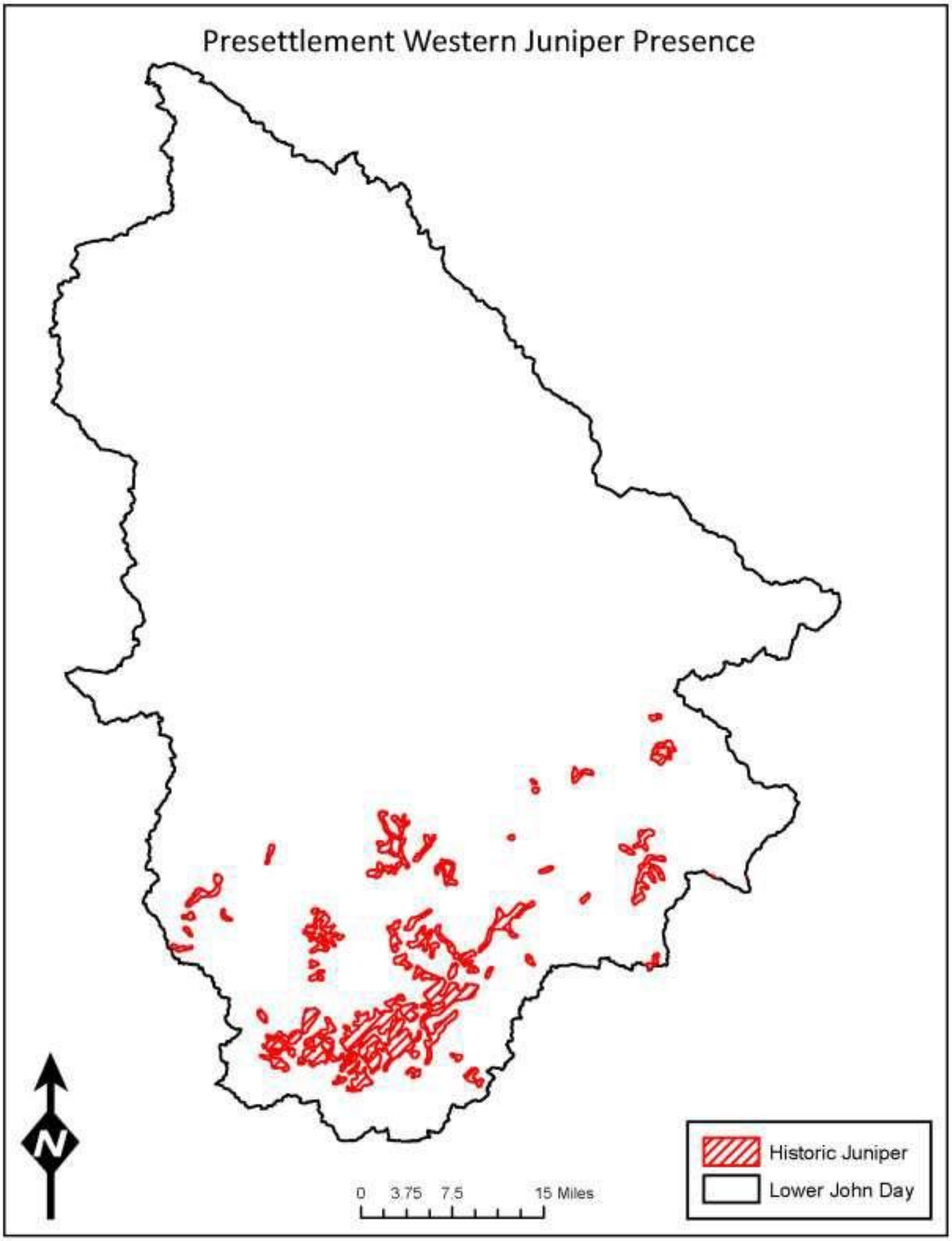


Figure 19: Western Juniper Max Age. Source: Gilliam SWCD.

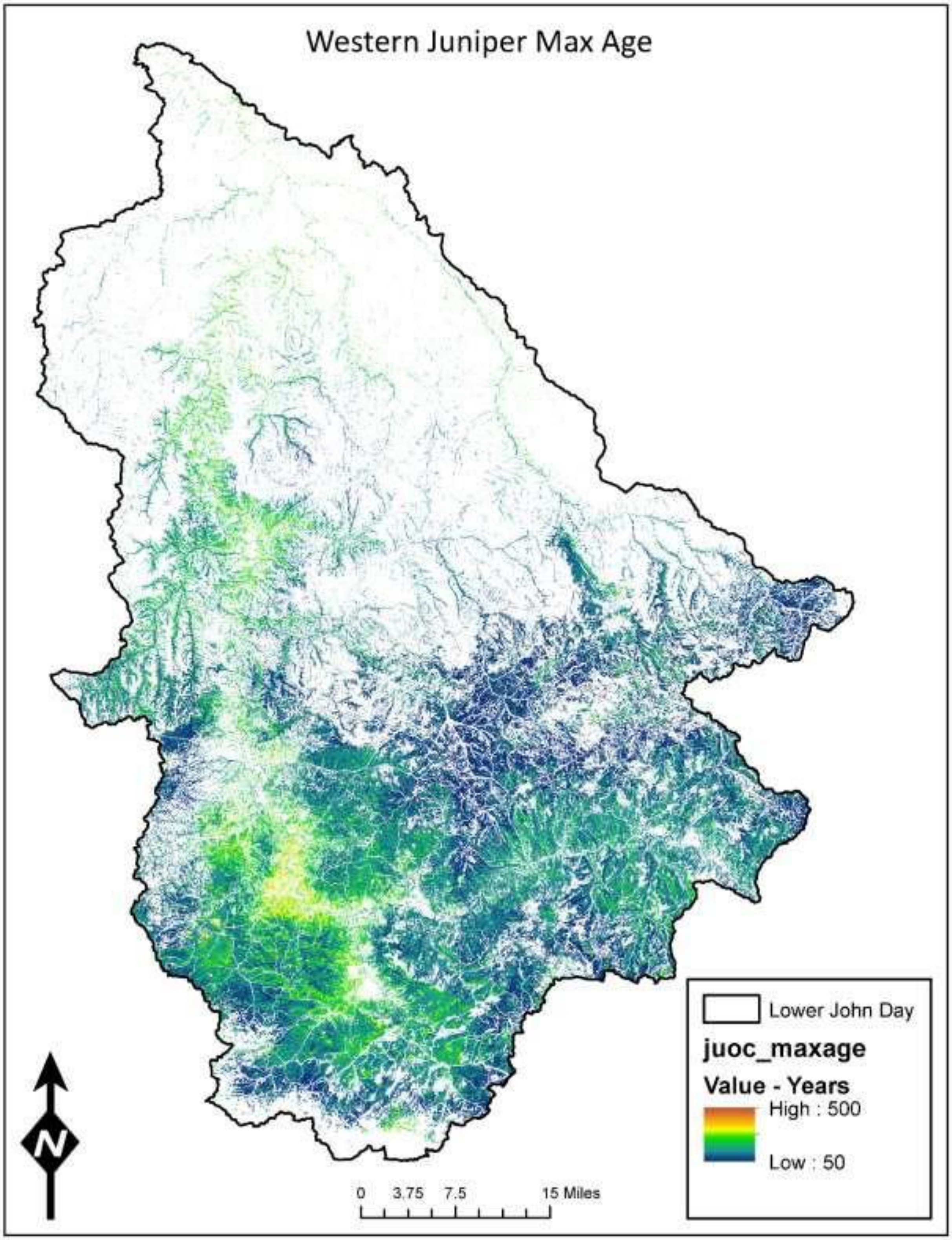


Figure 20: Mean Juniper Canopy Cover by WAB. Source: Gilliam SWCD.

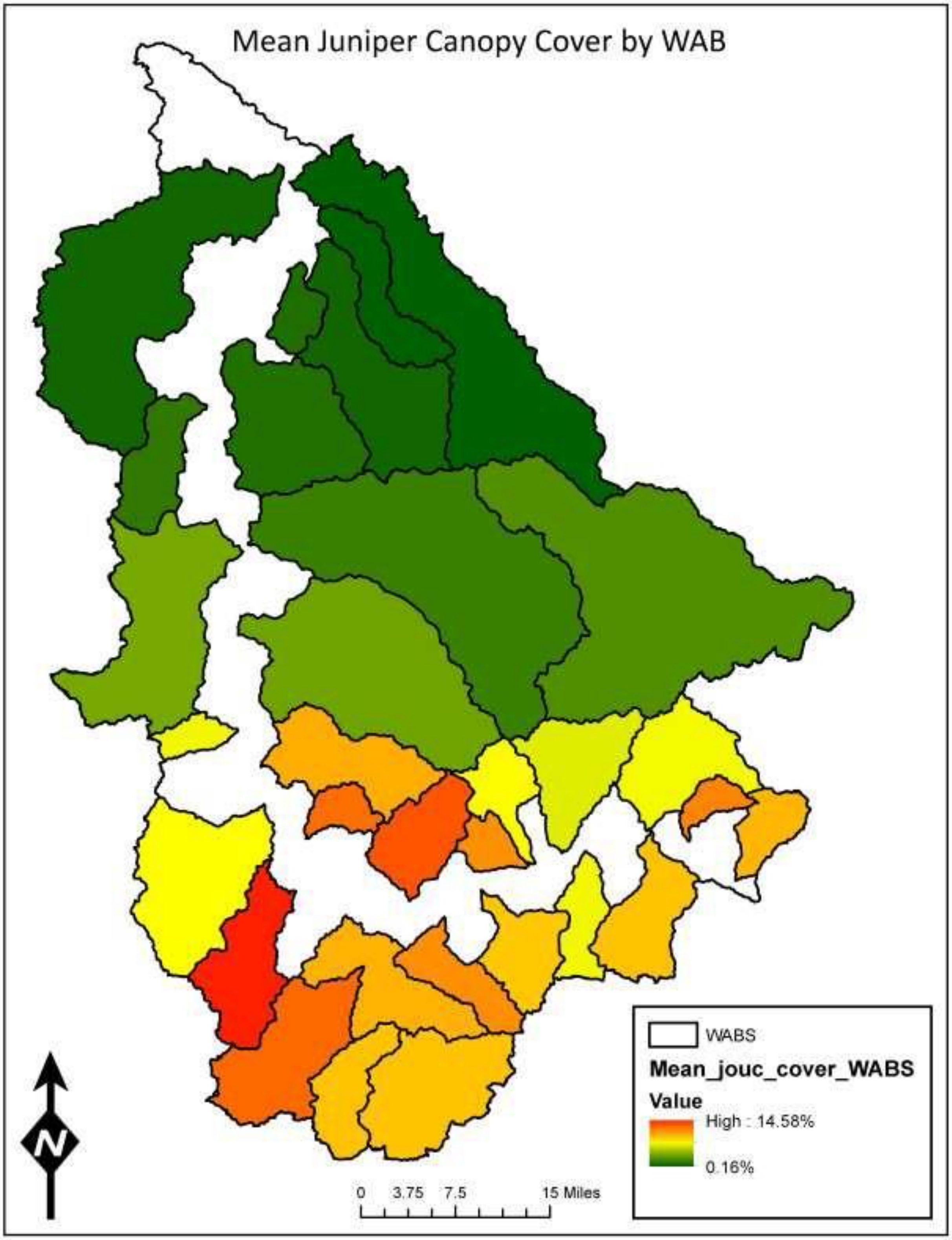
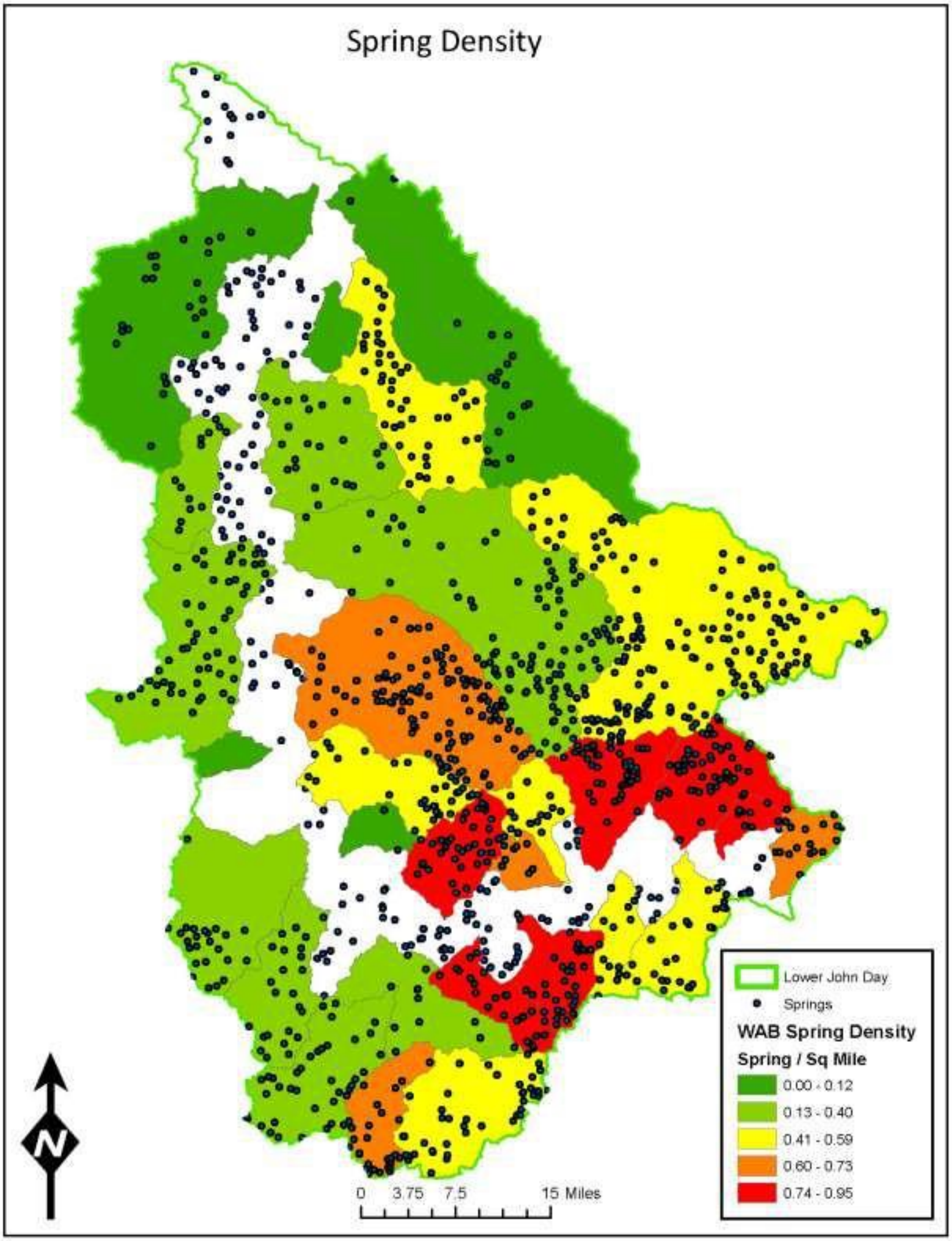


Figure 21: Spring Density. Source: Gilliam SWCD.



The basin also has human factors unique to the region that require close consideration as this action plan is pursued. These factors include the involvement of two Native American Tribes (Warm Springs and Umatilla), a strong reliance on natural resources for the economic base, a high percentage of economically distressed communities, and the high percentage and ecological significance of privately owned land within the planning area.

H. Local Economies

The economy of the Lower John Day River Basin was built around its natural resources. Mining remained a significant activity well into the early 20th century (NPCC, 2005). As mining declined, ranching became the lifeblood of commerce for the next 50 years. Dry-land wheat farming eventually supplanted ranching in the southern Columbia Plateau. The timber industry began in the 1930s, with large-scale logging continuing on public and private lands up to the 1980s. The modern economy developed around these three resource-dependent pursuits. In 2012, Grant, Wheeler, Gilliam, and Sherman Counties had 1.9 million acres in agriculture that generated a market value of products sold of $138 million. Market value in these counties has increased since 2007 by an average 43% (Business Oregon, 2015). Logging continues today at a much-reduced extent, and mining is minimal (BLM, 2006).

While the region still relies on the production of food and forest products, the economy has diversified and is predominantly driven by agricultural, wind energy, and waste handling. Agriculture is dominated by dryland wheat along with livestock pasturing. Wind turbines have become a prominant feature of the landscape with the first turbines arriving to the Basin in 2001. Waste Management's landfill complex is sited on the edge of the basin. The company is a large private employer for the basin.

The basin is home to 209 establishments employing 1,157 people according to Oregon's Quarterly Census of Employment and Wages (QCEW). An estimated 66 people are employed in Agriculture within the LJD Basin, equivalent to 6% of the of the Basin's total employment.
Collectively Agriculture, Utilities, Waste Services and Remediation, and the Information industries employ 19% of the Basin's workers, or 219 jobs. Specific job numbers by industry are not available due to low number of establishments and confidentiality of the data source.

Figure 22: USGS Interactive Wind Turbine Map eerscmap.usgs.gov/uswtdb/viewer

Above is USGS Interactive wind turbine map depicting the locations of wind turbines in Gilliam and Sherman Counties as well as wind farms across the Columbia River in Washington State. Within the LJD Basin, there are 642 turbines that have a rated capacity of 938 MW. In the Sherman County's portion of the basin there are 559 turbines. Gilliam County hosts 83 turbines in its part of the basin in the Condon I and II wind projects with a rated capacity of 50.0 MW. No wind turbines are located in Wheeler County.

Altogether 562 Turbines are located in Sherman County with a rated capacity of 1,061 MW. Gilliam County is home to 756 turbines with a rated capacity of 1,475.2 MW. In Gilliam County, only the Condon Wind Project Phase I and II are located within the basin.

Quarterly Census of Employment and Wages (QCEW, 2016) covering the Basin indicates that 19 establishments employing 50 employees catered to Arts, Entertainment, and Recreation (20), and Accommodation and Food Services (30). Combined these two sectors contributed to 5% of the Basin's work force.

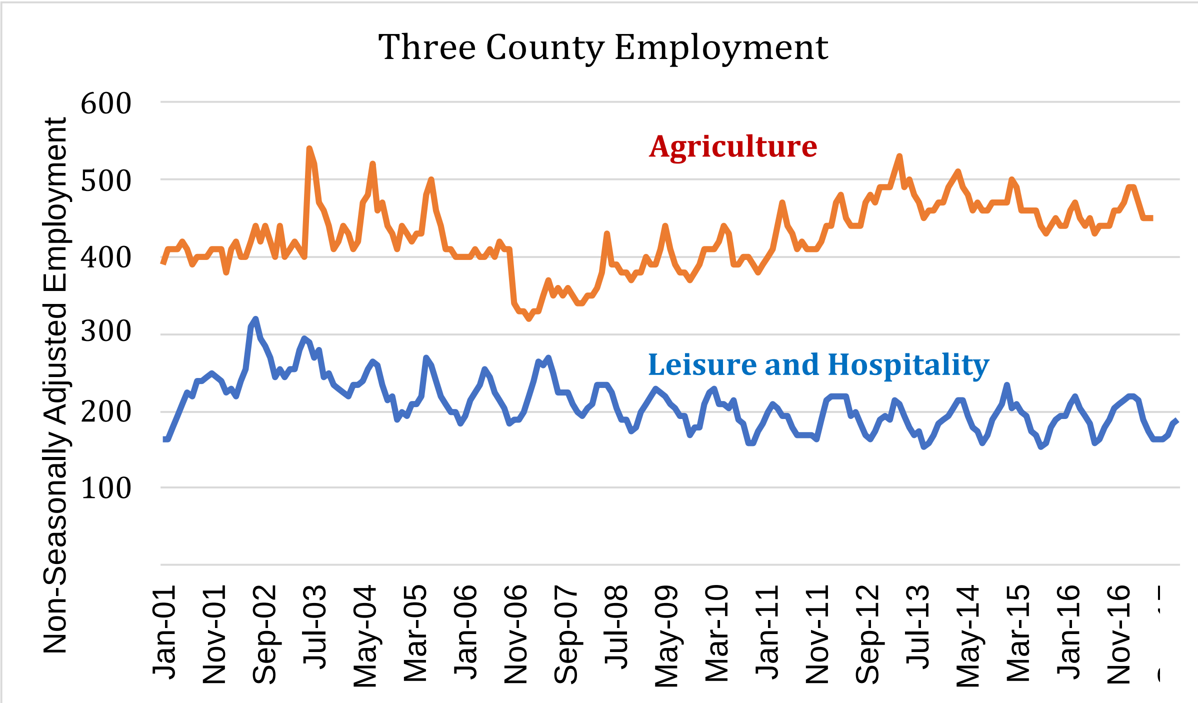
The primary employment in the Basin is government related. Education Services, Health Care, Social Assistance, and Public Administration account for 43% of the total jobs in the Basin.

Table 1: Oregon Quarterly Census of Employment and Wages (QCEW), Gilliam, Sherman and Wheeler Counties.

Lower John Day Basin Employment (2016)

Sector	Sector Name	Establishments	Employment	% of Total
11	Agriculture, Forestry, Fishing and Hunting	25	66	6%
22	Utilities	c	c	c
23	Construction	14	105	9%
31-32	Manufacturing	c	c	c
42	Wholesale Trade	4	21	2%
44-45	Retail Trade	14	69	6%
48-49	Transportation and Warehousing	c	c	c
51	Information	c	c	c
52	Finance and Insurance	10	23	2%
54	Professional, Scientific, and Technical Services	3	5	0%
55	Management of Companies and Enterprises	3	26	2%
56	Administrative and Support and Waste Management and Remediation Services	c	c	c
61	Educational Services	11	153	13%
62	Health Care and Social Assistance	16	133	11%
71	Arts, Entertainment, and Recreation	7	20	2%
72	Accommodation and Food Services	12	30	3%
81	Other Services (except Public Administration)	33	129	11%
92	Public Administration	25	224	19%
Grand Total		**209**	**1157**	87%
c = confidential			153	13%

Figure 23: Oregon Quarterly Census of Employment and Wages (QCEW), Gilliam, Sherman and Wheeler Counties.



Cottonwood Canyon State Park established in 2013, is a new tourist attraction for the basin. Coinciding with the Park's opening and economic recovery, the trajectory of job losses in tourism and hospitality appears to be stabilizing in the Three County area of which the LJD basin covers a portion. Between 2013 and 2017 Leisure and Hospitality jobs have fluctuate between 155 jobs in winter and 235 jobs during the summer for the three counties surrounding the LJD Basin, reaching a low of 155 jobs in the winter of 2014 and a high of 235 jobs in the summer of 2015. In 2017 the variation was 165 jobs during the winter and 220 jobs in the summer.

Park officials estimate that in 2017 there were 31,244 park visitors (Park's web site)[1]. A survey study by Oregon Parks and Recreation department (2016) estimated visitors spend between spend between $51 and $150, mostly on gas, camping, lodging and food (Visitor Survey of Day-Use Visitors Cottonwood State Park, 2016)[2]. While some could use spending surveys and visitor counts to estimate spending within the area of between $1,590,936 and $3,181,872 annually. Such dollar estimates for increased tourism activity have not yet translated to significant job growth within those employment sectors. Recreation, Accommodation and Food Service industries employ 50 people within the basin.

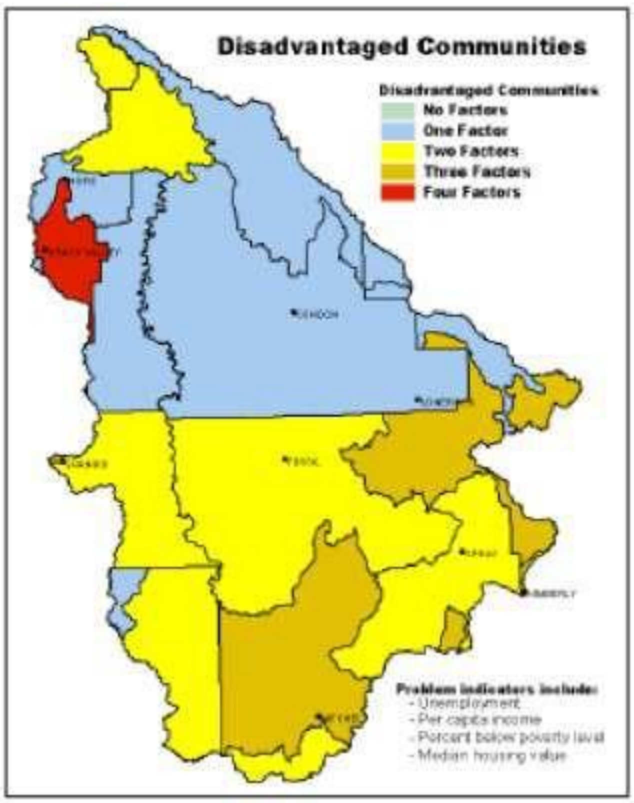
Counties within the I-84 corridor particularly benefit from more diverse economic opportunities (BLM, 2006). While dwarfed by state increases in employment, total employment in Grant and Wheeler counties increased by 19% between 1970 and 2003, largely due to increases in service

1 https://oregonstateparks.org/index.cfm?do=parkPage.dsp_parkHistory&parkId=195
2 https://www.oregon.gov/oprd/PLANS/docs/scorp/2016_Cottonwood_Canyon_Day_use_Survey_Report.pdf

(52%) and government (33%) employment. These increases have largely offset decreases in forest product manufacturing and farm related employment (BLM, 2006).

Figure 24 depicts disadvantaged communities in the basin.

Figure 24: Disadvantaged Communities in the Basin



More recently, the basin has worked to become more of a recreation and tourist destination. Many small businesses cater to tourists, and a substantial number of traditional ranches in the subbasin have become fee hunting preserves (NPCC, 2005). Hunting, fishing, boating, camping, wildlife observation, photography, hiking, swimming, fossil hunting, and scenic viewing on public and eased private lands are among the most common recreational activities (NPCC, 2005). Salmon alone are worth $1 billion to Oregon’s sport fishing and tourism industry (Fears, 2015). Grant County is internationally known for an extensive depository of fossils from the Cenozoic Era (BLM, 2006). The John Day Fossil Beds National Monument has a significant impact on the economy of the region, drawing 156,000 per year and bringing $6.5 million into the local economy of nearby towns (Darling, 2014).

Restoration activities also increasingly contribute positively to the local economy. They create short-term jobs, retain expenditures locally, and serve as a long-term investment in natural resources (Hibbard, M and S. Lurie, 2012; Nielsen-Pincus, M and C. Moseley, 2010; University of Oregon, 2013; Ecotrust, 2014). Over 90 cents of every dollar spend on ecological restoration projects stays in the state, and over 80 cents remain in the county where the project is located (Hibbard, M and S. Lurie, 2006). Further, every dollar spent on restoration work indirectly generates an average of $2.10-$2.40 in spending within the county (Nielsen-Pincus and Moseley, 2010). From 2001 to 2010 restoration projects in Grant, Wheeler, and Gilliam counties created an estimated 239 jobs and $36 million in economic output (CTWSRO, 2015).

Expansion of the economy is limited by the small population, isolation from major cities, and limited transportation infrastructure (NPCC, 2005). Five of the eight basin counties are designated as economically distressed—Wasco, Morrow, and Sherman counties are not. Local economies are heavily influenced by federal management decisions due to the considerable amount of federal lands in the basin. Many communities have been hard hit by sawmill closures and the decline in forestry jobs over the last forty years. Few new industrial opportunities have come along to replace these lost jobs (NPCC, 2005). The economic conditions contribute to a larger demographic shift. Young families have left the area due to lack of economic opportunity, while retirees and other new emigrants in search of rural living move into the area. This has resulted in an increase in average age, declines in school enrollment, and challenges providing public services (NPCC, 2005). Further, land values are increasing faster than commodity prices, limiting the opportunity for the expansion and/or generational transfer of agricultural operations. Consolidation and new technology that created greater efficiency have reduced overall agricultural employment. An increasing portion of the private land is owned by absentee landowners interested in recreation, land speculation, and retirement (NPCC, 2005).

Despite these economic challenges, the basin remains home to tightknit communities with strong connections to place. Local communities and residents are pursuing new economic opportunities at the same time they continue to actively pursue more watershed-protective agricultural practice and restorative forest harvests. New opportunities include tourism, recreation, value-added agricultural products (including specialty beef), value-added forest products (such as juniper products and crafts), and telecommunications.

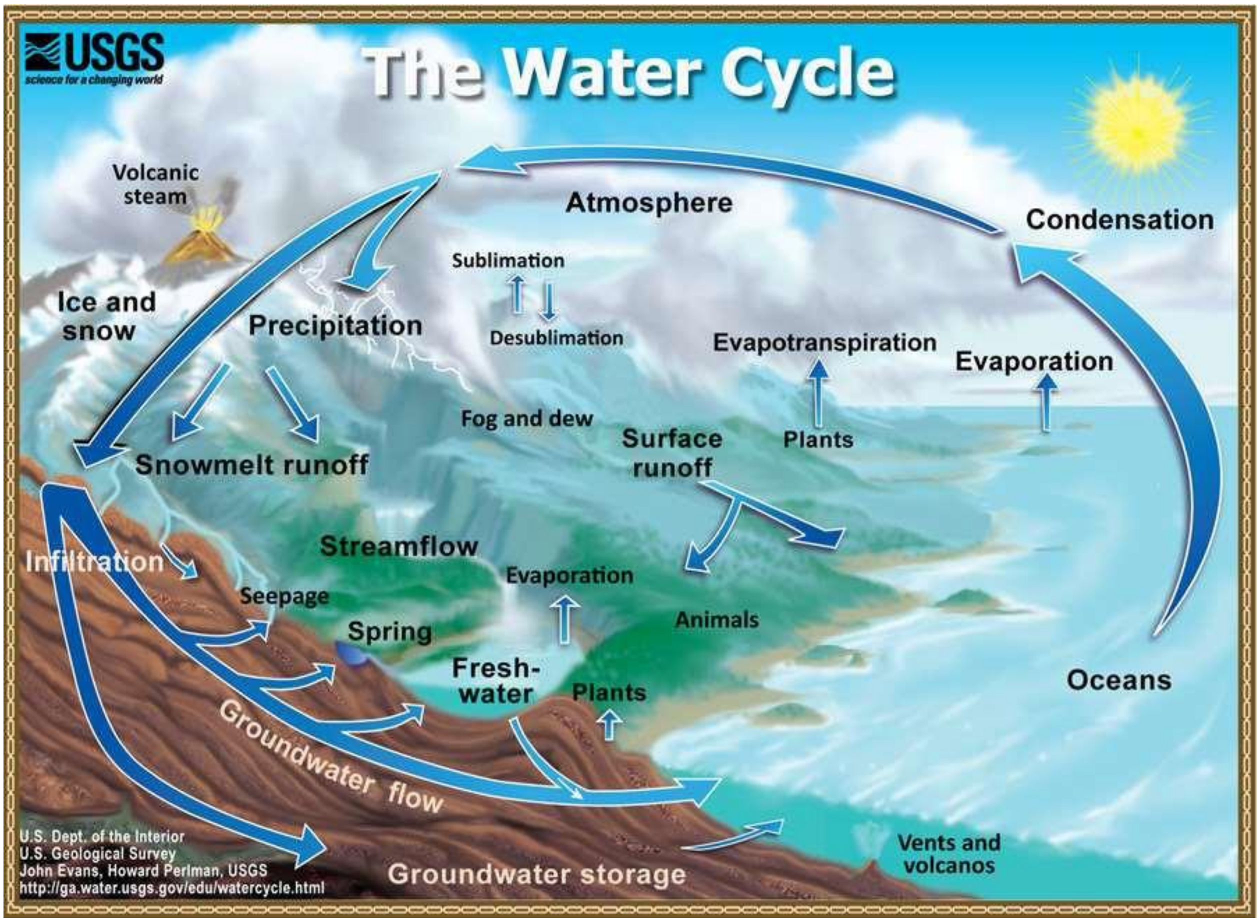
4. WATER BUDGET

A. Introduction

In an effort to quantify the variability of water conditions throughout the basin, water budgets were developed for each of the primary subwatersheds. Water supply conditions vary greatly across a basin as large as the Lower John Day; understanding and quantifying how these conditions vary can help the identify vulnerabilities in water supply, which in turn can focus the types of necessary solutions. This section includes the use of a theoretically based water budget computation. There are 30 OWRD water availability basins (WABs) in the Lower John Day Basin. For the water budget analyses, we included all WABs aside from two encompassing the mainstem Lower John Day River. The mainstem WABs were excluded because of the difficulty in accounting for all incoming surface and groundwater flows from tributary WABs and from the North and Upper John Day Rivers. It is important to note that this assessment provides a relative estimate of the different components of the water budget. This is appropriate for planning, though the collection of additional data to refine and inform these estimates may be required for future project or solution development.

B. Water Budget Calculations

Figure 25: The Water Cycle (USGS, 2017)



The essence of the water budget is to quantify all inputs, outputs, and changes in storage of water in a given basin (1). Primary inputs of moisture include precipitation (P), groundwater from neighboring basins (GW_{in}), and surface water inflows from out of basin ($Q_{surf.\,in}$). Primary outputs include groundwater outflow(GW_{out}), evapotranspiration (ET), and surface outflows ($Q_{surf.\,out}$). The difference between the cumulative inflow and outflow amounts to the change in total water stored (principally in the form of groundwater and soil moisture) in the basin (ΔS). We assess the water budget using long-term average annual values. Barring any significant changes in withdrawals, we can make the assumption that on average, the change in annual stored water is negligible (i.e., $\Delta S = 0$). Furthermore, due to the small size and topography of the WABs we can assume in most instances that groundwater inflows are minimal ($GW_{in} = 0$) and there are no surface inflows ($Q_{surf.\,in} = 0$). By rearranging (2), we can estimate groundwater output of the basin with (3). Relying again on the $\Delta S = 0$ assumption, we can infer that the amount of water infiltrated to the groundwater table is equivalent to groundwater outflow.

$$\Delta S = Inflow - Outflow \qquad (1)$$

$$\Delta S = (P + GW_{in} + Q_{surf.\ in}) - (GW_{out} + ET + Q_{surf.\ out}) \qquad (2)$$

$$Given\ \ \Delta S, GW_{in}, and\ Q_{surf.\ in} = 0 \qquad GW_{out} = P - (ET + Q_s) + Error \qquad (3)$$

Key input data for the water budget analysis include precipitation, natural surface outflows, and ET. A description of the data sources and other relevant information are included in Table 2. It is important to note that the water budget accounts only for major water fluxes into and out of a watershed, and not those within a watershed (e.g. withdrawals of water from streams or groundwater, irrigation return flows, etc.). The Error term in (3) addresses unaccounted for inputs, outputs, and changes in storage to a given basin. Examples of such unaccounted for water are inter-basin transfers of surface and groundwater, shallow groundwater return flows, changes in storage due to pumping. Etc. It is important to note that the results describing groundwater recharge are inclusive of the error term – many of which cannot be quantified. Errors and uncertainty associated with datasets used in this type of analysis are discussed later. Results from the water budget analysis can be used to compare subwatersheds for their relative precipitation input, surface water generation, groundwater production potential, as well as many other attributes.

Table 2: Key Water Budget Data Inputs

Metric	Peri	Resolution	Sourc
Mean Annual Precipitation	198 201	800	PRISM Climate Group (PRISM Climate Group, 2004) www.prism.oregonstate.udu
Mean Annual Evapotranspiration	201 201	1000	MODIS Global Evapotranspiration Project (Mu, 2011) www.ntsg.umt.edu/project/modis
Median Annual Surface Water Outflow	195 198	Water Availability Basin	OWRD Water Availability (Cooper, 2004) https://apps.wrd.state.or.us/apps/wars/wars_di ay_wa_tables/MainMenu1.aspx

Metric	Period	Resolution [m]	Source
Mean Annual Precipitation	1981-2010	800	PRISM Climate Group (http://www.prism.oregonstate.edu/)
Mean Annual Evapotranspiration	2010-2015	1000	U. of Montana (http://www.ntsg.umt.edu/project/modis/mod1
Median Annual Surface Outflow	1958-1987	WAB	OWRD (http://apps.wrd.state.or.us/apps/wars/wars_display_ wa_tables/search_for_WAB.aspx)

As mentioned earlier, precipitation is highly correlated with elevation and we see significantly higher annual totals in WABs originating in the Ochoco and Blue Mountains. ET patterns are less straightforward. ET is often evaluated in terms of potential and actual ET. Potential ET is a measure of the ET demand of a location and is a product of the vegetation and climatic variables (solar radiation, degree days, wind, etc.) driving transpiration and evaporation in an area. It specifically does not take into account the availability of soil moisture and precipitation to meet the demand. Conversely, actual ET is limited by the amount of available moisture to meet the demand. Figure 26 and Figure 27 illustrates this distinction. A comparison of Figure 26 and Figure 27 shows that areas with greatest potential ET tend to have the lowest relative actual ET and areas with the lowest potential have the greatest actual ET. Again, the actual ET is limited by the availability of moisture and the highest values tend to occur in locations with the greatest precipitation. ET estimates for this analysis are based on datasets from the MODIS Global Evapotranspiration Project(MOD16). The MOD16 ET datasets are estimated using algorithms in Mu et al., 2011 which are based on the Penman-Monteith equation (Monteith, 1965). Inputs to the model include both remotely sensed data (land cover, albedo, leaf area index, etc.) and global meteorological data. The model is used to account for all (including irrigated agriculture) evapotranspiration within a grid cell.

Figure 26: Annual Potential Evapotranspiration

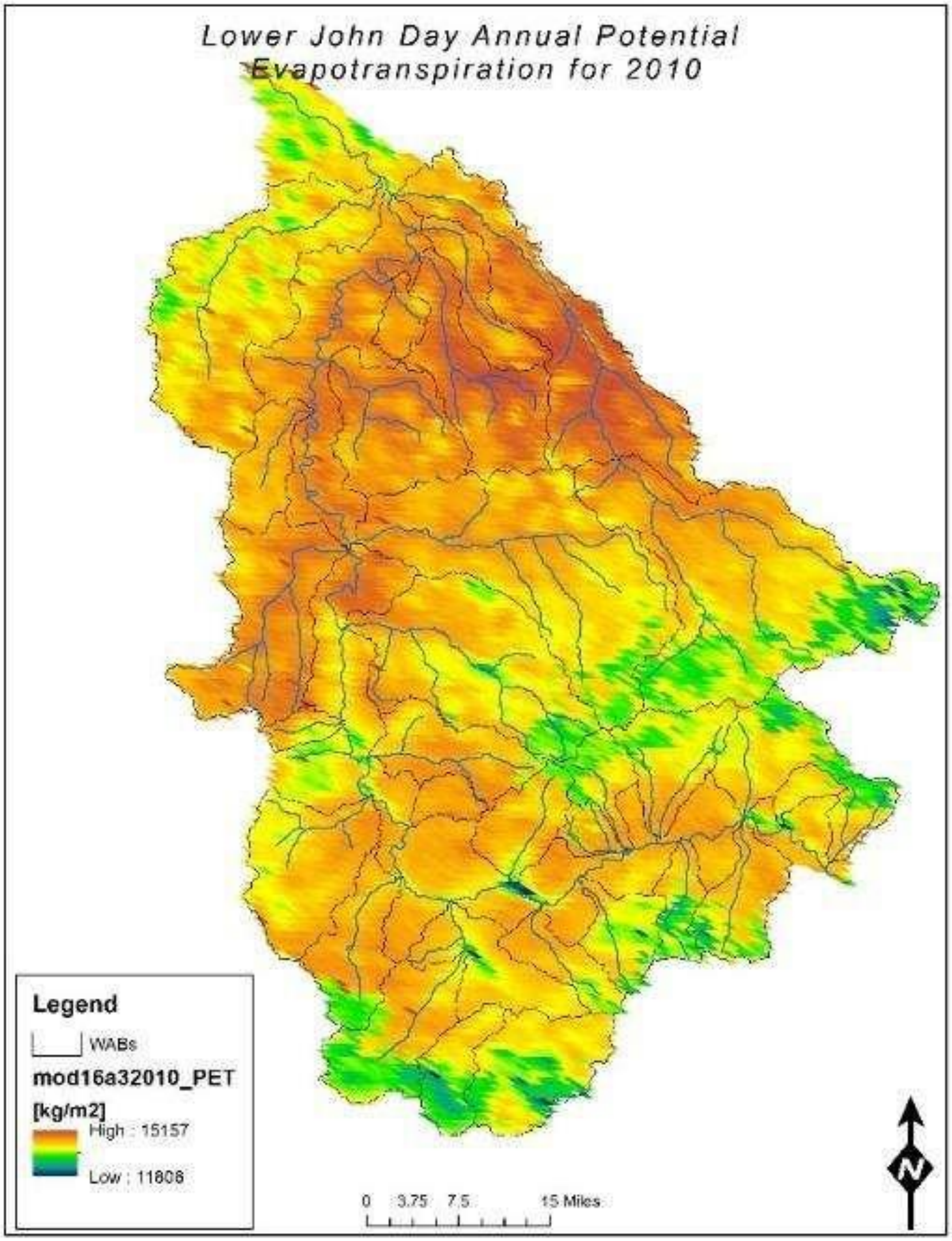
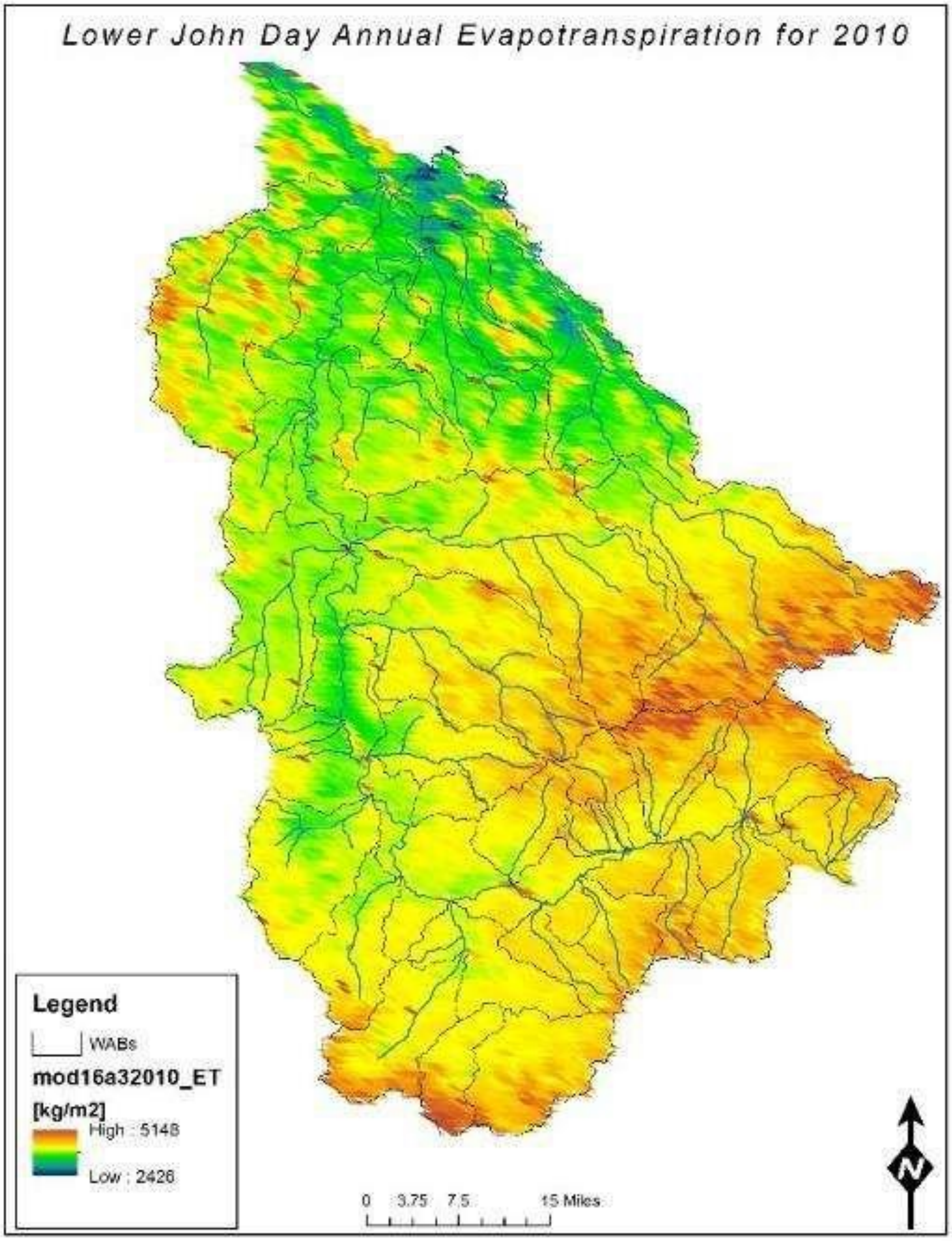


Figure 27: Annual Actual Evapotranspiration



Natural surface water outflows are a product of many factors. Figure 28 illustrates that in general, under natural conditions, basins with larger drainage areas, higher elevations, and ultimately greater precipitation input have greater surface outflows. The two largest WABs, Butte Creek and Upper Rock Creek, generate the largest total annual surface outflows. Figure 29 shows that when basin outflows are normalized by drainage area to compute runoff per unit area, many smaller WABs in the southern extent of the basin are identified as producing the greatest surface flows (Shoofly, Horseshoe, Parrish, Bridge, Kahler, Alder, and Service Creek). Figure 30 shows per unit precipitation. In instances where there are nested WABs (e.g. Rock and Bridge Creeks), streamflow generation estimates were calculated on a per-WAB basis to remove the influence of inflows form upstream WABs. See Section 5 for further discussion of OWRD's WAB data set and computation of natural streamflow.

Figure 28: Natural Surface Outflows: WAB Totals

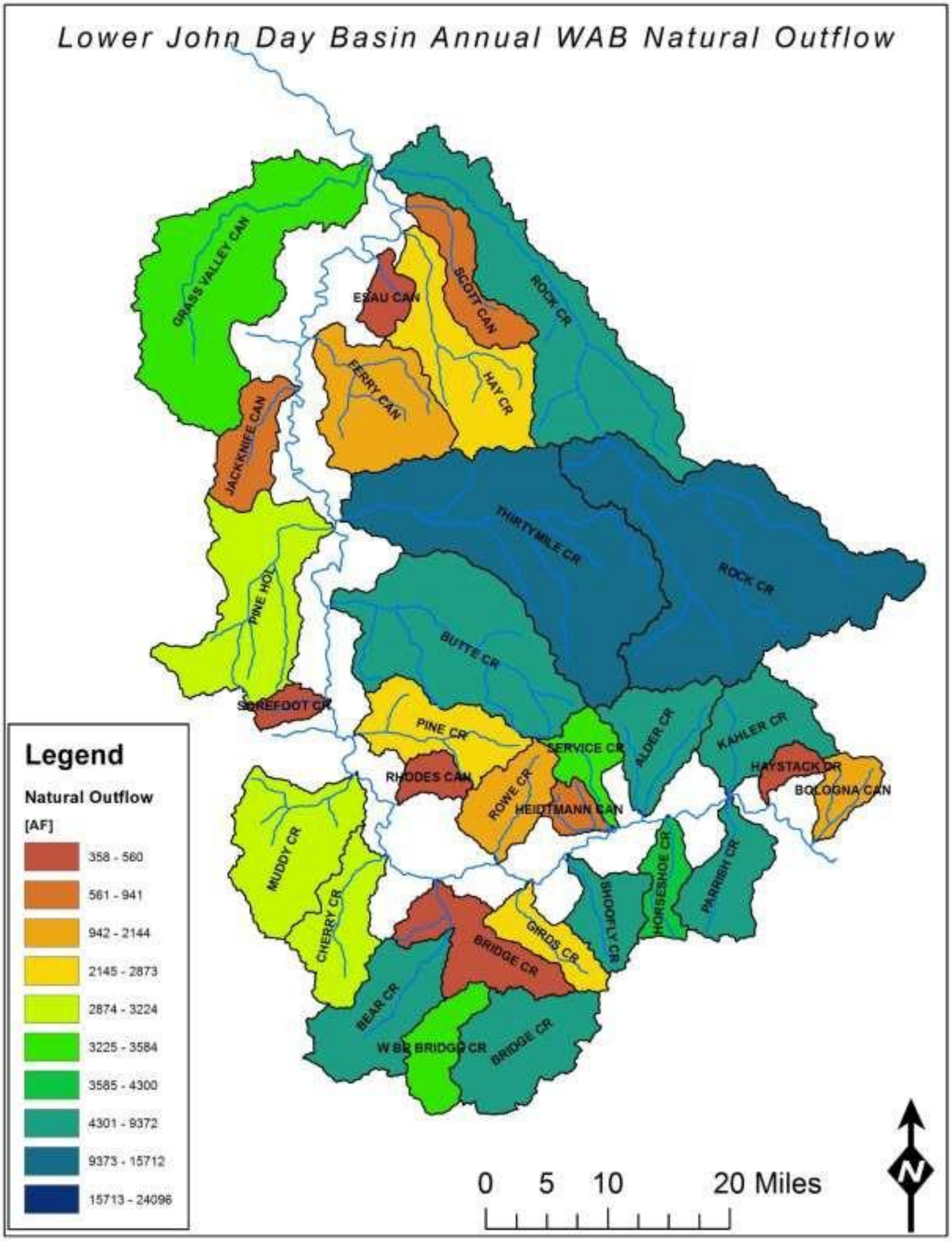


Figure 29: Natural Surface Outflows: Area Normalized Values

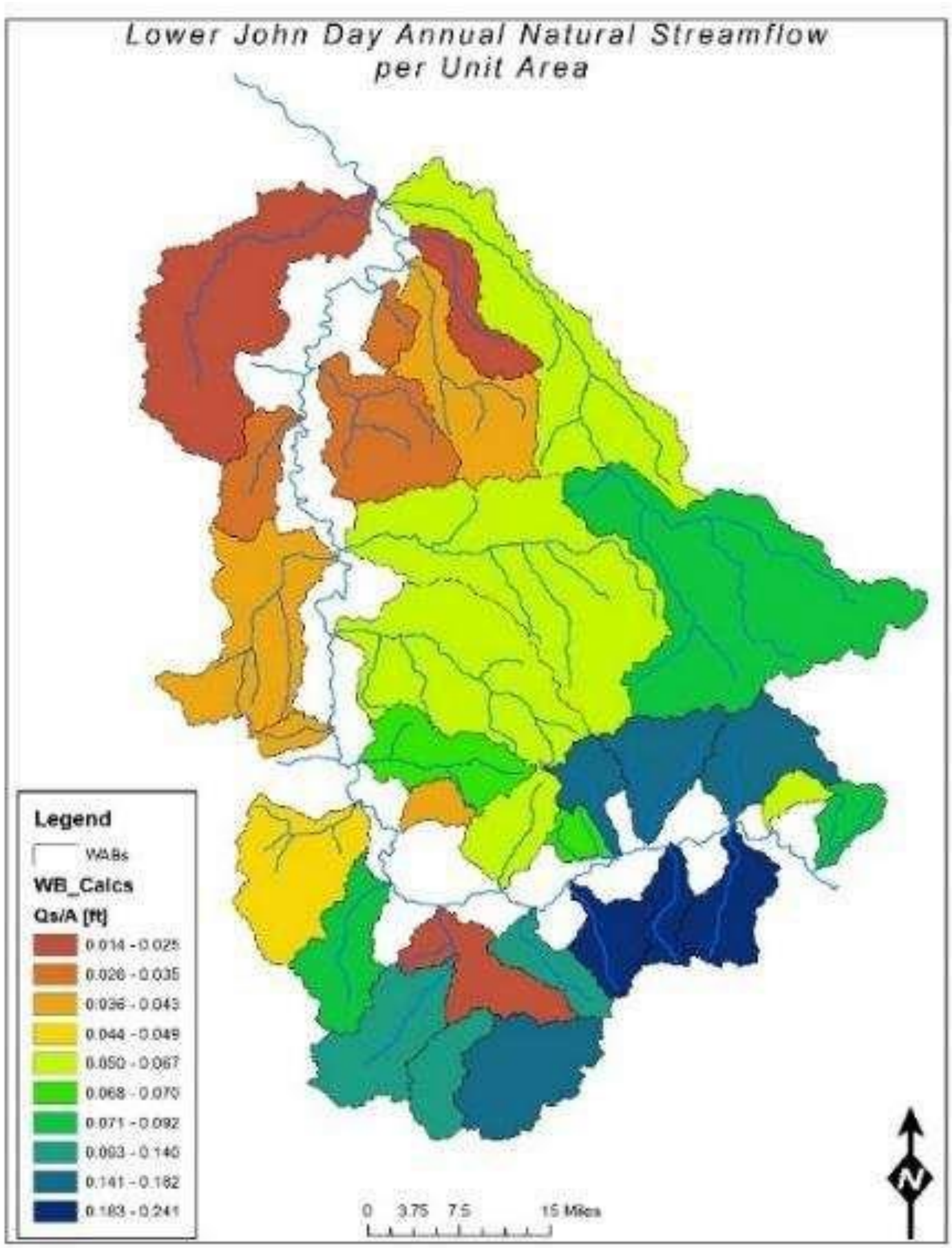
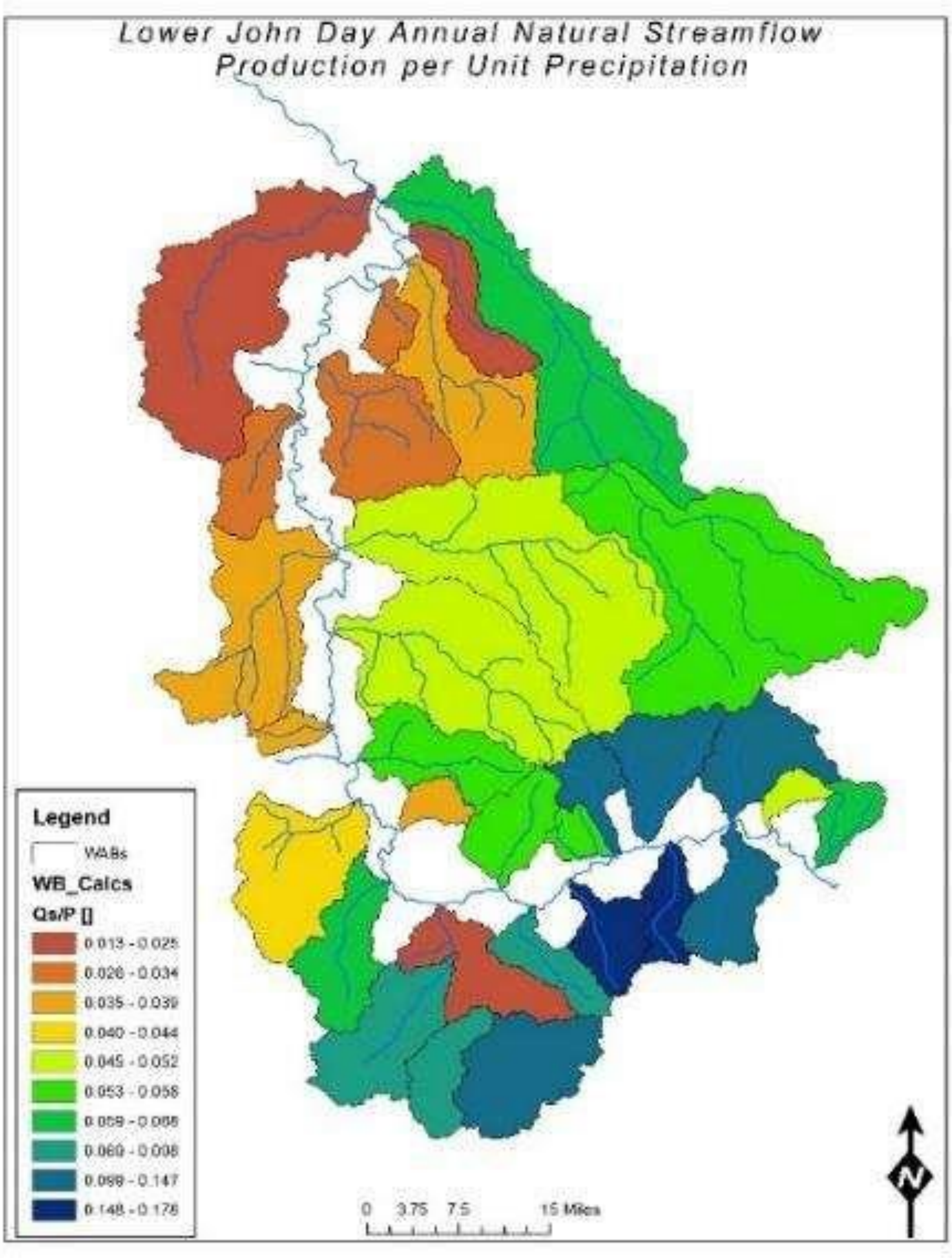


Figure 30: Natural Surface Outflows: Per Unit Precipitation



Based on equations discussed above, the water budget analysis allows for the estimation of annual groundwater recharge per WAB. Figure 31 below illustrates the annual groundwater recharge volume per WAB, as well as the area-normalized recharge per WAB in Figure 32. Similar to surface water outflow, basins with the greatest surface drainage area, elevation, and precipitation typically have the greatest annual volumes of groundwater recharge (e.g., Upper Rock, Thirtymile, Butte, Bridge, and Bear Creeks). When area normalized, top groundwater recharge basins tend to be those with high elevation headwaters (e.g., the Upper Bridge Creek Basin tributaries, Upper Rock, Butte, and Pine Creeks).

Figure 31: Annual Potential Groundwater Production: Total per WAB

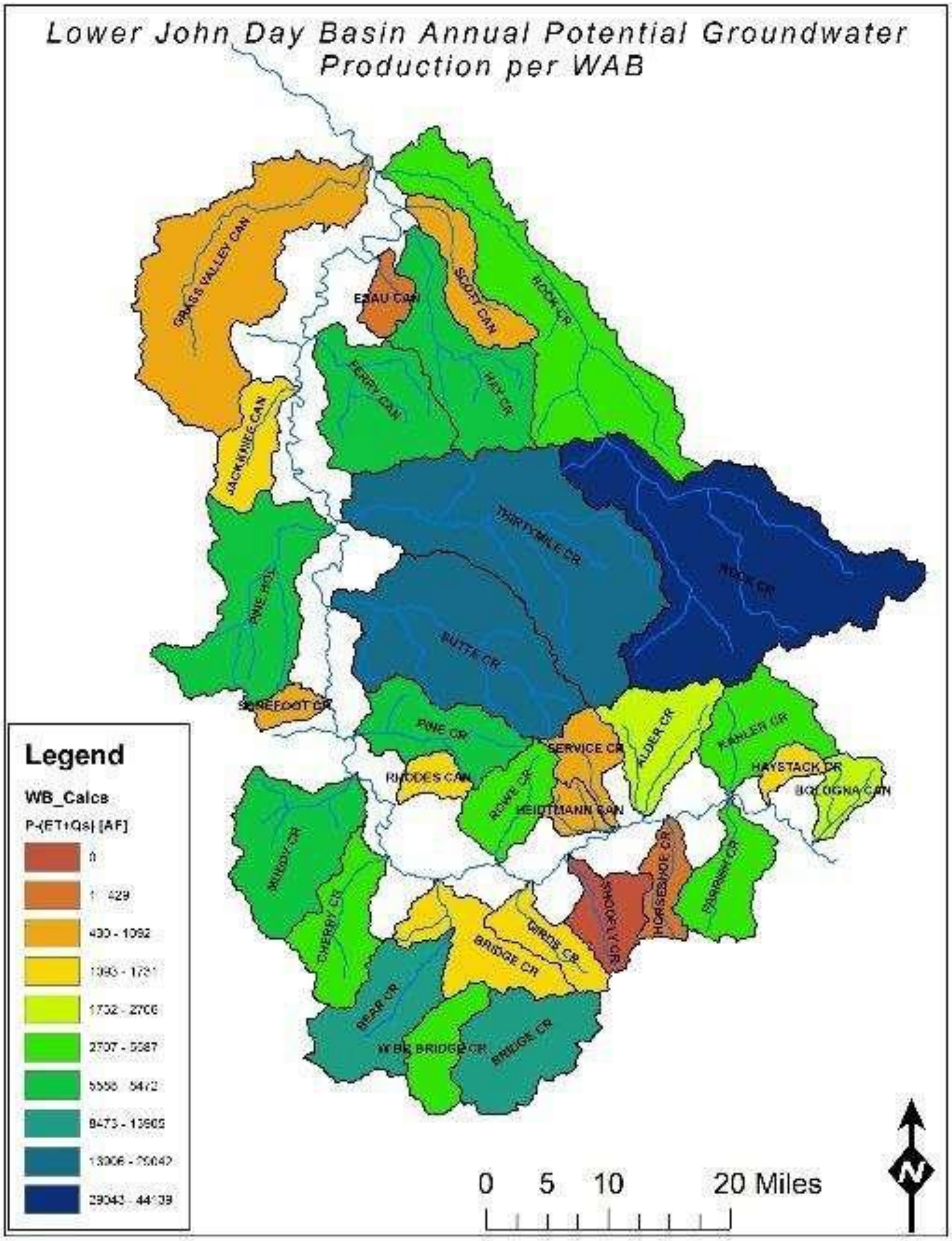


Figure 32: Annual Potential Groundwater Production: per Unit Area and WAB

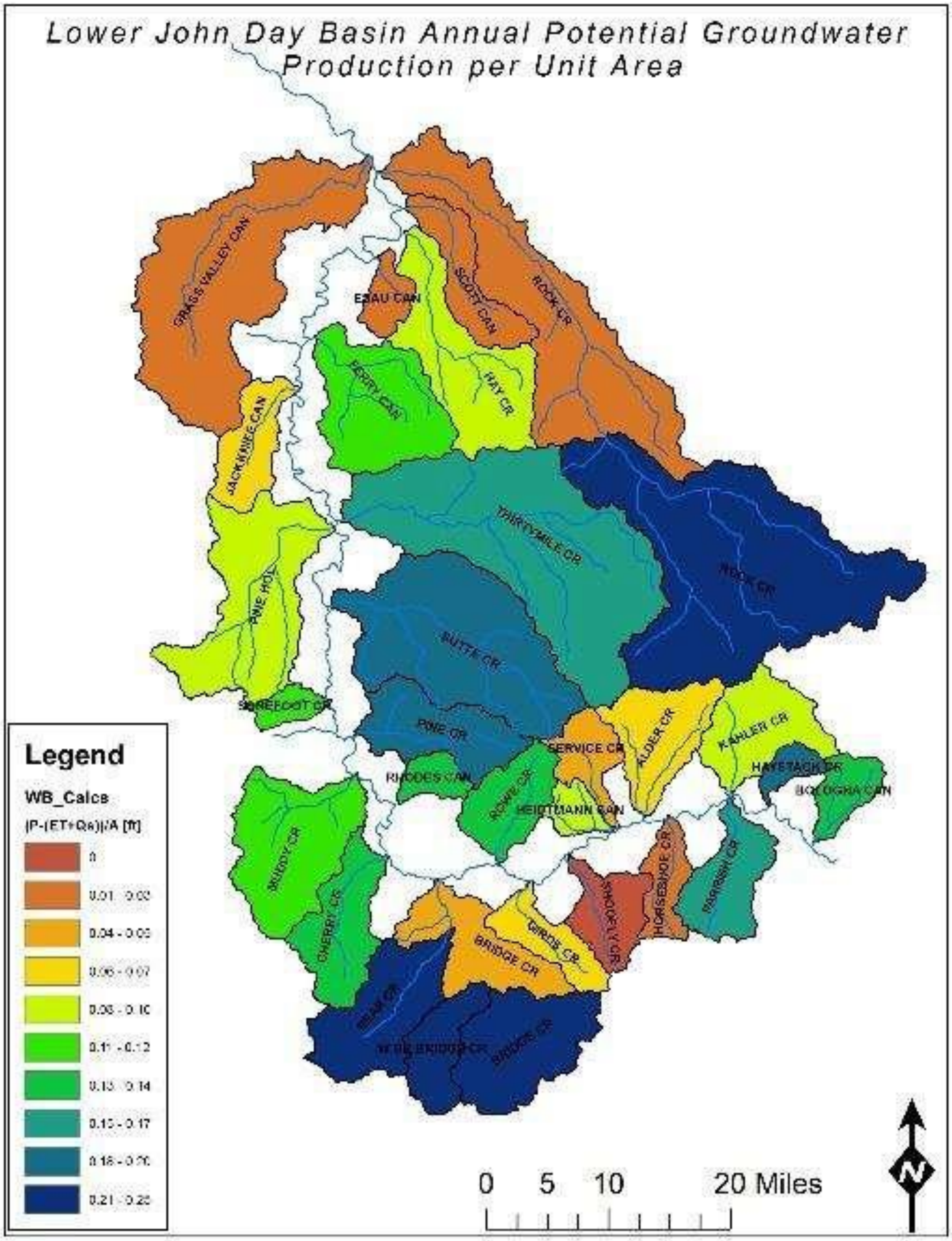


Table 3 and Table 5 summarize the natural water budgets of the Lower John Day subwatershed WABs. Table 3 provides quantitative results for each WAB and Table 5 lists the top 10 ranked subwatersheds for a subset of key categories (area-normalized precipitation, precipitation-normalized surface outflow, area-normalized surface outflow, and area- normalized groundwater recharge). A number of basins consistently rank high in the area- normalized categories of: precipitation, surface outflow, and groundwater recharge. These basins are: Bear, Bridge, Parrish, W. Bridge, Alder, Horseshoe, Kahler, Rock abv Wallace Canyon, and Service Creeks. Within the Lower John Day Basin, these subwatersheds receive the greatest water input per area, generate the greatest annual streamflow volumes per unit area, and produce the greatest groundwater recharge per unit area. Consequently, these basins may be focal areas for further water resources planning and project work.

Table 3: Key Water Budget Metrics. In Order: Area-normalized precip., Area-normalized E.T., surface water outflow normalized by input precip., Area-normalized surface water outflow, Total groundwater recharge, Area-normalized groundwater recharge. Color coded by column with cool colors representing high values.

WAB	P/A [ft]	ET/A [ft]	Surface Outflow/P []	Surface Outflow/A [ft]	GW Recharge [AF]	Mean GW Recharge [AF/acre]
ALDER CR > JOHN DAY R - AT MOUTH	1.41	1.16	0.12	0.17	2706	0.07
BEAR CR > BRIDGE CR - AT MOUTH	1.46	1.08	0.09	0.13	12825	0.25
BOLOGNA CAN > JOHN DAY R - AT MOUTH	1.35	1.12	0.07	0.09	2161	0.13
BRIDGE CR > JOHN DAY R - AB W BR BRIDGE CR	1.51	1.09	0.11	0.17	13905	0.25
BRIDGE CR > JOHN DAY R - AT MOUTH	1.04	0.99	0.01	0.01	1573	0.04
BUTTE CR > JOHN DAY R - AT MOUTH	1.29	1.03	0.05	0.07	22607	0.19
CHERRY CR > JOHN DAY R - AT MOUTH	1.21	1.00	0.06	0.08	5341	0.13
ESAU CAN > JOHN DAY R - AT MOUTH	0.95	0.90	0.03	0.03	198	0.02
FERRY CAN > JOHN DAY R - AT MOUTH	1.08	0.94	0.03	0.03	6553	0.11
GIRDS CR > JOHN DAY R - AT MOUTH	1.25	1.05	0.10	0.12	1657	0.07
GRASS VALLEY CAN > JOHN DAY R - AT MOUTH	1.01	0.97	0.02	0.02	918	0.01
HAY CR > JOHN DAY R - AT MOUTH	1.04	0.91	0.04	0.04	6259	0.09
HAYSTACK CR > JOHN DAY R - AT MOUTH	1.32	1.06	0.05	0.07	1664	0.19
HEIDTMANN CAN > JOHN DAY R - AT MOUTH	1.21	1.05	0.06	0.07	902	0.09
HORSESHOE CR > JOHN DAY R - AT MOUTH	1.39	1.13	0.17	0.24	429	0.02
JACKKNIFE CAN > JOHN DAY R - AT MOUTH	1.02	0.92	0.03	0.03	1731	0.06
KAHLER CR > JOHN DAY R - AT MOUTH	1.39	1.13	0.12	0.16	3817	0.09
MUDDY CR > JOHN DAY R - AT MOUTH	1.10	0.94	0.04	0.05	7011	0.11
PARRISH CR > JOHN DAY R - AT MOUTH	1.45	1.08	0.15	0.21	5156	0.15
PINE CR > JOHN DAY R - AT MOUTH	1.26	0.98	0.05	0.07	8472	0.20
PINE HOL > JOHN DAY R - AT MOUTH	1.06	0.93	0.04	0.04	8022	0.10
RHODES CAN > JOHN DAY R - AT MOUTH	1.15	0.97	0.04	0.04	1547	0.14
ROCK CR > JOHN DAY R - AB WALLACE CAN	1.43	1.12	0.06	0.08	44139	0.22
ROCK CR > JOHN DAY R - AT MOUTH	0.97	0.88	0.07	0.07	3631	0.03
ROWE CR > JOHN DAY R - AT MOUTH	1.22	1.02	0.05	0.07	4079	0.14
SCOTT CAN > JOHN DAY R - AT MOUTH	0.93	0.88	0.02	0.02	862	0.03
SERVICE CR > JOHN DAY R - AT MOUTH	1.34	1.11	0.14	0.18	1055	0.05
SHOOFLY CR > JOHN DAY R - AT MOUTH	1.27	1.08	0.18	0.23	-838	-0.03
SOREFOOT CR > JOHN DAY R - AT MOUTH	1.08	0.92	0.04	0.04	1092	0.12
THIRTYMILE CR > JOHN DAY R - AT MOUTH	1.25	1.02	0.05	0.06	29042	0.17
W BR BRIDGE CR > BRIDGE CR - AT MOUTH	1.50	1.14	0.09	0.14	5587	0.22

Uncertainties and errors are inherent in all three of the modeled datasets (precipitation, evapotranspiration, and natural streamflow) used in the water budget analysis. Fortunately, all three datasets have associated error and uncertainty estimates determined through comparisons with other measured, rather than modeled datasets. Table 4 provides an overview of error and uncertainty values associated with each input dataset. When available, location-specific uncertainty values were used (e.g., PRISM uncertainty based on comparative analysis of Oregon precipitation stations rather than global mean error). Table 5 includes the associated high and low estimates of recharge by incorporating input data errors. Low estimates are all less than zero, indicating no recharge. The high estimates are generally between 200-300% of recharge estimates excluding uncertainty.

The spatial resolution and time periods of the input datasets are also inconsistent and can introduce error (Table 2). This is of course not ideal, but a product of a severe lack of data in the region and statewide. Annual and multi-decadal climate patterns can have notable impacts on precipitation, evapotranspiration and ultimately streamflow. By comparing datasets from different periods we introduce an additional uncertainty into the water budget analysis that cannot be quantified but must be acknowledged.

Table 4: Water budget input data uncertainty.

Parameter	Dataset	Uncertainty	Source
Precipitation	PRISM	+11%	Daly et al., 2008
Evapotranspiration	MOD 16	± 0.076 mm/day	Mu et al., 2011
Streamflow	WARs	± (34-71) % Standard Error	Cooper, 2002

Table 5: Groundwater recharge estimates including upper and lower ranges based on data input uncertainty.

WAB	GW Recharge [AF]	GW Recharge High Estimate [AF]	GW Recharge Low Estimate [AF]
ALDER CR > JOHN DAY R - AT MOUTH	2706	9188	-9811
BEAR CR > BRIDGE CR - AT MOUTH	12825	20749	-3361
BOLOGNA CAN > JOHN DAY R - AT MOUTH	2161	4251	-2324
BRIDGE CR > JOHN DAY R - AB W BR BRIDGE CR	13905	23580	-4868
BRIDGE CR > JOHN DAY R - AT MOUTH	1573	5540	-7055
BUTTE CR > JOHN DAY R - AT MOUTH	22607	36699	-8011
CHERRY CR > JOHN DAY R - AT MOUTH	5341	10406	-5086
ESAU CAN > JOHN DAY R - AT MOUTH	198	1475	-2368
FERRY CAN > JOHN DAY R - AT MOUTH	6553	13078	-7287
GIRDS CR > JOHN DAY R - AT MOUTH	1657	4952	-4726
GRASS VALLEY CAN > JOHN DAY R - AT MOUTH	918	14690	-27871
HAY CR > JOHN DAY R - AT MOUTH	6259	13625	-8742
HAYSTACK CR > JOHN DAY R - AT MOUTH	1664	2671	-587
HEIDTMANN CAN > JOHN DAY R - AT MOUTH	902	2157	-1742
HORSESHOE CR > JOHN DAY R - AT MOUTH	429	4041	-5908
JACKKNIFE CAN > JOHN DAY R - AT MOUTH	1731	4618	-4236
KAHLER CR > JOHN DAY R - AT MOUTH	3817	10334	-8875
MUDDY CR > JOHN DAY R - AT MOUTH	7011	14256	-8036
PARRISH CR > JOHN DAY R - AT MOUTH	5156	11358	-6343
PINE CR > JOHN DAY R - AT MOUTH	8472	13631	-2440
PINE HOL > JOHN DAY R - AT MOUTH	8022	17005	-10723
RHODES CAN > JOHN DAY R - AT MOUTH	1547	2737	-1031
ROCK CR > JOHN DAY R - AB WALLACE CAN	44139	69875	-12581
ROCK CR > JOHN DAY R - AT MOUTH	3631	19942	-26267
ROWE CR > JOHN DAY R - AT MOUTH	4079	7642	-3496
SCOTT CAN > JOHN DAY R - AT MOUTH	862	3896	-5267
SERVICE CR > JOHN DAY R - AT MOUTH	1055	4402	-5190
SHOOFLY CR > JOHN DAY R - AT MOUTH	-838	4198	-9507
SOREFOOT CR > JOHN DAY R - AT MOUTH	1092	2070	-964
THIRTYMILE CR > JOHN DAY R - AT MOUTH	29042	49750	-15597
W BR BRIDGE CR > BRIDGE CR - AT MOUTH	5587	9650	-2666

Table 6: Ranked Subwatersheds by Metric (Higher rank indicates a larger value)

Rank	P/A [ft]	Surface Outflow/P []	Surface Outflow/A [ft]	Mean GW Recharge [AF/acre]
1	BRIDGE CR > JOHN DAY R - AB W BR BRIDGE CR	SHOOFLY CR > JOHN DAY R - AT MOUTH	HORSESHOE CR > JOHN DAY R - AT MOUTH	BRIDGE CR > JOHN DAY R - AB W BR BRIDGE CR
2	W BR BRIDGE CR > BRIDGE CR - AT MOUTH	HORSESHOE CR > JOHN DAY R - AT MOUTH	SHOOFLY CR > JOHN DAY R - AT MOUTH	BEAR CR > BRIDGE CR - AT MOUTH
3	BEAR CR > BRIDGE CR - AT MOUTH	PARRISH CR > JOHN DAY R - AT MOUTH	PARRISH CR > JOHN DAY R - AT MOUTH	ROCK CR > JOHN DAY R - AB WALLACE CAN
4	PARRISH CR > JOHN DAY R - AT MOUTH	SERVICE CR > JOHN DAY R - AT MOUTH	SERVICE CR > JOHN DAY R - AT MOUTH	W BR BRIDGE CR > BRIDGE CR - AT MOUTH
5	ROCK CR > JOHN DAY R - AB WALLACE CAN	ALDER CR > JOHN DAY R - AT MOUTH	ALDER CR > JOHN DAY R - AT MOUTH	PINE CR > JOHN DAY R - AT MOUTH
6	ALDER CR > JOHN DAY R - AT MOUTH	KAHLER CR > JOHN DAY R - AT MOUTH	BRIDGE CR > JOHN DAY R - AB W BR BRIDGE CR	HAYSTACK CR > JOHN DAY R - AT MOUTH
7	KAHLER CR > JOHN DAY R - AT MOUTH	BRIDGE CR > JOHN DAY R - AB W BR BRIDGE CR	KAHLER CR > JOHN DAY R - AT MOUTH	BUTTE CR > JOHN DAY R - AT MOUTH
8	HORSESHOE CR > JOHN DAY R - AT MOUTH	GIRDS CR > JOHN DAY R - AT MOUTH	W BR BRIDGE CR > BRIDGE CR - AT MOUTH	THIRTYMILE CR > JOHN DAY R - AT MOUTH
9	BOLOGNA CAN > JOHN DAY R - AT MOUTH	W BR BRIDGE CR > BRIDGE CR - AT MOUTH	BEAR CR > BRIDGE CR - AT MOUTH	PARRISH CR > JOHN DAY R - AT MOUTH
10	SERVICE CR > JOHN DAY R - AT MOUTH	BEAR CR > BRIDGE CR - AT MOUTH	GIRDS CR > JOHN DAY R - AT MOUTH	RHODES CAN > JOHN DAY R - AT MOUTH

Estimating annual groundwater recharge is often an important component of water resources planning as it provides a starting point for understanding how much water might be removed from the system while minimally impacting groundwater storage levels and/or connected surface water discharge. The annual recharge does not represent the volume of water that can be pumped each year. There are numerous methods to estimate recharge, including the water budget based approach detailed earlier. Some of the other commonly used methods are employed when there is insufficient data to develop a complete water budget and are based on groundwater level time series and hydrograph analysis. Table 5 compares results from an OWRD basin investigation(Gannett, 1984) using a number of these other methods and estimates range from .06 in/yr to 0.93 in/yr, with a mean value of 0.5 in/yr.

Table 5: Estimated Annual Recharge Rates Based on Method for Lower John Day Basin. All methods aside from "Water Budget" are based on Gannett, 1984.

Recharge Estimates		
Region	**Annual Recharge [in]**	**Method**
JDR at Service Creek	0.59	Low Flow Stats.
JDR at McDonald Ferry	0.42	Low Flow Stats.
Lower John Day Basin	0.06	Hydrograph Analysis
Lower John Day Basin	0.93	Water Budget

Table 6 provides a comparison of the primary fluxes of water out of WABs annually. On average, loss of moisture to transpiration, evaporation, and interception dominate the water budgets in all WABs. The range of loss to the atmosphere is 72%-97%, with a mean value across all WABs of 84%. On average, the remaining fluxes are roughly equivalent (7% surface outflow, 9% groundwater outflow). There are anomalies (e.g., Shoofly-18% surface outflow, 0% groundwater outflow; Haystack-5% surface outflow, 15% groundwater outflow), but relatively speaking, surface and groundwater outputs are of the same order of magnitude relative to ET loss.

Table 6: Summary of Relative Input and Output of Water in WAB

WAB	% ET and Interception	% Surface Outflow	% GW Recharge
ALDER CR > JOHN DAY R - AT MOUTH	83%	12%	5%
BEAR CR > BRIDGE CR - AT MOUTH	74%	9%	17%
BOLOGNA CAN > JOHN DAY R - AT MOUTH	83%	7%	10%
BRIDGE CR > JOHN DAY R - AB W BR BRIDGE CR	72%	11%	17%
BRIDGE CR > JOHN DAY R - AT MOUTH	95%	1%	4%
BUTTE CR > JOHN DAY R - AT MOUTH	80%	5%	15%
CHERRY CR > JOHN DAY R - AT MOUTH	83%	6%	11%
ESAU CAN > JOHN DAY R - AT MOUTH	95%	3%	2%
FERRY CAN > JOHN DAY R - AT MOUTH	87%	3%	10%
GIRDS CR > JOHN DAY R - AT MOUTH	84%	10%	6%
GRASS VALLEY CAN > JOHN DAY R - AT MOUTH	97%	2%	1%
HAY CR > JOHN DAY R - AT MOUTH	87%	4%	9%
HAYSTACK CR > JOHN DAY R - AT MOUTH	80%	5%	15%
HEIDTMANN CAN > JOHN DAY R - AT MOUTH	87%	6%	7%
HORSESHOE CR > JOHN DAY R - AT MOUTH	81%	17%	2%
JACKKNIFE CAN > JOHN DAY R - AT MOUTH	90%	3%	6%
KAHLER CR > JOHN DAY R - AT MOUTH	81%	12%	7%
MUDDY CR > JOHN DAY R - AT MOUTH	86%	4%	10%
PARRISH CR > JOHN DAY R - AT MOUTH	75%	15%	11%
PINE CR > JOHN DAY R - AT MOUTH	78%	5%	16%
PINE HOL > JOHN DAY R - AT MOUTH	87%	4%	9%
RHODES CAN > JOHN DAY R - AT MOUTH	84%	4%	12%
ROCK CR > JOHN DAY R - AB WALLACE CAN	79%	6%	16%
ROCK CR > JOHN DAY R - AT MOUTH	90%	7%	3%
ROWE CR > JOHN DAY R - AT MOUTH	83%	5%	11%
SCOTT CAN > JOHN DAY R - AT MOUTH	94%	2%	3%
SERVICE CR > JOHN DAY R - AT MOUTH	82%	14%	4%
SHOOFLY CR > JOHN DAY R - AT MOUTH	85%	18%	0%
SOREFOOT CR > JOHN DAY R - AT MOUTH	85%	4%	11%
THIRTYMILE CR > JOHN DAY R - AT MOUTH	82%	5%	13%
W BR BRIDGE CR > BRIDGE CR - AT MOUTH	76%	9%	15%
Median	**83%**	**5%**	**10%**
Mean	**84%**	**7%**	**9%**

Uncertainty

In general, the Lower John Day Basin is extremely data sparse. In order to estimate water budgets at the WAB scale, analyses rely heavily on modeled, rather than measured datasets. Each of these input modeled datasets (precipitation, evapotranspiration, and natural streamflow) has a degree of uncertainty that must be accounted for.

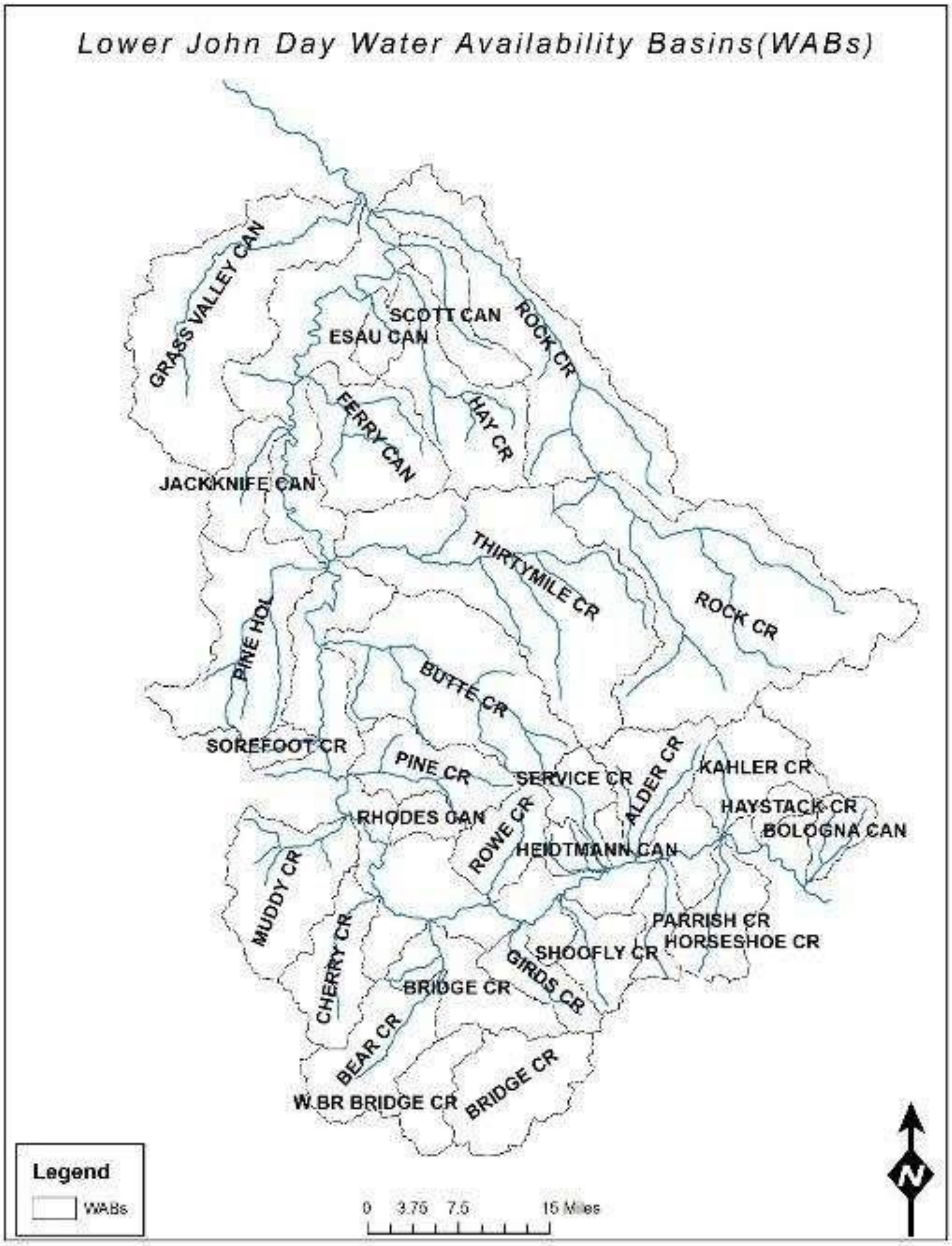
5. SURFACE WATER

Streamflows for both gaged and ungagged locations are described in this section. To help estimate the availability of water for new water appropriation permits, OWRD delineates the state into watersheds and sub-watersheds called Water Availability Basins (WABs).[1] OWRD has populated adatabase for each WAB that estimates median monthly natural surface outflow, consumptive surface water diversions, and the resulting instream flows remaining after withdrawals take place (Cooper, 2002). OWRD developed estimated natural streamflow at hundreds of gaging stations across Oregon for a 30-year period of record (POR), 1958 to 1987 (Cooper, 2002). This POR was utilized because it was assumed that the range of streamflow variability during the base period was representative of long-term average streamflow conditions. To compute natural streamflow, measured streamflow data at gaging stations were adjusted for existing consumptive upstream uses. Existing consumptive uses includes any use that removes water from the stream channel, including storage, irrigation, and municipal uses. The average estimated consumptive use during the period of record for the gage, including everything upstream, is added back into the gage records. These "natural flow" records were analyzed statistically to determine the flow in the stream channel that is available at different "exceedance" levels (typically 50 percent and 80 percent). For locations with no stream gage, regression equations were used to estimate these same statistics using the gaged basins and watershed characteristics.

Figure 33 shows the 30 WABs in the Lower John Day Basin.

[1] In theory, every distinct stream could be a separate WAB but resource and data limitations generally limit the level of detail for a particular WAB to sub-watersheds with multiple tributaries. WABs are nested, meaning that a WAB for a sub-watershed is within a WAB for the larger watershed of which it is a part. Thus, for example, the Bridge Creek WAB in the Lower John Day Basin is part of the WAB for the John Day River as a whole.

Figure 33: Lower John Day WABs



Looking first at modeled median tributary flows, Table 7 summarizes total annual natural surface outflow (streamflow), natural outflow during the irrigation season (4/1-9/30), and natural outflow during the mid-summer months when water is typically in greatest demand. A small subset of the tributaries account for a very large percentage of mid-summer surface flow production. The top six tributaries, Rock above Wallace Canyon, Bridge above west Branch, Thirtymile, Butte, Rock at mouth, and Bear Creeks account for nearly 60% of all mid-summer natural surface outflow.

Table 7: Natural Streamflow Production by WAB

WAB	Annual Sum [AF]	Irrigation Season Sum [AF]	July-Sept. Sum [AF]	July-Sept. Sum % Total
ROCK CR > JOHN DAY R - AT MOUTH	24096	8085	501	5%
ROCK CR > JOHN DAY R - AB WALLACE CAN	15712	10321	2066	22%
THIRTYMILE CR > JOHN DAY R - AT MOUTH	10938	4374	782	8%
BRIDGE CR > JOHN DAY R - AB W BR BRIDGE CR	9372	6527	957	10%
BUTTE CR > JOHN DAY R - AT MOUTH	7825	3180	514	6%
PARRISH CR > JOHN DAY R - AT MOUTH	7083	3481	397	4%
ALDER CR > JOHN DAY R - AT MOUTH	6699	3111	279	3%
BEAR CR > BRIDGE CR - AT MOUTH	6698	4083	472	5%
KAHLER CR > JOHN DAY R - AT MOUTH	6608	2913	227	2%
SHOOFLY CR > JOHN DAY R - AT MOUTH	5876	3050	396	4%
HORSESHOE CR > JOHN DAY R - AT MOUTH	4300	2367	335	4%
SERVICE CR > JOHN DAY R - AT MOUTH	3584	1565	143	2%
W BR BRIDGE CR > BRIDGE CR - AT MOUTH	3556	2364	300	3%
GRASS VALLEY CAN > JOHN DAY R - AT MOUTH	3375	677	66	1%
PINE HOL > JOHN DAY R - AT MOUTH	3224	890	122	1%
MUDDY CR > JOHN DAY R - AT MOUTH	3144	960	147	2%
CHERRY CR > JOHN DAY R - AT MOUTH	3138	1215	229	2%
PINE CR > JOHN DAY R - AT MOUTH	2873	1303	403	4%
GIRDS CR > JOHN DAY R - AT MOUTH	2759	1214	223	2%
HAY CR > JOHN DAY R - AT MOUTH	2699	1225	379	4%
FERRY CAN > JOHN DAY R - AT MOUTH	2144	475	58	1%
ROWE CR > JOHN DAY R - AT MOUTH	1966	635	99	1%
BOLOGNA CAN > JOHN DAY R - AT MOUTH	1485	485	53	1%
JACKKNIFE CAN > JOHN DAY R - AT MOUTH	941	170	16	0%
HEIDTMANN CAN > JOHN DAY R - AT MOUTH	732	201	24	0%
SCOTT CAN > JOHN DAY R - AT MOUTH	699	81	4	0%
HAYSTACK CR > JOHN DAY R - AT MOUTH	560	138	14	0%
BRIDGE CR > JOHN DAY R - AT MOUTH	559	188	24	0%
RHODES CAN > JOHN DAY R - AT MOUTH	467	102	13	0%
ESAU CAN > JOHN DAY R - AT MOUTH	397	42	3	0%
SOREFOOT CR > JOHN DAY R - AT MOUTH	358	88	13	0%

Stream gages located on the mainstem Lower John Day provide excellent datasets to evaluate flow statistics. It is important to note that unlike the modeled natural streamflow values discussed above for tributaries, the measured streamflow data represent actual conditions resulting from all diversions and return flows. Figure 34: Lower John Day Mainstem Streamgages depicts the two mainstem gages USGS gages, at Service Creek (14046500) and McDonald Ferry (14048000). Both of these gages have exceptionally long records with data collection beginning in 1929 and 1904 respectively. The period 1929- 2017 was used for comparative analyses.

Figure 34: Lower John Day Mainstem Streamgages

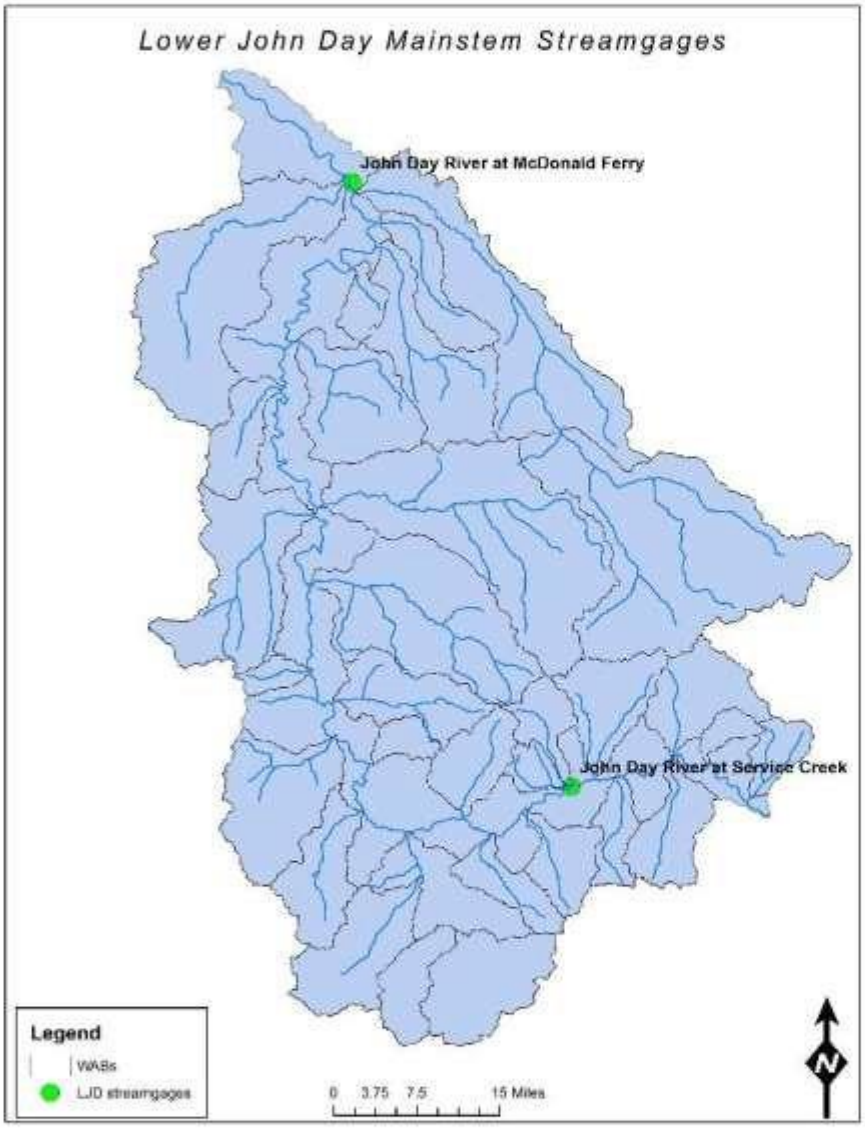
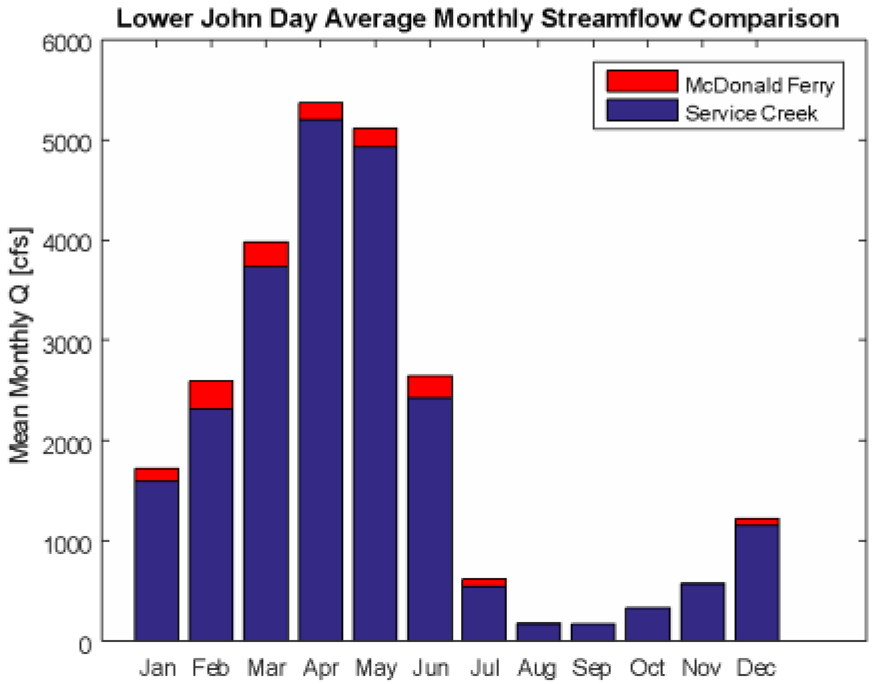


Figure 35 illustrates the inter-annual and intra-annual variability in streamflow in the Mainstem Lower John Day River. Mean monthly flows peak during periods of snowmelt in April and May at over 5,000 cfs, while in late summer flows are typically under 200 cfs. Relative to incoming mainstem flows, there is minimal surface water contribution from the Lower Basin between Service Creek and McDonald Ferry (100-200 cfs during high flow periods and -3-10 during late summer)(Table 8). It is important to note that the bulk of streamflow production in the entire basin(Lower, upper, main, north) occurs in months either outside of the irrigation season(Dec-March) or during the early portion of the season when demand is not high(April-May).

Figure 35: Comparison of Mean Monthly & Annual Flows for Two Lower John Day Streamgages



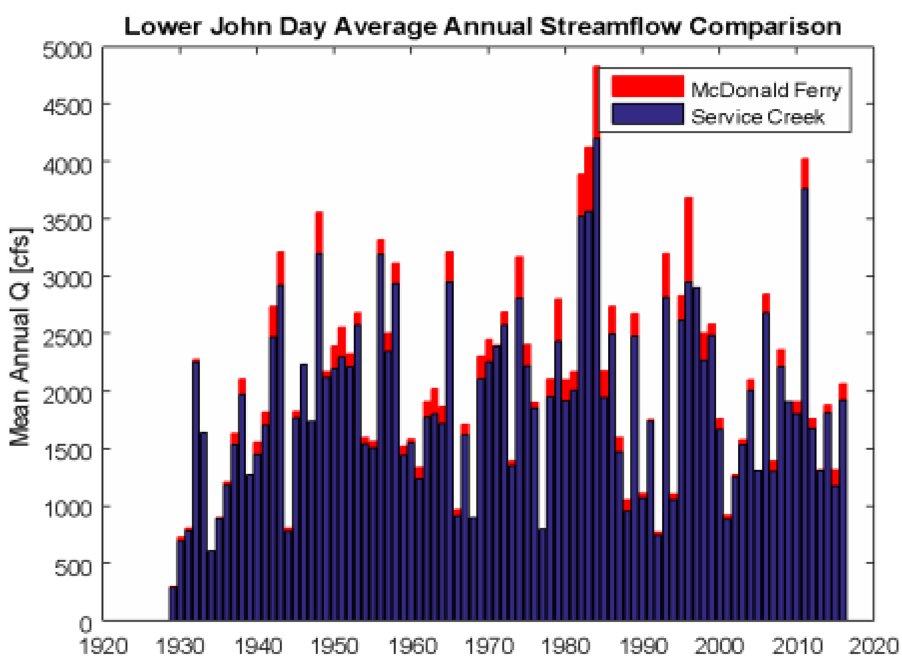


Table 8 shows the average monthly flows for the two mainstem Lower John Day gages, including differences between the two.

Table 8: Average Monthly Flows for Two Mainstem Lower John Day Gages (Based on period of record for each)

Month	Average Q at Service Creek [cfs]	Average Q at Mcdonald Ferry [cfs]	Diff. [cfs]	Diff. %
Jan	1595	1722	127	8%
Feb	2315	2592	278	12%
Mar	3733	3975	242	6%
Apr	5201	5369	168	3%
May	4928	5117	189	4%
Jun	2424	2648	224	9%
Jul	547	618	71	13%
Aug	171	180	9	5%
Sep	173	169	-3	-2%
Oct	328	326	-2	-1%
Nov	569	577	8	1%
Dec	1154	1219	65	6%

The Lower John Day is the largest subbasin of the greater John Day Basin, encompassing over 2 million acres and accounting for 40% of the total Basin area. The breakdown of area per sub-basin of the John Day is provided in Table 9. Although large, the Lower Basin produces only a fraction of surface flow relative to the rest of the subbasins as show in Table 10. On average, all lower basin subbasin WABs between Service Creek and McDonald Ferry contribute 0.00007 cfs/acre, relative to 0.00059 cfs/acre for the entire John Day Basin upstream of Service Creek. In terms of annual surface flow volume, average total outflow from the entire John Day Basin is 1.48×10^{6} acre feet per year (AFY), while the lower basin area between Service Creek and McDonald Ferry contributes just 8.3×10^{4} AFY, roughly 5.6% of the total. These numbers highlight the fact that the Lower John Day has the greatest water resources production challenges of the four primary subbasins. Although 40% of total area, the Lower John Day produces only roughly 5.6% of total surface flow.

Table 9: John Day Subbasin Areas

NAME	Area [acre]	% total
North Fork John Day	1182773	23%
Middle Fork John Day	506947	10%
Lower John Day	2014892	40%
Upper John Day	1368992	27%

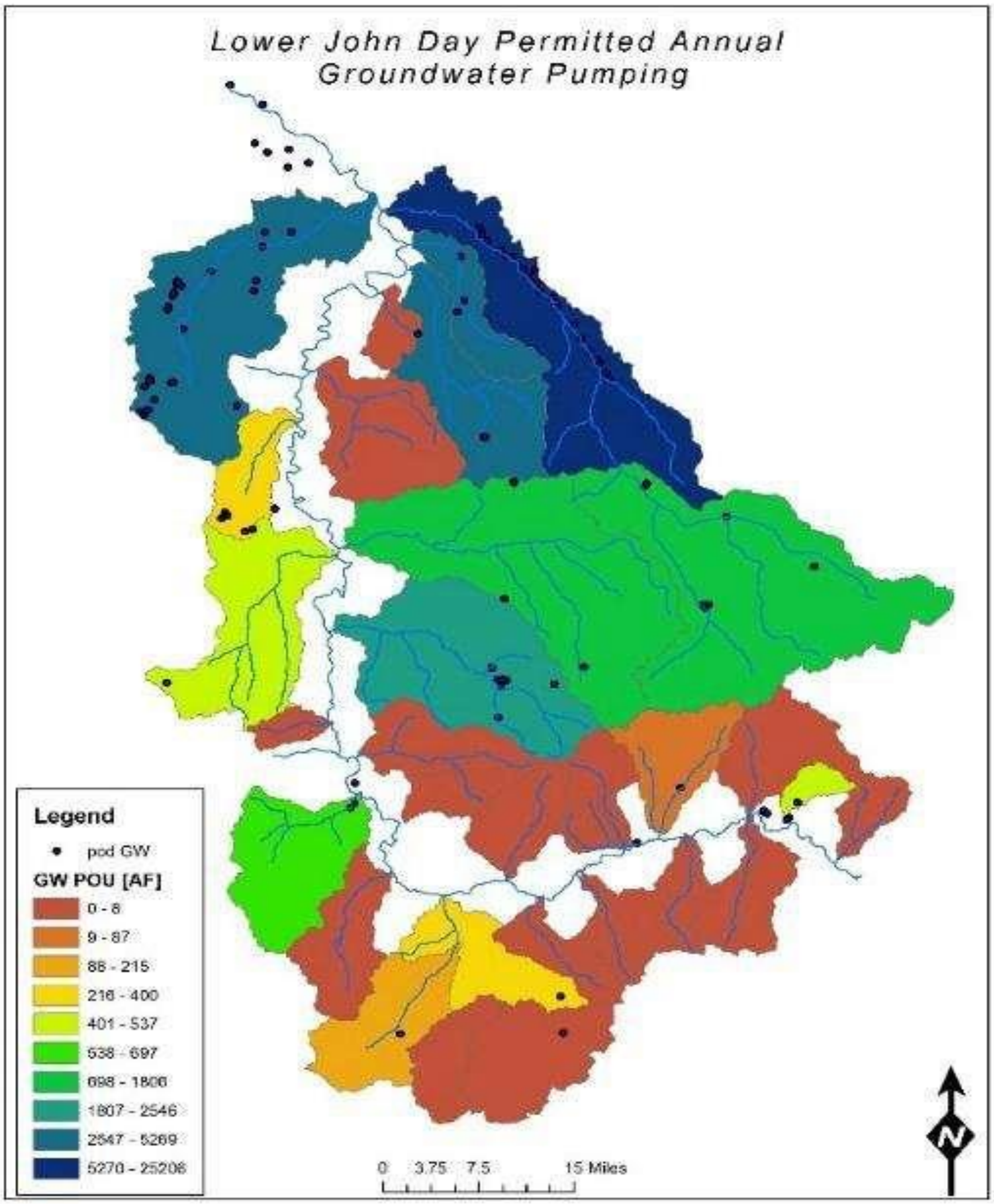
Table 10: Flow Contribution per Unit Area

Streamflow Production			
Reach	**Q/A [cfs/acre]**	**Volume [AFY]**	**% Volume**
Service Creek-McDonald Ferry	0.00007	8.30E+04	6%
Above McDonald Ferry	0.00041	1.48E+06	100%
Above Service Creek	0.00059	1.40E+06	94%

6. GROUNDWATER

There is a distinct, increasing spatial gradient from south to north in the number of, and ultimately the abstraction volume associated with, groundwater water rights within the basin. As shown in Figure 36: Certified Groundwater PODs and Volume the vast majority of certificated groundwater rights are in the very northern reaches of the basin, where surface water production is typically relatively low.

Figure 36: Certified Groundwater PODs and Volume



When water is diverted from a system, that water comes from either increased recharge into the basin, decreased discharge to streams, springs, or other groundwater systems, or from groundwater storage. Figure 37 and Figure 38 illustrate the ratio of current groundwater consumption to estimated groundwater recharge. This ratio provides an estimate of how current groundwater usage compare to within-WAB sustainable yield. Sustainable yield refers to the amount of water than can be pumped, here estimated using rates of recharge, while minimally changing storage and maintaining necessary stream and groundwater discharge. When pumping exceeds sustainable yield, declines in groundwater elevations are expected. It is important to note however, that even when pumping is less than the sustainable yield, negative impacts on streamflow and other groundwater dependent ecosystems can still occur, since the diverted water must be taken from one of these pools.

To understand where groundwater pumping maybe be exceeding estimates of sustainable yield, the ratio of groundwater consumption to recharge is computed (Figure 37 and Figure 38). Values of less than one indicates consumption is less than recharge, and values greater than one suggest pumping is greater than recharge. All but three tributary WABs have ratios substantially less than one, indicating that the current level of certificated pumping is much less than the predicted sustainable yield of the basins. The Grass Valley Canyon, Scott Canyon, and Lower Rock WABs have pumping rates significantly greater than estimated within-basin groundwater recharge. This suggests that at current rates, pumping may cause groundwater elevation declines and/or connected surface water discharge in these basins and that long-term groundwater use may not be sustainable at current rates.

There are a few important assumptions that were made in the above analysis that need to be noted. The groundwater recharge estimates are based strictly on the surface area drainage basin of each WAB. Groundwater basins do not necessarily follow surface topography nor does recharge occur over their entire surface, but this was a necessary assumption made in the analysis. Furthermore, specifically for Lower Rock Creek, groundwater inflows from the Upper Rock Creek Basin are not included in the recharge term. This analysis focuses strictly on within-WAB groundwater production. Assuming lower Rock Creek ultimately receives all of the groundwater recharge minus usage in upper Rock Creek, the ratio of consumption to available groundwater reduces to 0.51 from 6.4 for lower Rock Creek, indicating current consumption is less than sustainable yield. This analysis does not incorporate exempt wells, the impact of which is likely highly variable across WABs.

Figure 37: Certified Groundwater Consumption to Production Ratio

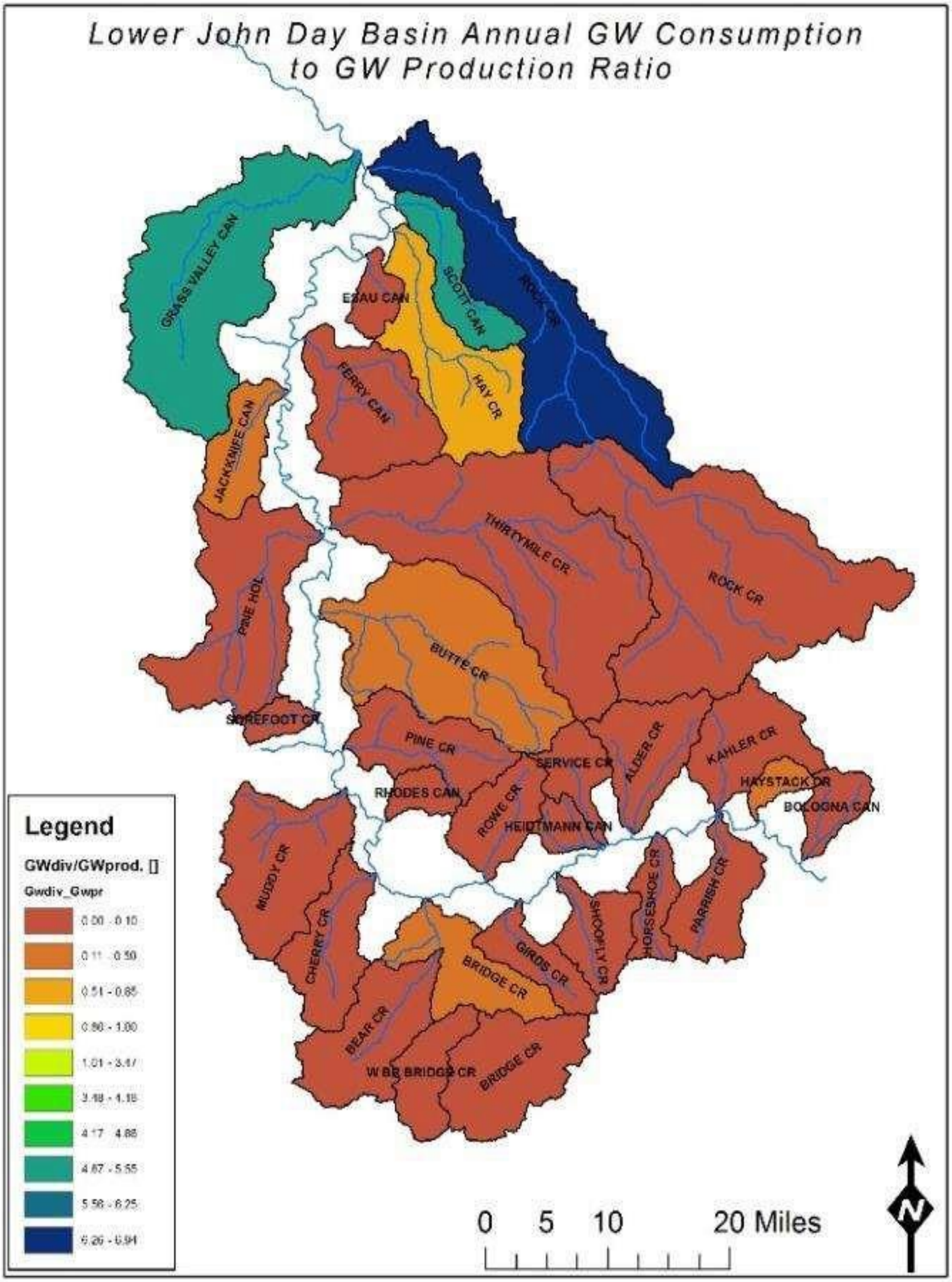


Figure 38: Ratio of Annual Certified Groundwater Duty to Surface Water Duty per WAB

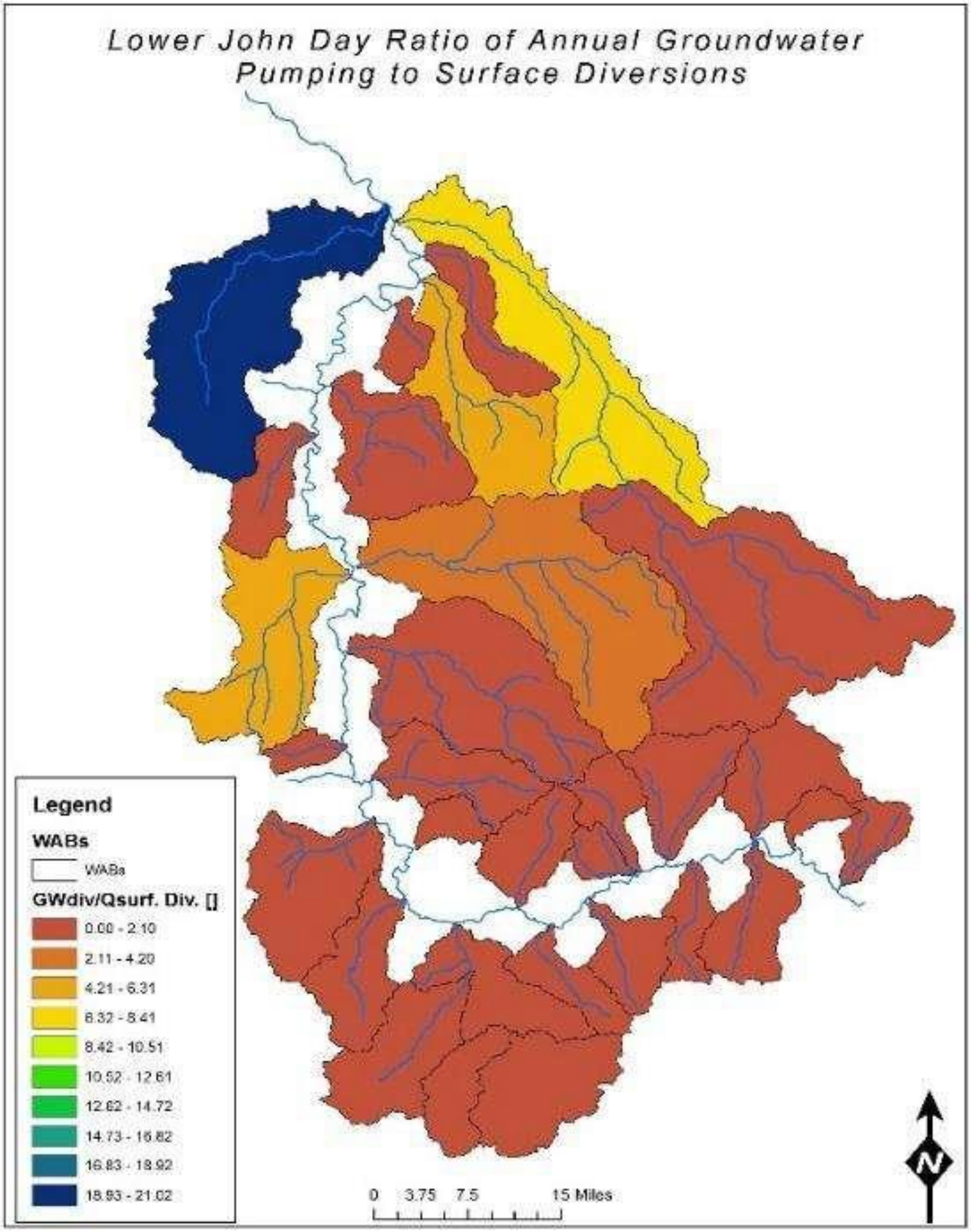


Table 11 shows the following key water use metrics: (1) Ratio of surface water consumption to natural surface water production, (2) Ratio of groundwater extraction to surface water extraction, (3) and Ratio of groundwater diversion to groundwater productionby WAB.

Table 11: Key Water Use Metrics

WAB	Surface Div./Surface Out. [ ]	GW Div./Surface Div. [ ]	GW Div./GW Prod. [ ]
ALDER CR > JOHN DAY R - AT MOUTH	0.11	0.12	0.03
BEAR CR > BRIDGE CR - AT MOUTH	0.09	0.34	0.02
BOLOGNA CAN > JOHN DAY R - AT MOUTH	0.02	0.00	0.00
BRIDGE CR > JOHN DAY R - AB W BR BRIDGE CR	0.28	0.00	0.00
BRIDGE CR > JOHN DAY R - AT MOUTH	4.49	0.16	0.25
BUTTE CR > JOHN DAY R - AT MOUTH	0.17	1.89	0.11
CHERRY CR > JOHN DAY R - AT MOUTH	0.15	0.00	0.00
ESAU CAN > JOHN DAY R - AT MOUTH	0.00	0.00	0.00
FERRY CAN > JOHN DAY R - AT MOUTH	0.04	0.00	0.00
GIRDS CR > JOHN DAY R - AT MOUTH	0.07	0.00	0.00
GRASS VALLEY CAN > JOHN DAY R - AT MOUTH	0.07	21.02	5.40
HAY CR > JOHN DAY R - AT MOUTH	0.32	6.12	0.84
HAYSTACK CR > JOHN DAY R - AT MOUTH	0.48	2.01	0.32
HEIDTMANN CAN > JOHN DAY R - AT MOUTH	0.00	0.00	0.00
HORSESHOE CR > JOHN DAY R - AT MOUTH	0.04	0.00	0.00
JACKKNIFE CAN > JOHN DAY R - AT MOUTH	0.00	0.00	0.21
KAHLER CR > JOHN DAY R - AT MOUTH	0.12	0.00	0.00
MUDDY CR > JOHN DAY R - AT MOUTH	0.41	0.54	0.10
PARRISH CR > JOHN DAY R - AT MOUTH	0.02	0.00	0.00
PINE CR > JOHN DAY R - AT MOUTH	0.12	0.00	0.00
PINE HOL > JOHN DAY R - AT MOUTH	0.03	4.49	0.06
RHODES CAN > JOHN DAY R - AT MOUTH	0.11	0.00	0.00
ROCK CR > JOHN DAY R - AB WALLACE CAN	0.22	0.52	0.04
ROCK CR > JOHN DAY R - AT MOUTH	0.44	6.87	6.94
ROWE CR > JOHN DAY R - AT MOUTH	0.41	0.00	0.00
SCOTT CAN > JOHN DAY R - AT MOUTH	0.00	0.00	5.20
SERVICE CR > JOHN DAY R - AT MOUTH	0.03	0.00	0.00
SHOOFLY CR > JOHN DAY R - AT MOUTH	0.07	0.00	0.00
SOREFOOT CR > JOHN DAY R - AT MOUTH	0.14	0.00	0.00
THIRTYMILE CR > JOHN DAY R - AT MOUTH	0.06	2.10	0.05
W BR BRIDGE CR > BRIDGE CR - AT MOUTH	0.21	0.00	0.00

As noted earlier, the Lower John Day Basin is comprised of 5 primary geologic units: Columbia River Basalt Group(CRBG), John Day/Clarno Group, Quaternary Alluvium(Qal), Mitchell Group, and the Dalles Group. CRBG dominates in terms of total coverage area. Similarly, the majority of certified wells in the basin draw from CRBG units (77%), followed by Clarno/John Day (12%), and Alluvium units (11%). Table 12 displays water use by target aquifer system and beneficial use.

Table 12: Groundwater Source Units and Intended Uses

DRAFT Water Rights by Aquifer Unit with Lower John Day Basin				
	Count	CFS	AF/year	Mgal/year
Alluvium	18	8	5,593	1,822
CRBG	146	55	40,038	13,046
Clarno/John Day	27	9	6,568	2,140

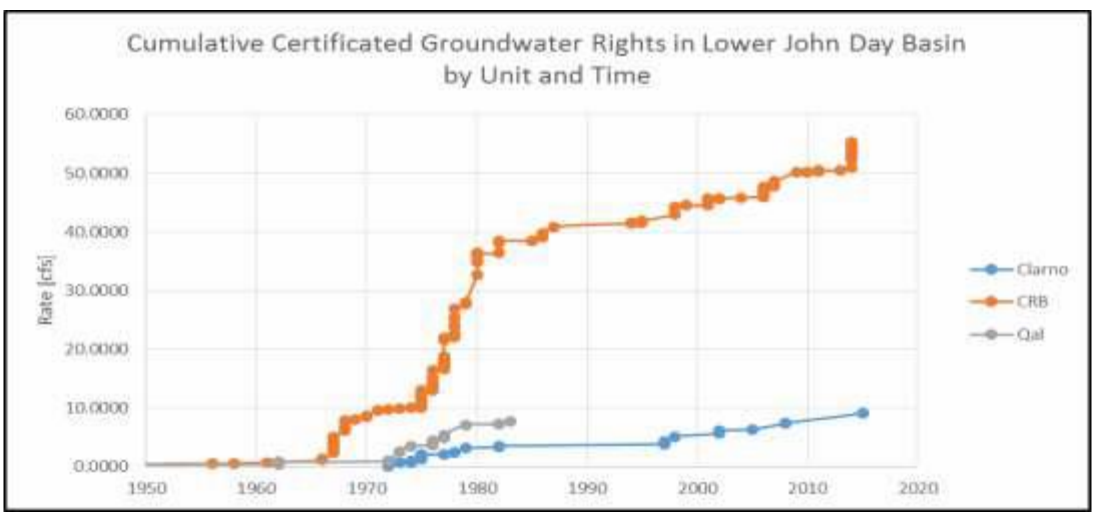
Water Rights by Use Type				
	Count	CFS	AF/year	Mgal/year
Irrigation	116	58	42330	13792
Municipal	29	11	7976	2599
Other	46	3	1894	617

As noted earlier in this report, a John Day Basin-wide evaluation for groundwater resources in 1984 showed groundwater movement is generally northward toward the Columbia River, however it is locally structurally controlled. Average annual groundwater recharge rates over the basin were estimated at 0.4-0.6 in/yr. The high horizontal transmissivity and relatively shallow static water levels in the CRBG make yields adequate for domestic and stock use in most areas. And although some small- scale irrigation use is assumed possible, the overall regional low recharge and significant depth of wells necessary to extract high volumes of water in the CRBG likely make large-scale groundwater irrigation development uneconomical or impractical. Low vertical transmissivity and precipitation input are primarily responsible for the low recharge in the CRBG group.

The alluvial deposits located in river and stream valleys are one of the most important aquifer units in the John Day Basin, second only to the CRBG. Significant Quaternary alluvial deposits are located in the vicinity of Spray, Twickenham, and Clarno and have high porosity, permeability, specific yields of up to 25% and a high potential for recharge. Well yields can often be adequate for irrigation, but the shallow aquifers in Quaternary alluvium are typically directly connected to surface waters. As such, removal of alluvial aquifer water can cause decreases in streamflow and the management of the two resources must be considered together (Gannett, 1984).

Figure 39 shows that the cumulative certificated groundwater use in the basin has increased dramatically over the last fifty years. The period between 1965-1980 saw significant growth in the number of wells, particularly those targeting production from aquifers within the CRBG unit. Relatively minimal increases in groundwater appropriations have occurred since the early 1980s.

Figure 39: Trends in Groundwater Water Right Certificates in the Lower John Day by Aquifer (Clarno, Columbia River Basalt, and Quarternary Alluvium).



Observation wells are used to track changes in water table elevations with time. Unfortunately, there are only two long-term and operational observation wells in the entire Lower John Day Basin. The two wells are described in Table 13.

Table 13: Observation Well Data for Lower John Day Basin

County	Long Term and Current OWRD	Other	Wells
Wheeler	0	0	
Sherman	1	0	Sher 340
Gilliam	1	0	Gill 60

The two datasets show annual fluctuations and some specific declines; however, they do not indicate any long-term water table declines. It is impossible however to extrapolate the long-term water table trends in the greater basin based on such sparse data. Groundwater data from other nearby areas (Olex, Willow Creek, and Umatilla) do show sharp downward trends of groundwater head with time. This available data is depicted in Figure 40 and 41 below. The two wells depicted, although both in the CRBG, likely represent quite different systems within the unit based upon groundwater elevations.

Figure 40: Groundwater Table Elevation Time-Series for Observation Well GILL 60

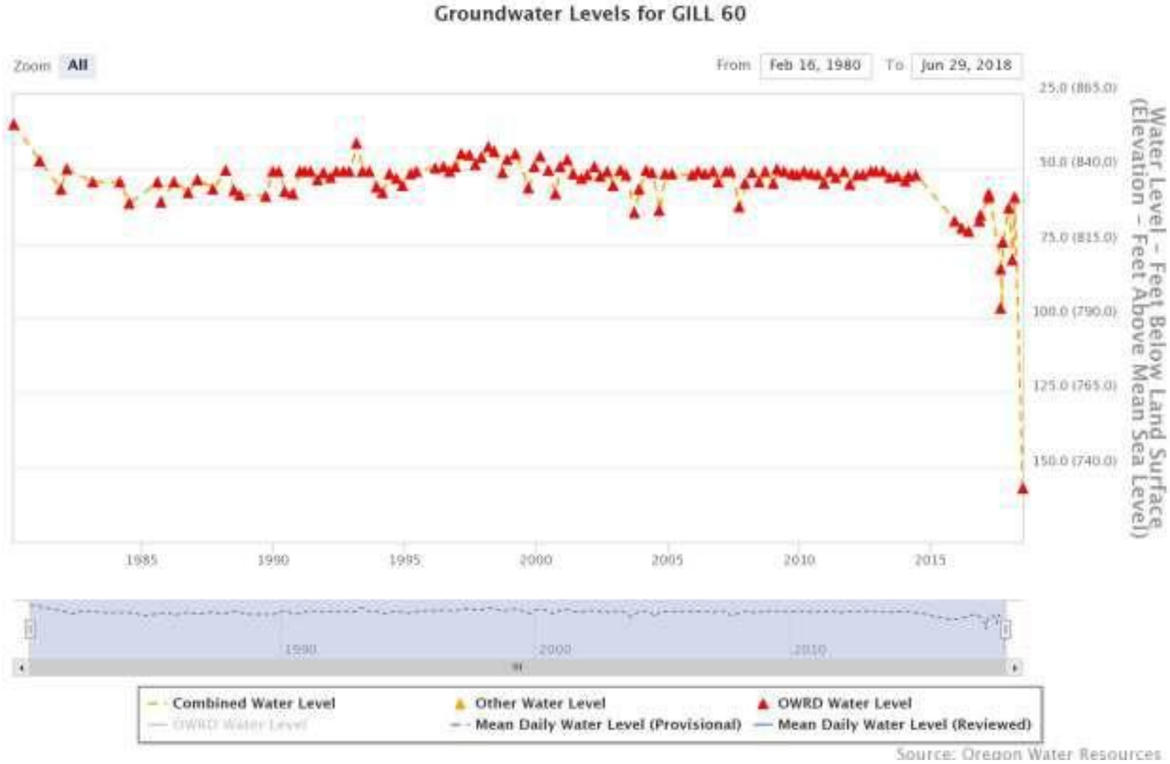
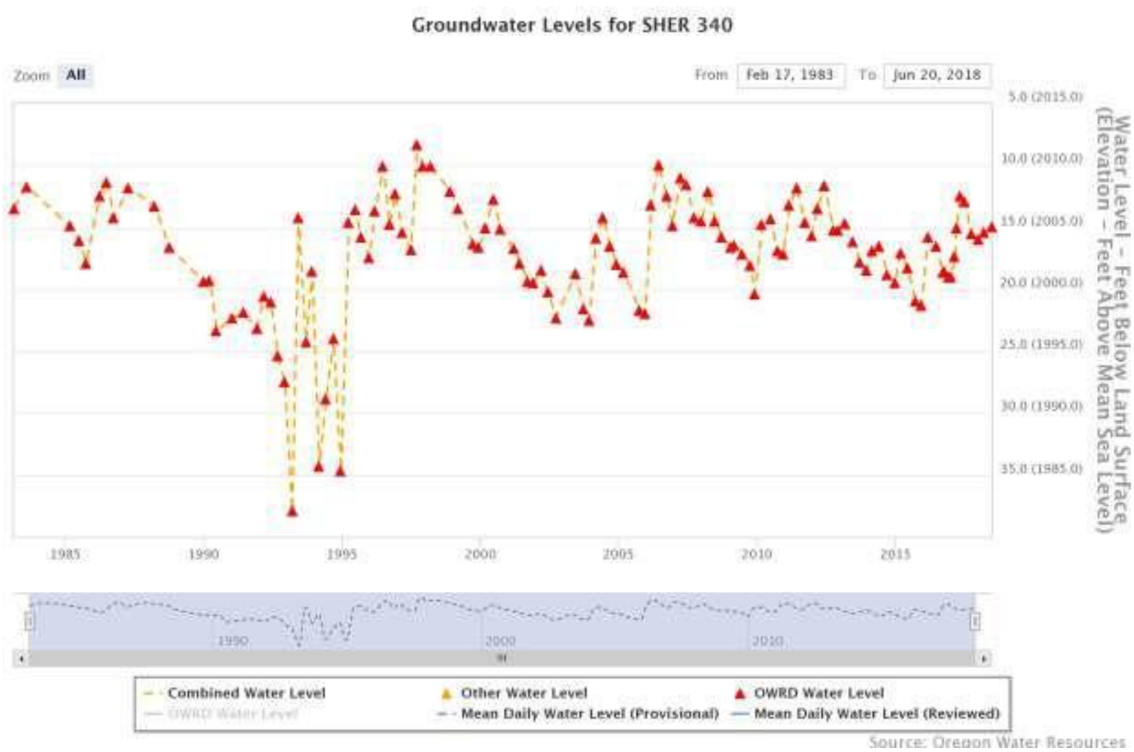


Figure 41: Groundwater Table Elevation Time-Series for Observation Well SHER 340



7. WATER STORAGE

In terms of volume, roughly one-quarter of all surface water diversion consumptive use is for storage water rights in the Lower John Day Basin. Of these storage rights, the vast majority have an intended use of either livestock or wildlife water as show in Table 14.

Table 14: Storage Water Use Categories

Category	POU Count
LIVESTOCK	205
WILDLIFE	127
FIRE PROTECTION	42
IRRIGATION	36
MULTIPLE PURPOSE	22
RECREATION	19
STORAGE	18
SUPPLEMENTAL IRRIGATION	14
FISH CULTURE	11
DOMESTIC	5
MUNICIPAL USES	3
POND MAINTENANCE	3
DOMESTIC EXPANDED	2
AESTHETICS	1
AGRICULTURE USES	1
FOREST MANAGEMENT	1
INDUSTRIAL/MANUFACTURING USES	1

WABs with the greatest number of storage rights are Upper Rock, Thirtymile and Butte. In terms of total storage volume based on water right description, Upper Rock, Muddy, Lower Bridge, and Rowe Creek WABs account for over 85% of all storage in the Basin. Figure 41, Figure 42, and Table 15 depict basin storage (OWRD Water Rights Database).

Figure 41: Number of Storage Water Rights

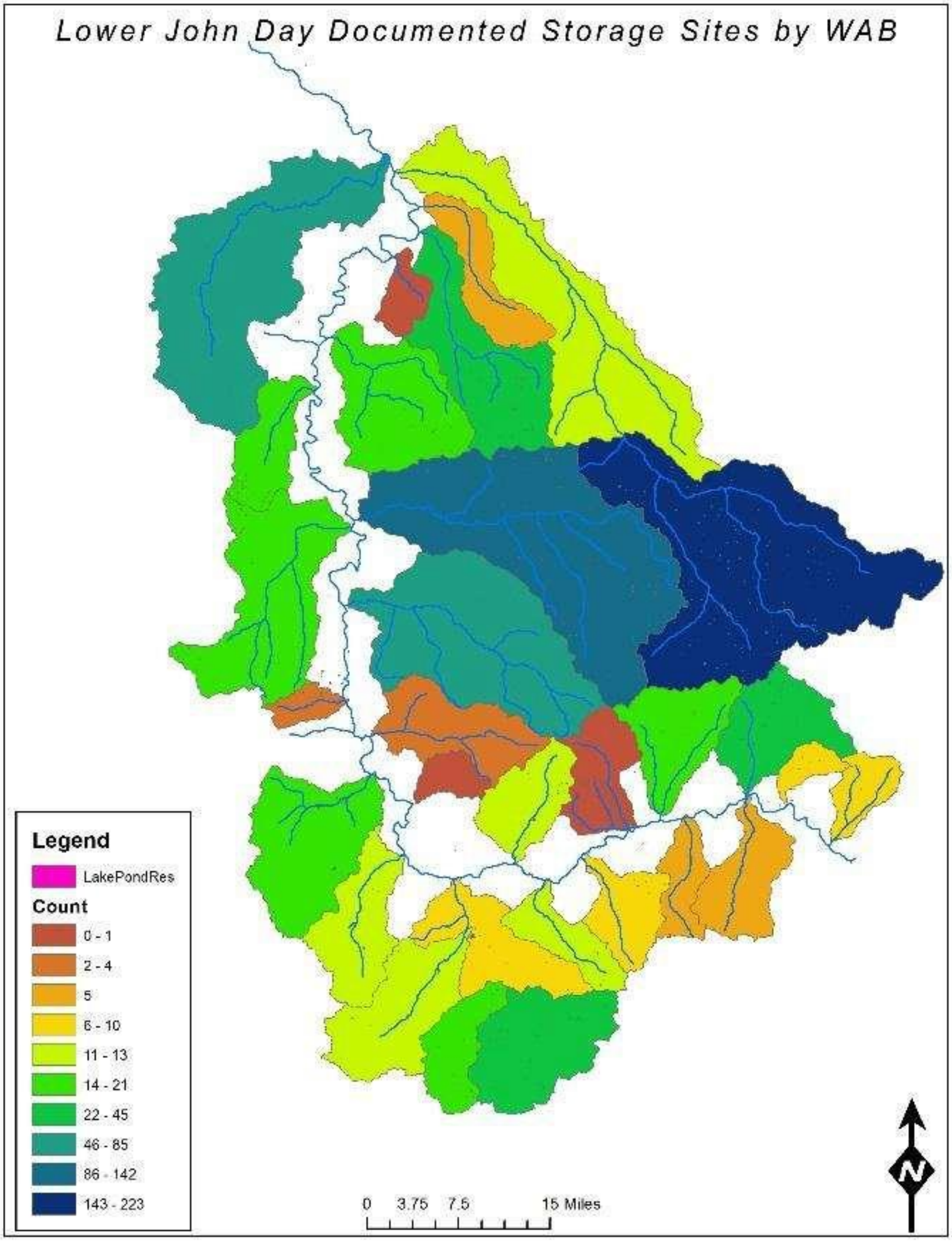


Figure 42: Storage Rights Volume Annually by WAB

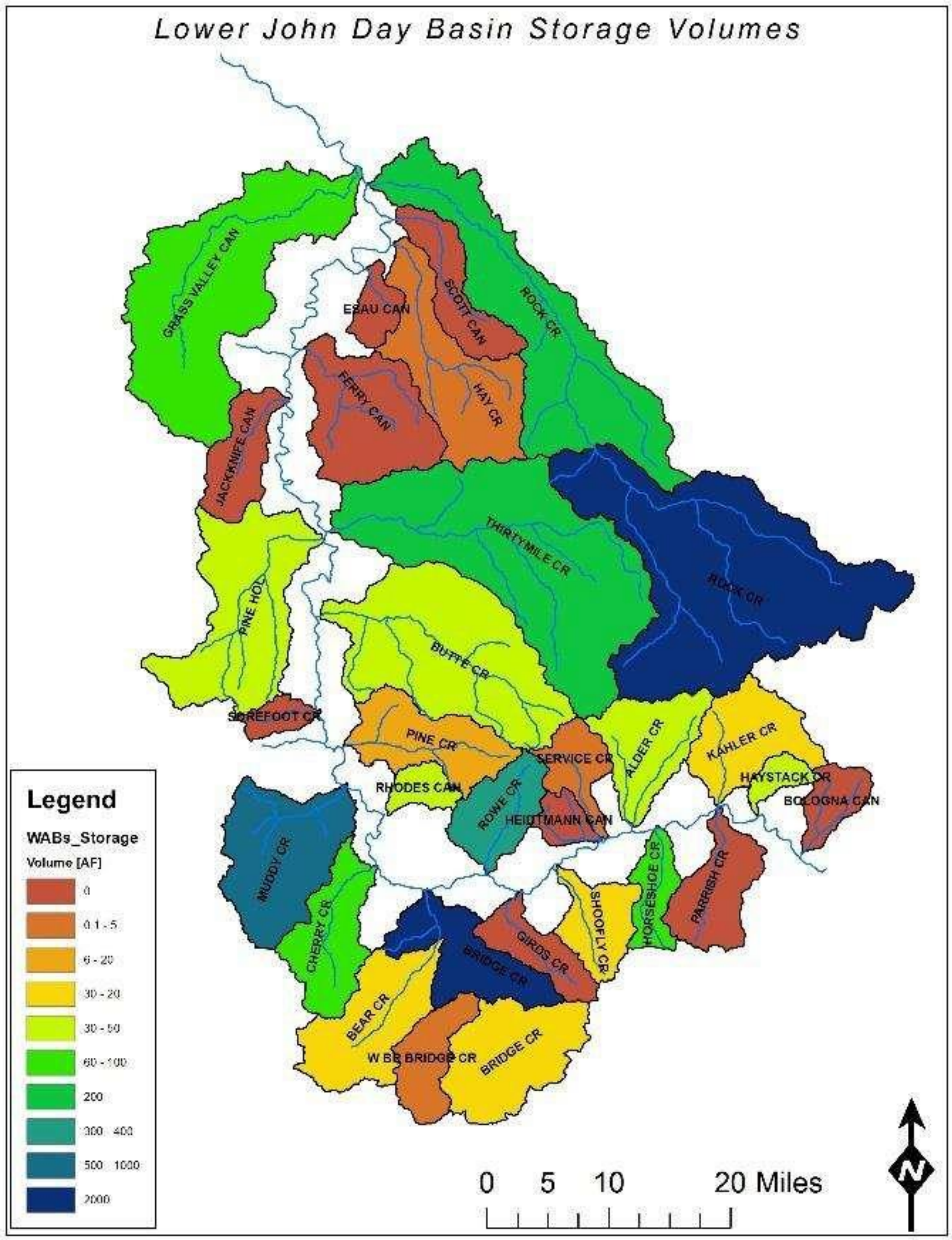
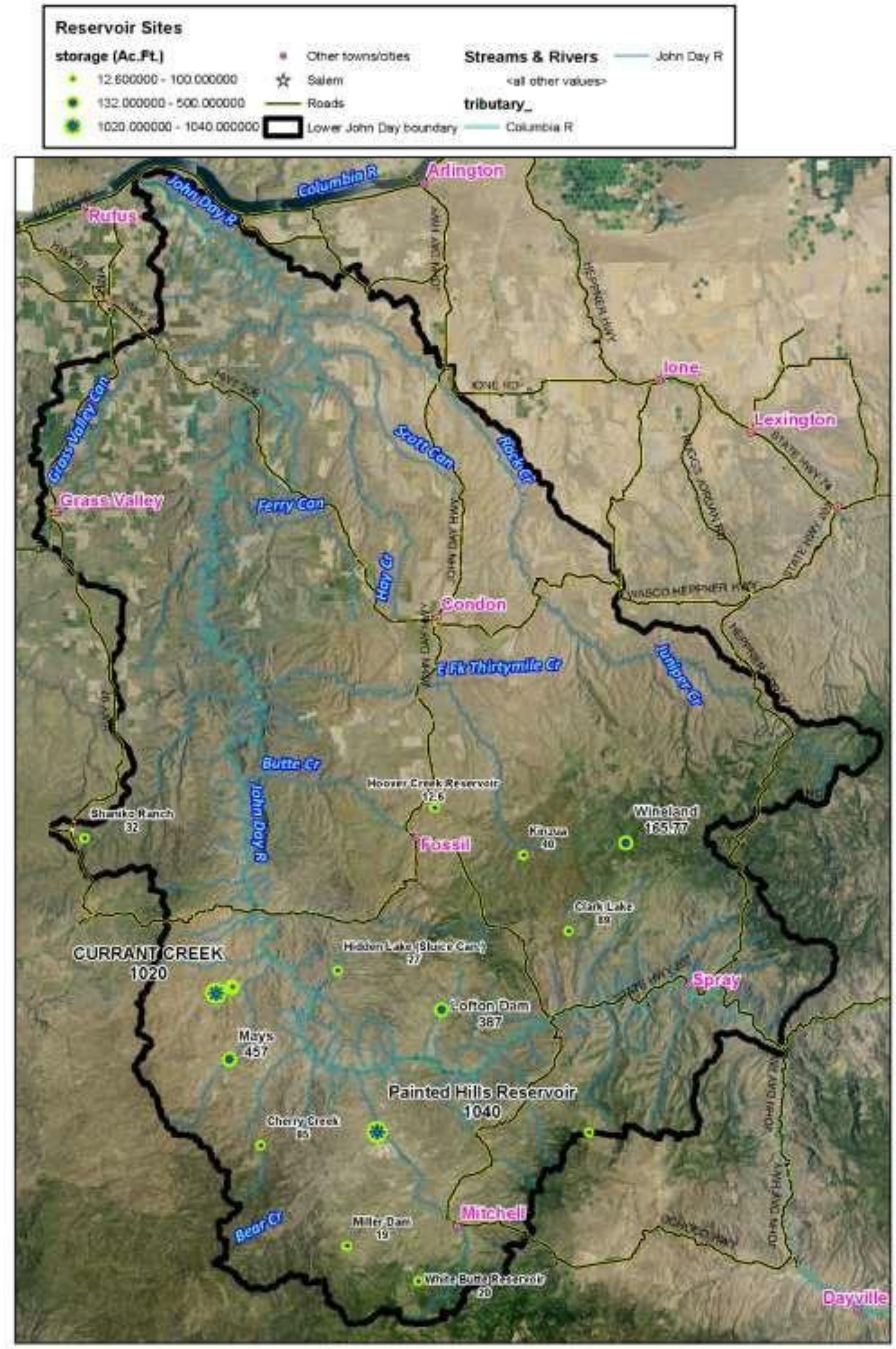


Table 15: Total Certificated Storage Volume per WAB

WAB	Volume [AF]
ROCK CR > JOHN DAY R - AB WALLACE CAN	2497
BRIDGE CR > JOHN DAY R - AT MOUTH	1841
MUDDY CR > JOHN DAY R - AT MOUTH	1069
ROWE CR > JOHN DAY R - AT MOUTH	403
ROCK CR > JOHN DAY R - AT MOUTH	238
THIRTYMILE CR > JOHN DAY R - AT MOUTH	202
GRASS VALLEY CAN > JOHN DAY R - AT MOUTH	123
CHERRY CR > JOHN DAY R - AT MOUTH	87
HORSESHOE CR > JOHN DAY R - AT MOUTH	67
RHODES CAN > JOHN DAY R - AT MOUTH	51
PINE HOL > JOHN DAY R - AT MOUTH	33
BUTTE CR > JOHN DAY R - AT MOUTH	32
ALDER CR > JOHN DAY R - AT MOUTH	30
HAYSTACK CR > JOHN DAY R - AT MOUTH	29
BEAR CR > BRIDGE CR - AT MOUTH	23
SHOOFLY CR > JOHN DAY R - AT MOUTH	22
BRIDGE CR > JOHN DAY R - AB W BR BRIDGE CR	21
KAHLER CR > JOHN DAY R - AT MOUTH	21
PINE CR > JOHN DAY R - AT MOUTH	19
W BR BRIDGE CR > BRIDGE CR - AT MOUTH	5
HAY CR > JOHN DAY R - AT MOUTH	4
SERVICE CR > JOHN DAY R - AT MOUTH	4
BOLOGNA CAN > JOHN DAY R - AT MOUTH	0
ESAU CAN > JOHN DAY R - AT MOUTH	0
FERRY CAN > JOHN DAY R - AT MOUTH	0
GIRDS CR > JOHN DAY R - AT MOUTH	0
HEIDTMANN CAN > JOHN DAY R - AT MOUTH	0
JACKKNIFE CAN > JOHN DAY R - AT MOUTH	0
PARRISH CR > JOHN DAY R - AT MOUTH	0
SCOTT CAN > JOHN DAY R - AT MOUTH	0
SOREFOOT CR > JOHN DAY R - AT MOUTH	0

Figure 43: Current Reservoirs in the Basin

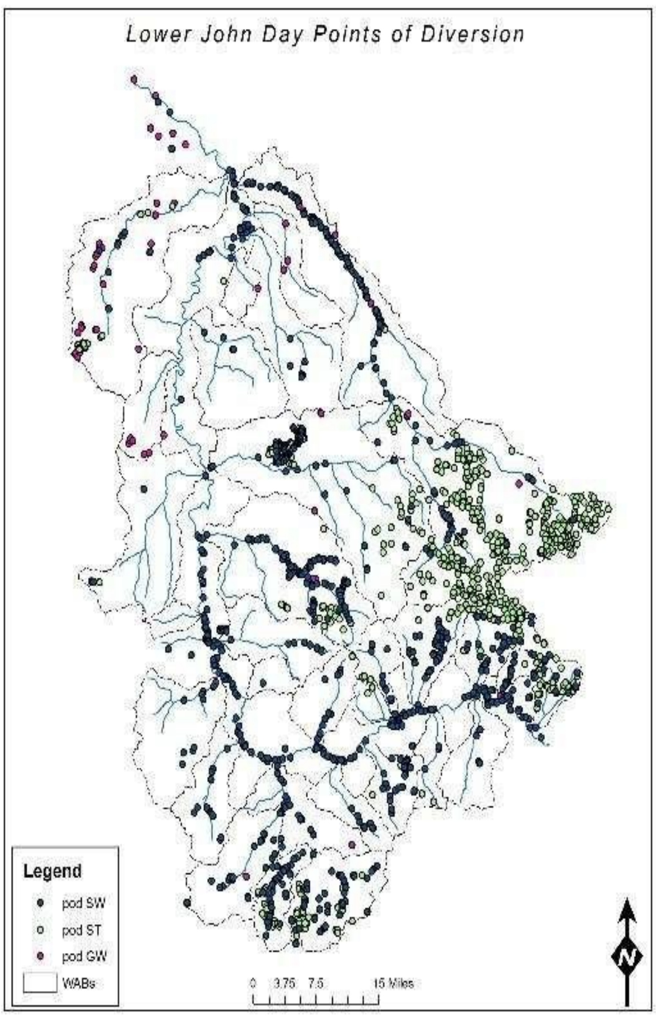


8. WATER USE

Up to this point, the water budgets presented are based entirely on natural inputs and outputs (e.g., no accounting of out-of-basin water transfers) and have not dealt with within-basin water fluxes (e.g., water diversions). In general, water rights can be classified by source as a groundwater, surface water, or storage right. Water rights are further classified based on intended use, including whether they are consumptive or non-consumptive. There are a multitude of different water right use classifications, though in the sections below, we primarily focus analysis on consumptive (irrigation and stock water, municipal) and non-consumptive (instream or environmental water rights). As an overview of the distribution of water rights in the basin, illustrates the distribution of water right points of diversion (PODs) based on source for all water right uses.

This section includes a description of withdrawals from the system, estimates of current available water

Figure 44: Points of Diversion Categorized by Source (SW-Surface Water, ST-Storage, GW-Groundwater



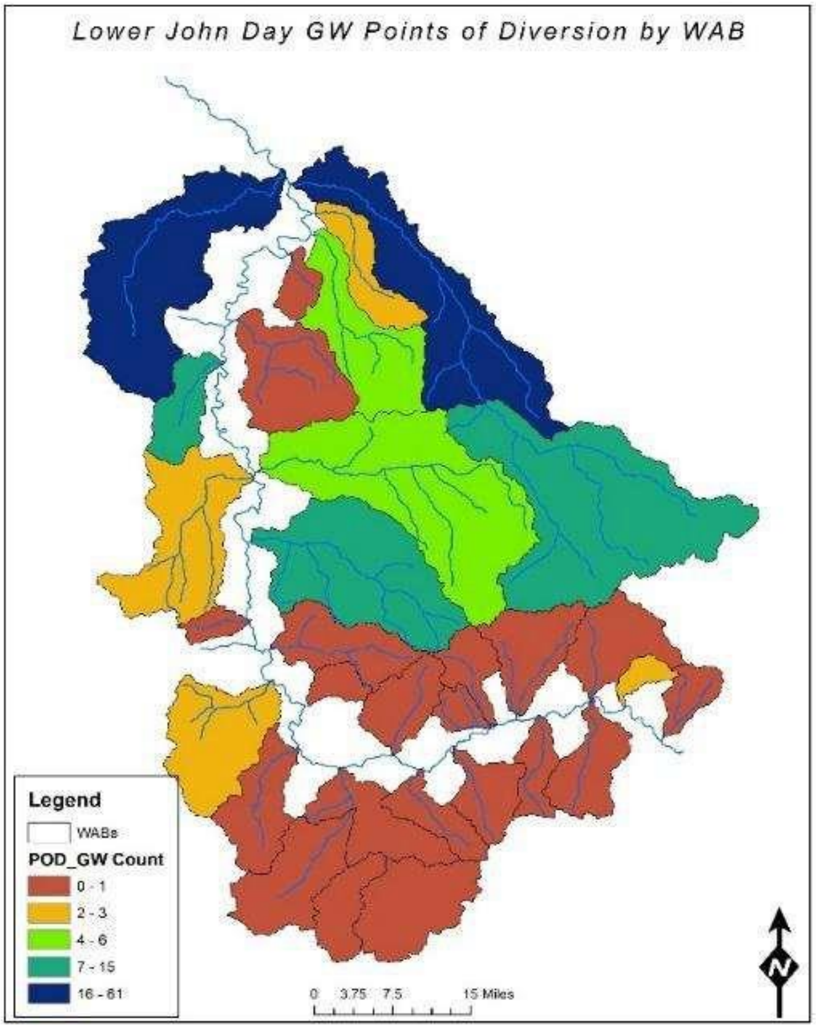
A. Withdrawals

In this section, consumptive water use are summarized per WAB and are compared to natural water budget metrics.

Storage water rights (POD ST) are primarily located on Umatilla and Ochoco National Forest lands and are associated with stock water rights in upper elevation portions of watersheds. There is a distinct gradient in the number of certificated groundwater PODs in the greater Lower John Day Basin. This analysis excludes wells that are exempt from water right certification. Exempt uses include: group or single domestic use, up to 15,000 gallons per day; irrigation of lawn and/or non-commercial garden of ½ acre or less; single industrial or commercial purpose not to exceed 5,000 gallons per day; irrigation of school property up to 10 acres in critical groundwater areas; stock water; and down-hole heat exchange.

Over 77% of all certificated wells are located in two subwatersheds, Grass Valley and Lower Rock. Most WABs in the southern portion of the basin have 0-1 certified wells each. There is a less consistent pattern in terms of the number of surface water PODs. In general, there are fewer pods in WABs on the western edge of the basin, and particularly in the northwestern section of the basin. Figure 44 and Figure 45 represent the number of PODs for groundwater and surface water, respectively.

Figure 45: Certified Points of Diversion for Groundwater per WAB



Data on submitted groundwater applications were provided by OWRD. The dataset includes all processed applications from 2004 to the present. Figure 46 illustrates the approximate locations of well applications. Similar to Figure 37, there is a pronounced increase in both applications and permitted wells from south to the north in the basin. Since 2004 there have been 24 total groundwater permit applications, with 7 of them representing limited license (5 yrs.) applications (Table 16). Of the 24 applications, 10 were identified as having some issue of concern (e.g. close proximity to surface water, proximity and potential injury to other nearby wells, etc.). Of the 10 applications identified with issues, 9 were eventually approved, 3 of which were approved but conditioned for water availability.

Figure 46: Well Locations of Groundwater Right Applications

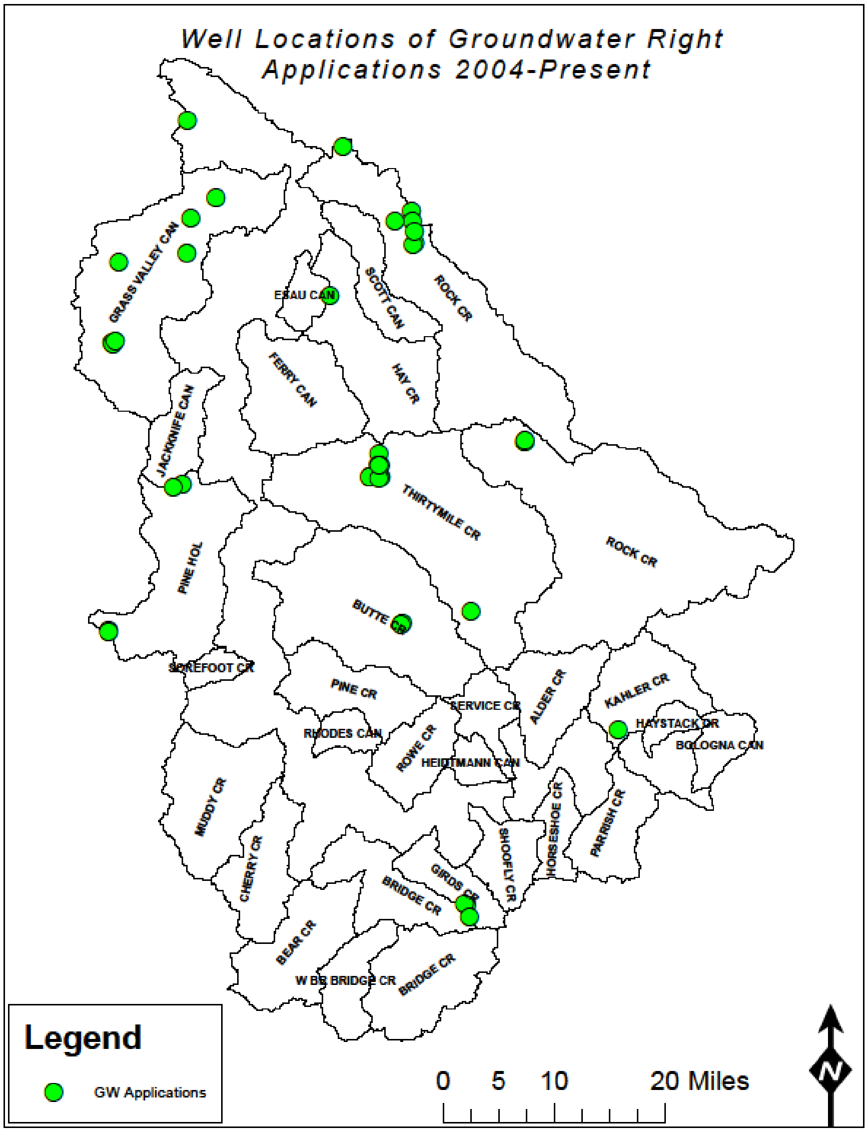


Table 16: Groundwater Application Statistics

Total Applications	**24**
Limited Licenses	**7**
Those with Identified Issues	**10**
Denied	**1**
Conditioned for Water Availability	**3**

Figure 47: Certified Points of Diversion for Surface Water per WAB

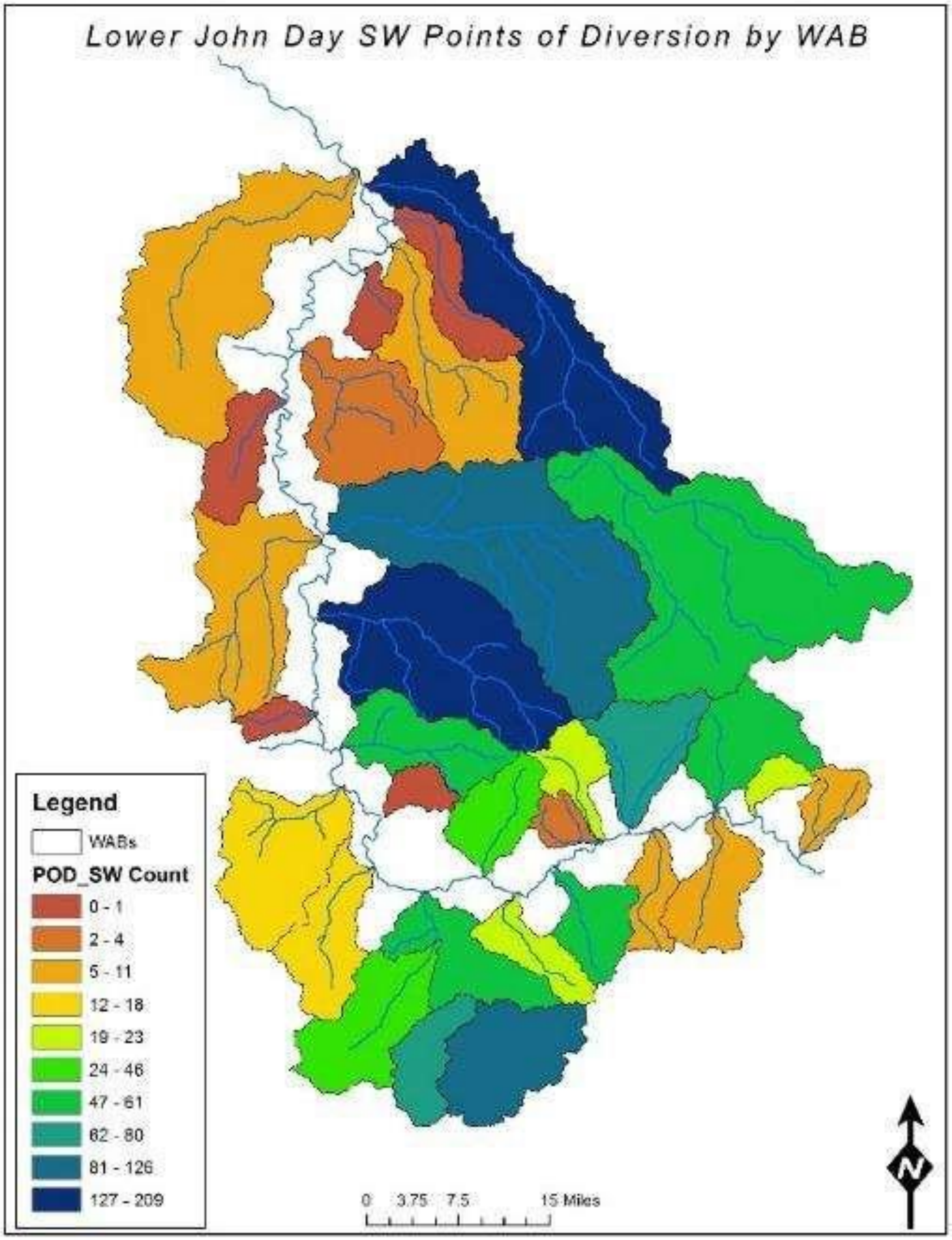


Figure 48 and Table 17 quantify the volume of surface water consumed annually per WAB (Water Availability Reporting System, OWRD). Surface water consumption in the region is dominated by the large WAB encompassing the mainstem John Day River valley, from Service Creek down to the Columbia River confluence. Surface water users in the WAB consume nearly 24,000 acre-ft per year, representing just over 50% of all surface water consumed in the Lower John Day Basin. There are 8 WABs with consumption totals over 1000 acre-ft per year (the two John Day mainstem WABS, Bridge Creek at mouth and above the West Branch, both Rock Creek WABs, Butte Creek, and Muddy Creek). Combined, these WABs account for 83% of all surface water consumption in the Lower John Day Basin.

In addition to being affected by withdrawals from surface water, surface water flows may be affected by withdrawals from groundwater that is hydrologically connected to surface water. In certain circumstances, OWRD rules assume new groundwater withdrawals have the potential to impact surface flows, but the overall extent of groundwater interactions with surface water in the basin is not fully understood.

Figure 48: Estimated Consumption of Surface Water Sources

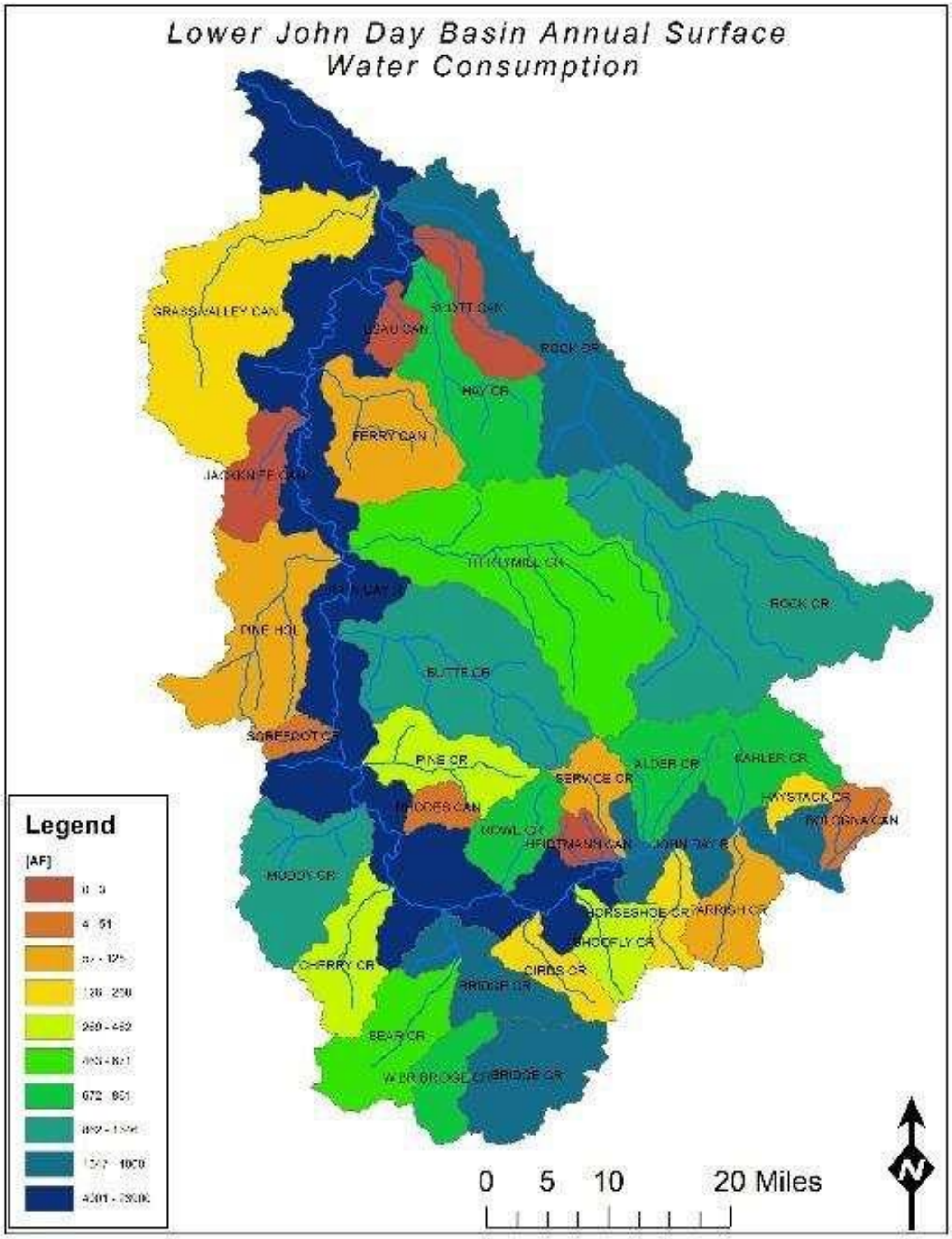


Table 17: Cumulative Surface Water Consumption by WAB(as of July 2017)

WAB	Consumption [AF]	% Total	% Cummulative
JOHN DAY R - AT MOUTH	23900	51%	51%
JOHN DAY R - AB HEIDTMANN	4000	8%	59%
BRIDGE CR- AB W BR BRIDGE CR	2650	6%	65%
ROCK CR - AT MOUTH	2551	5%	70%
BRIDGE CR - AT MOUTH	2509	5%	75%
BUTTE CR	1346	3%	78%
MUDDY CR	1289	3%	81%
ROCK CR - AB WALLACE CAN	1120	2%	83%
HAY CR	861	2%	85%
ROWE CR	804	2%	87%
KAHLER CR	775	2%	89%
W BR BRIDGE CR	745	2%	90%
ALDER CR	730	2%	92%
THIRTYMILE CR	671	1%	93%
BEAR CR	631	1%	94%
CHERRY CR	462	1%	95%
SHOOFLY CR	398	1%	96%
PINE CR	343	1%	97%
HAYSTACK CR	268	1%	98%
GRASS VALLEY CAN	236	0%	98%
GIRDS CR	185	0%	98%
HORSESHOE CR	175	0%	99%
PARRISH CR	125	0%	99%
SERVICE CR	108	0%	99%
PINE HOL	101	0%	100%
FERRY CAN	84	0%	100%
RHODES CAN	51	0%	100%
SOREFOOT CR	50	0%	100%
BOLOGNA CAN	27	0%	100%
HEIDTMANN CAN	3	0%	100%
ESAU CAN	0	0%	100%
JACKKNIFE CAN	0	0%	100%
SCOTT CAN	0	0%	100%

Figure 49 and Figure 50 compare annual WAB surface water consumption to two key metrics, natural streamflow production and precipitation input. These ratios provide an indication of the relative magnitude of consumed water to that produced in the WAB. The highest scores for both ratios occur in the two WABs that are part of nested groups (Rock Creek and Bridge Creek). In both of these basins tributary WABs drain into a lower WAB (Bridge Creek at Mouth and Rock Creek at

Mouth). Both of these receiving WABs have very high ratios of consumed water to both natural streamflow production and precipitation input. What these values indicate is that although large volumes of water are diverted in these lower elevations receiving WABs, the bulk of precipitation input and streamflow generation is located in their higher elevation upstream source WABs (Rock above Wallace Canyon; Bridge above West Branch, Bear, and West Branch Bridge).

Figure 49: Comparison of Annual Surface Water Consumption per WAB Relative to Natural Streamflow Production

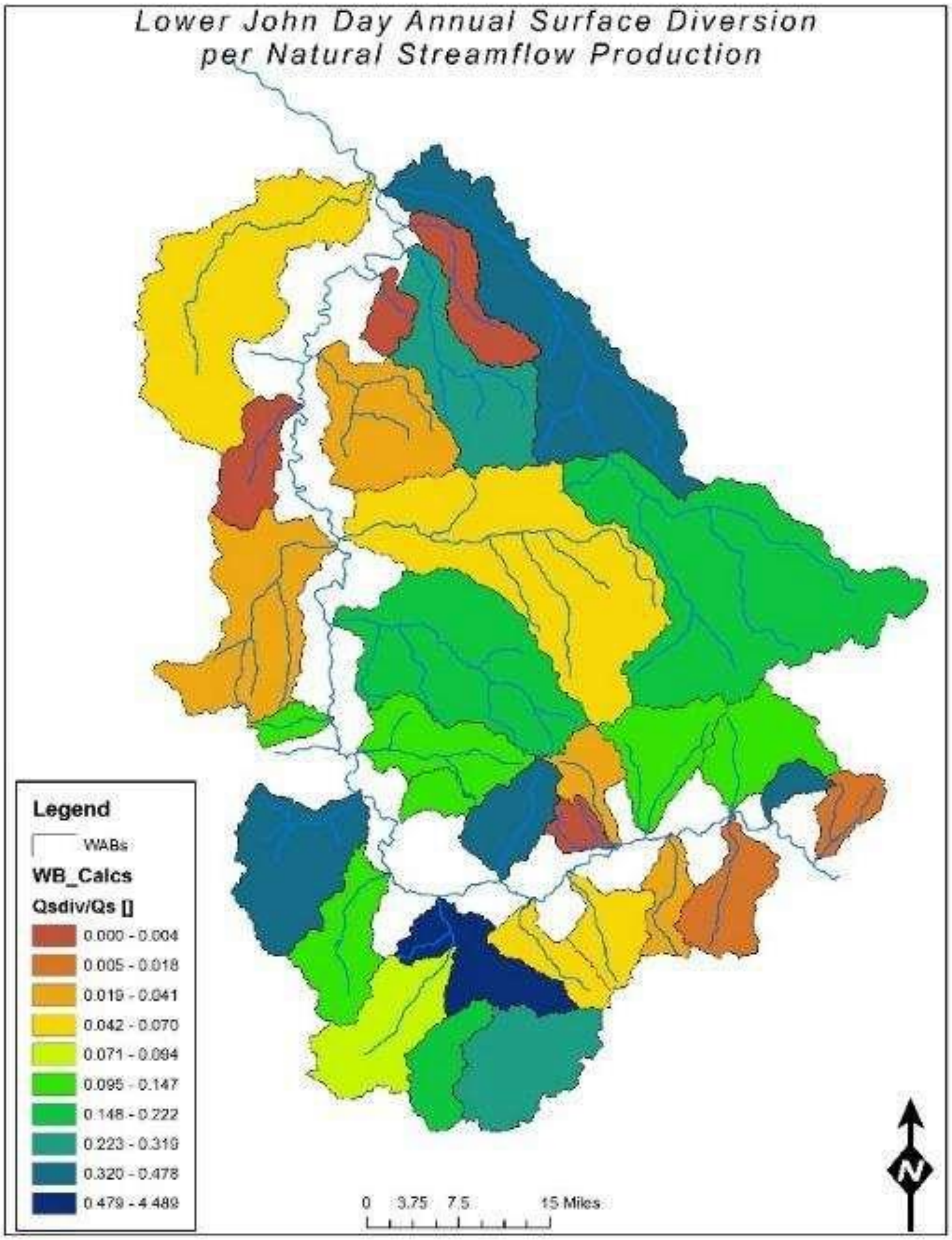
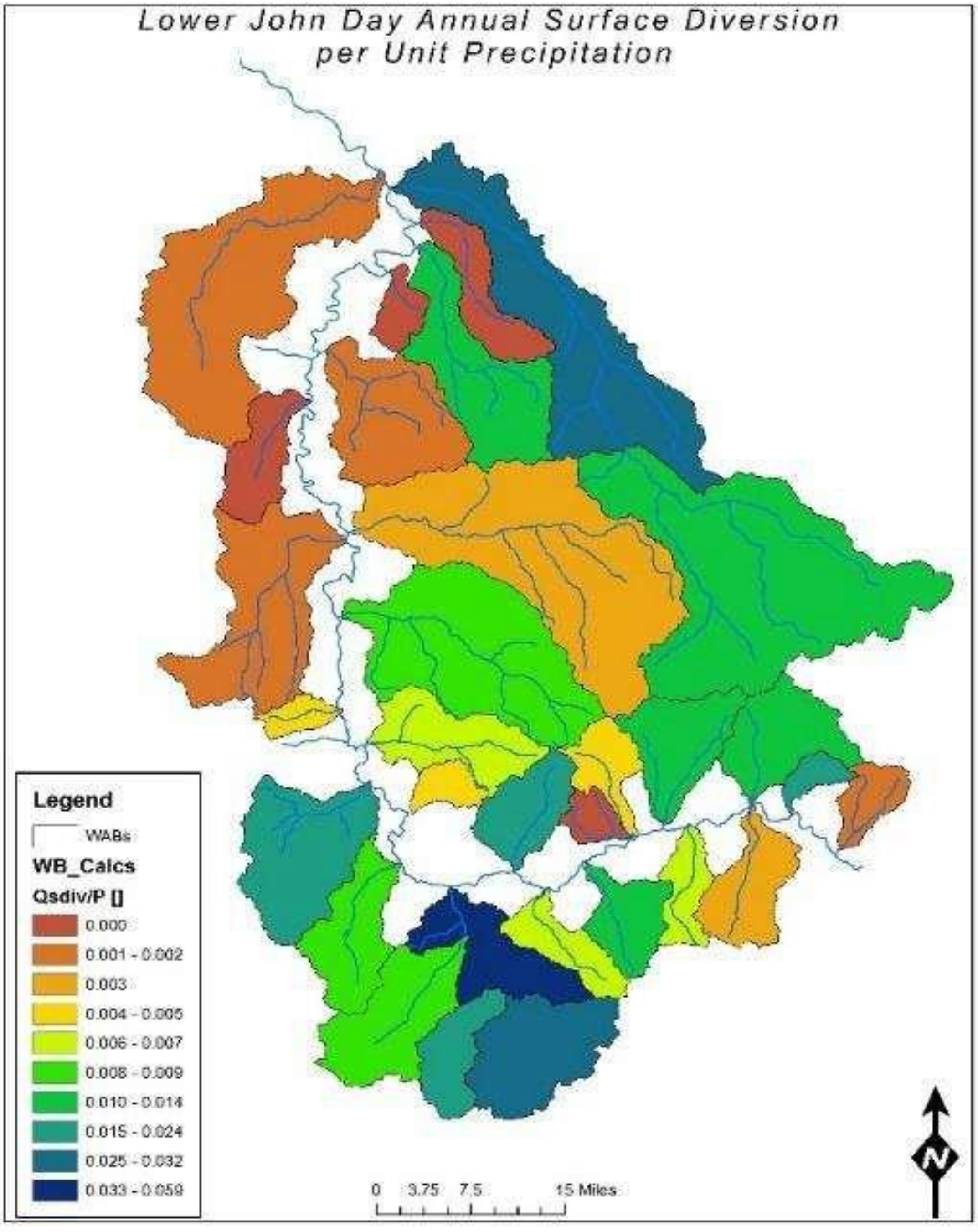


Figure 50: Comparison of Annual Surface Water Consumption per WAB Relative to Precipitation



B. Water Availability

OWRD provides data on the monthly amount of flow available for new water rights in all WABs in the state. This analysis compares modeled natural streamflow with all existing consumptive uses within and downstream of the basin to determine the amount of water available for additional water rights – the upstream senior rights limit the amount of water available downstream for additional use. Table 18 provides computed monthly median available streamflow. From July-

October, the period when water is generally in greatest demand, there is no available new surface water in the Basin. The bulk of available water in the basin occurs from January-May. However, two of the three largest surface-water producing subwatersheds, Rock Creek and Bridge Creek, have no available flow during the majority of these winter and spring months due to existing water rights. In terms of volume, the two Mainstem John Day WABs have by far the greatest potential for future non-irrigation season water development. The remaining tributary WABs with the greatest amount of available water are Thirtymile, Parrish, Butte, Alder, Kahler and Shoofly Creeks. It is notable that in regards to regulation of decreed water rights within the John Day basin, there are unique regulatory restrictions on decreed water rights. Tributary water rights granted under the John Day decree are not subject to regulation for mainstem decreed water rights.

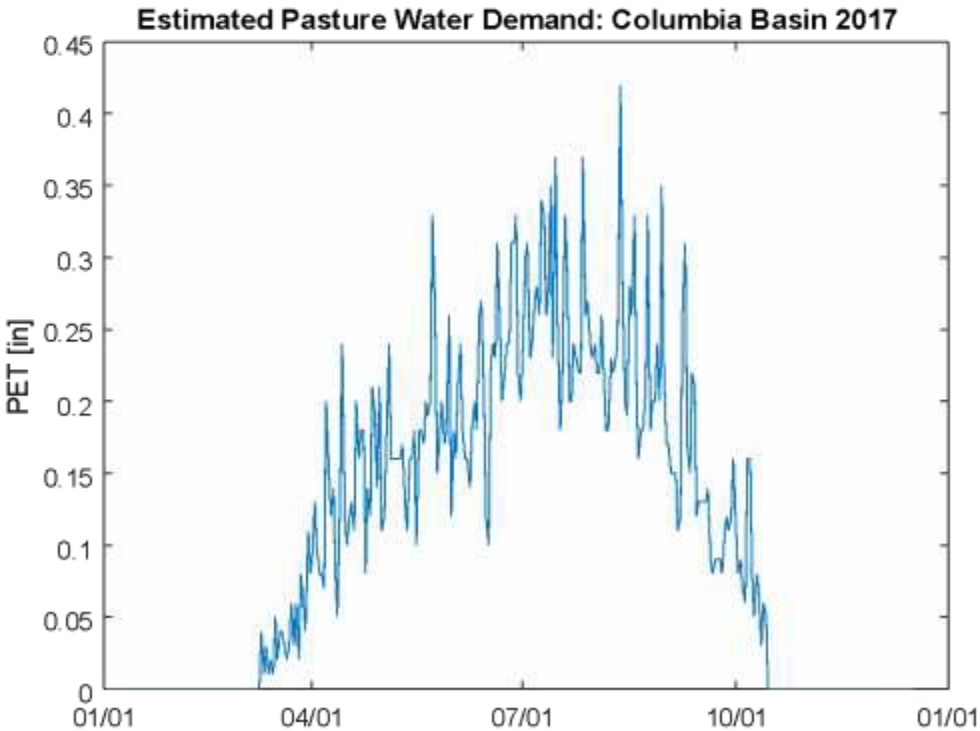
Table 18: Water Availability Reports for Lower John Day WABs at 50% Exceedance. Monthly Values Represent Average Rate (cfs) Available; Storage Represents Total Annual Volume (AF) Available

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	STOR
JOHN DAY R > COLUMBIA R - AT MOUTH	671	1290	1030	2420	2490	338	-54.4	-357	-362	-178	22.7	385	519000
JOHN DAY R > COLUMBIA R - AB HEIDTMANN CAN	566	942	699	2250	2330	147	-83.5	-370	-364	-178	-6.3	313	436000
THIRTYMILE CR > JOHN DAY R - AT MOUTH	11.1	28.7	50	26	15.3	6.52	-54.4	-357	-362	-178	6.19	9.4	9190
PARRISH CR > JOHN DAY R - AT MOUTH	10.7	18.5	20.4	23.8	17.7	6.97	-83.5	-370	-364	-178	-6.3	6.32	6260
BUTTE CR > JOHN DAY R - AT MOUTH	8.17	21.6	34.2	17.7	6	0.638	-54.4	-357	-362	-178	4.69	6.63	5970
ALDER CR > JOHN DAY R - AT MOUTH	9.3	18.6	23	24.1	13.7	3.28	-83.5	-370	-364	-178	-6.3	5.23	5820
KAHLER CR > JOHN DAY R - AT MOUTH	9.59	19.4	24.1	24.8	11.7	2.05	-83.5	-370	-364	-178	-6.3	5.3	5800
SHOOFLY CR > JOHN DAY R - AT MOUTH	7.99	14.3	15.8	17.4	14.3	5.75	-54.4	-357	-362	-178	3.2	4.67	5000
HORSESHOE CR > JOHN DAY R - AT MOUTH	5.37	9.36	10.6	12.5	12.9	6.07	-83.5	-370	-364	-178	-6.3	3.35	3610
SERVICE CR > JOHN DAY R - AT MOUTH	5.75	10.8	12	12.2	7.56	2.4	-83.5	-370	-364	-178	-6.3	3.2	3220
GRASS VALLEY CAN > JOHN DAY R - AT MOUTH	2.72	9.28	28.6	6.3	1.42	0.106	-54.4	-357	-362	-178	0.28	1.67	3030
PINE HOL > JOHN DAY R - AT MOUTH	3.76	10.9	18.6	6.85	3.34	1.39	-54.4	-357	-362	-178	1.56	2.89	2960
CHERRY CR > JOHN DAY R - AT MOUTH	3.56	9.18	12.6	5.88	2.78	1.25	-54.4	-357	-362	-178	2.4	3	2430
GIRDS CR > JOHN DAY R - AT MOUTH	2.95	7.45	10.5	6.48	4.23	2.21	-54.4	-357	-362	-178	2.04	2.49	2300
PINE CR > JOHN DAY R - AT MOUTH	5.22	8.2	6.41	4.12	2.82	1.36	-54.4	-357	-362	-178	2.33	3.3	2020
FERRY CAN > JOHN DAY R - AT MOUTH	2.62	7.84	14.1	3.98	1.39	0.42	-54.4	-357	-362	-178	0.72	1.92	1980
MUDDY CR > JOHN DAY R - AT MOUTH	2.55	6.97	10.7	3.99	1.28	0.23	-54.4	-357	-362	-178	1.28	2.05	1740
ROCK CR > JOHN DAY R - AB WALLACE CAN	-7.95	-0.71	26.9	-8.27	-48	-15.1	-54.4	-357	-362	-178	-0.464	-8.01	1650
ROCK CR > JOHN DAY R - AT MOUTH	-7.95	-0.71	26.9	-8.27	-48	-15.1	-54.4	-357	-362	-178	-0.464	-8.01	1650
HAY CR > JOHN DAY R - AT MOUTH	3.9	6.71	5.12	3.33	2.88	1.26	-54.4	-357	-362	-178	1.16	2.09	1580
BOLOGNA CAN > JOHN DAY R - AT MOUTH	2.45	6.11	6.31	3.69	1.97	1.18	-83.5	-370	-364	-178	-6.3	1.2	1370
ROWE CR > JOHN DAY R - AT MOUTH	1.97	5.26	7.33	2.57	-0.31	-0.89	-54.4	-357	-362	-178	1.07	1.6	1180
JACKKNIFE CAN > JOHN DAY R - AT MOUTH	1.22	3.74	6.58	1.69	0.57	0.2	-54.4	-357	-362	-178	0.3	0.86	907
HEIDTMANN CAN > JOHN DAY R - AT MOUTH	1.02	2.78	3.61	1.58	0.8	0.37	-54.4	-357	-362	-178	0.54	0.81	688
SCOTT CAN > JOHN DAY R - AT MOUTH	0.74	2.6	6.33	0.89	0.23	0.07	-54.4	-357	-362	-178	0.06	0.44	682
HAYSTACK CR > JOHN DAY R - AT MOUTH	0.888	2.47	2.69	0.798	0.018	-0.312	-83.5	-370	-364	-178	-6.3	0.388	431
RHODES CAN > JOHN DAY R - AT MOUTH	0.561	1.67	2.35	0.716	0.38	0.19	-54.4	-357	-362	-178	0.24	0.47	393
ESAU CAN > JOHN DAY R - AT MOUTH	0.56	1.79	3.07	0.46	0.13	0.04	-54.4	-357	-362	-178	0.06	0.37	388
SOREFOOT CR > JOHN DAY R - AT MOUTH	0.42	1.34	2.27	0.53	0.03	-0.05	-54.4	-357	-362	-178	0.11	0.28	298
BRIDGE CR > JOHN DAY R - AB WEIR BRIDGE CR	-5.31	-20.6	-6.37	-5.26	0.567	1.82	-54.4	-357	-362	-178	-10.5	-9.52	143
BRIDGE CR > JOHN DAY R - AT MOUTH	-5.31	-20.6	-6.37	-5.26	0.567	1.82	-54.4	-357	-362	-178	-10.5	-9.52	143
WEIR BRIDGE CR > BRIDGE CR - AT MOUTH	-5.31	-20.6	-6.37	-5.26	0.567	1.82	-54.4	-357	-362	-178	-10.5	-9.52	143
BEAR CR > BRIDGE CR - AT MOUTH	-5.31	-20.6	-6.37	-5.26	0.567	0.552	-54.4	-357	-362	-178	-10.5	-9.52	68

C. Crops

Figure 51 below shows estimated daily water demand for pasture in the Mid-Columbia Basin.

Figure 51: Water Demand from Pasture (AgriMet Network, Hermiston station)



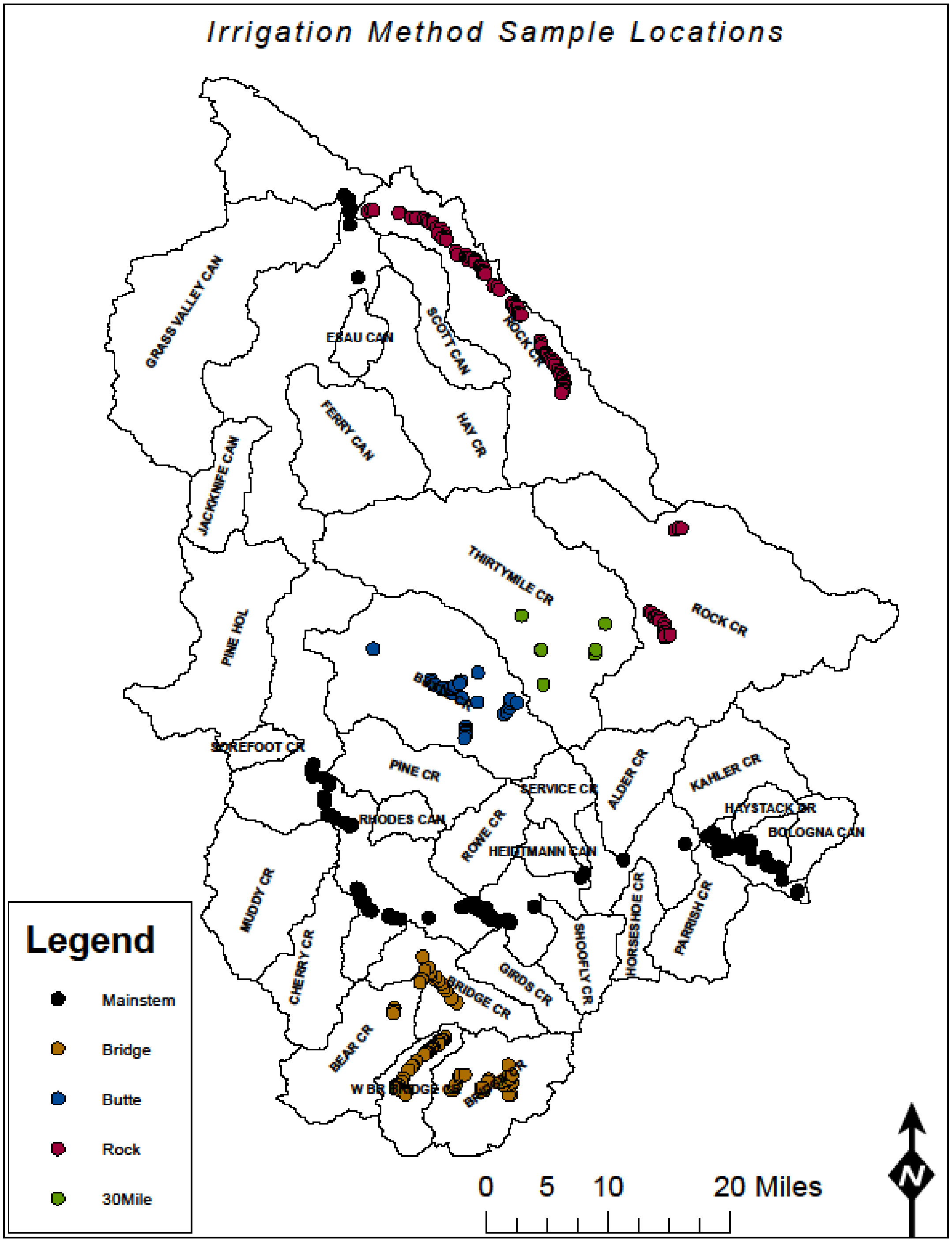
D. Irrigation Methods

To assess the distribution of irrigation methods within the Basin, remote imagery and local knowledge were used to map irrigation infrastructure in four tributary basins and the mainstem (Figure 52). The tributary basins include: Rock Creek, Bridge Creek Basin, Butte Creek, and Thirtymile Creek. Irrigation classifications include: center pivot, big gun, wheel line, hand line, and flood. A summary of results is included in Table 19: Irrigation Method by Location.

Table 19: Irrigation Method by Location

Irrigation Methods By Subbasin								
	Bridge Cr. Basin	Butte Cr.	30 Mile Cr.	Rock Cr.	Mainstem		Trib Percentage	Mainstem Percentage
Center Pivot	0	0	0	10	26		5%	25%
Big Gun	0	0	0	1	2		0%	2%
Wheel Line	34	7	1	41	56		41%	54%
Hand Line	22	6	1	34	20		31%	19%
Flood	21	11	2	10	0		22%	0%

Figure 52: Irrigation Infrastructure Assessment Locations



The distribution of irrigation methods varies by location and source stream. In general, non- pivot sprinkler irrigation (wheel lines, hand lines, and pivots) are the most frequently employed methods (74% of all infrastructure), with wheel lines being most popular. Center pivots are primarily limited to the mainstem river, the exception being the Rock Creek Basin. Flood irrigation appears to be limited to tributary basins (i.e. no mainstem usage) and makes up from 10%-50% with an average of

22% in such basins.

E. Irrigation Water Reliability

In an effort to assess the reliability of irrigation water rights in the basin, an analysis was performed using Landsat satellite imagery and OWRD's geospatial database of irrigation surface water rights. NDVI scores (Normalized Difference Vegetation Index), a measure of chlorophyll, are calculated from the Landsat datasets. NDVI scores are used as a surrogate for water application. Based on the region, if a pixel has an irrigation water right and shows an NDVI score above a set threshold (high chlorophyll) in August, it is generally safe to assume that is has been irrigated recently. Looking at a multi-year average (2013, 2015, 2016) for late July to mid-August provides an assessment of recent water use and/or reliability. Results from this analysis provide an estimate of a water right's reliability. We make the key assumption that all non-irrigated parcels are the product of a lack of available water and not on-farm management decisions. All results are averaged by WAB and are provided in Figure 53.

Figure 53: WAB Water Right Reliability

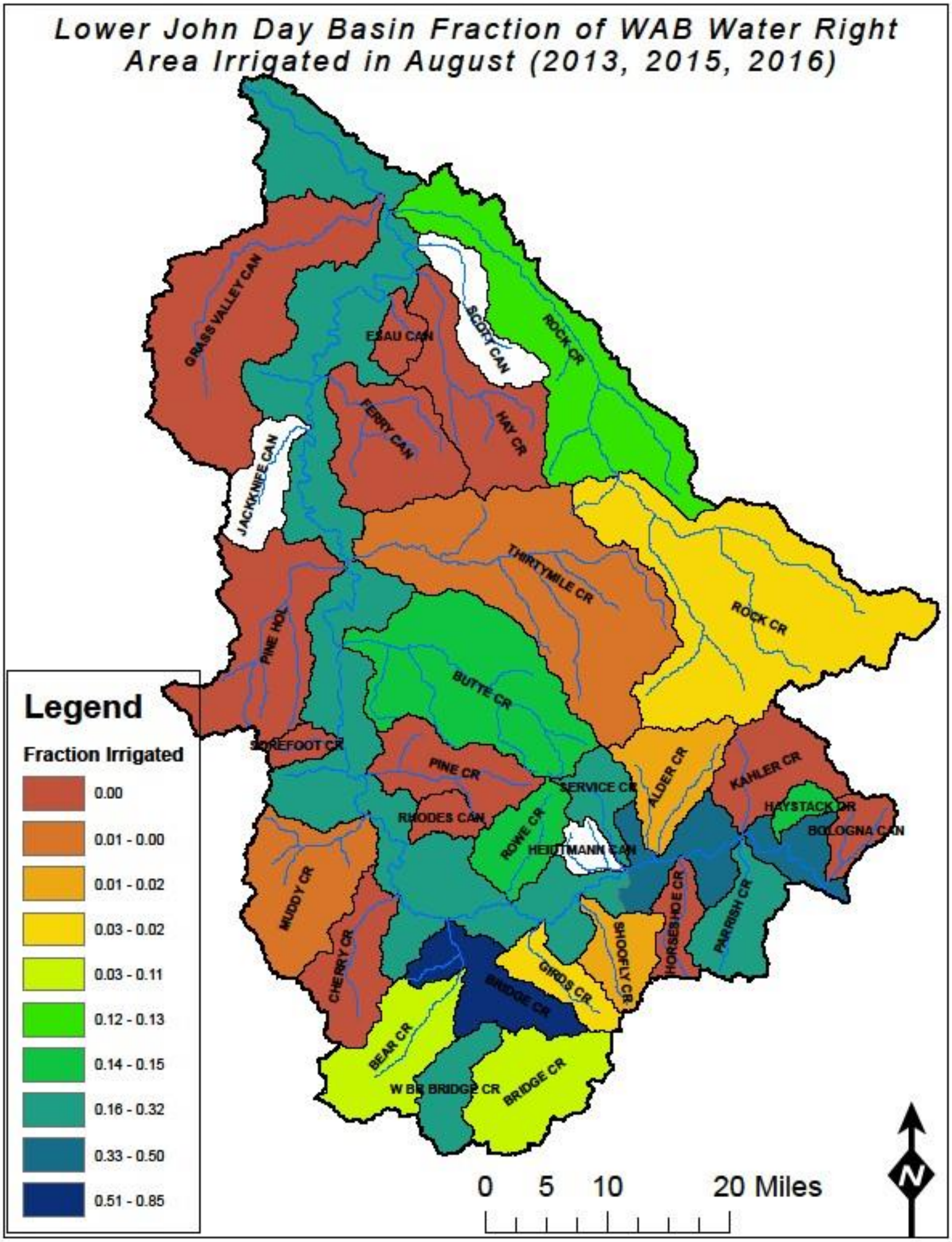


Table 20. On average, most WABs show incredibly poor mid-summer water right reliability. The two exceptions are Lower Bridge Creek and the mainstem John Day above Heidtmann Canyon that have 87% and 56% of water rights with reliable summer water respectively. On average, less than 24% of Lower John Day Basin surface-water irrigation water rights are estimated to be reliable in mid-late summer.

Table 20: Average Mid-Summer Water Right Reliability by WAB

NAME	% of Water Right Area Irrigated in August
ALDER CR > JOHN DAY R - AT MOUTH	1%
BEAR CR > BRIDGE CR - AT MOUTH	12%
BOLOGNA CAN > JOHN DAY R - AT MOUTH	0%
BRIDGE CR > JOHN DAY R - AB W BR BRIDGE CR	16%
BRIDGE CR > JOHN DAY R - AT MOUTH	87%
BUTTE CR > JOHN DAY R - AT MOUTH	21%
CHERRY CR > JOHN DAY R - AT MOUTH	0%
ESAU CAN > JOHN DAY R - AT MOUTH	0%
FERRY CAN > JOHN DAY R - AT MOUTH	0%
GIRDS CR > JOHN DAY R - AT MOUTH	3%
GRASS VALLEY CAN > JOHN DAY R - AT MOUTH	0%
HAY CR > JOHN DAY R - AT MOUTH	0%
HAYSTACK CR > JOHN DAY R - AT MOUTH	15%
HORSESHOE CR > JOHN DAY R - AT MOUTH	0%
JOHN DAY R > COLUMBIA R - AB HEIDTMANN CAN	56%
JOHN DAY R > COLUMBIA R - AT MOUTH	33%
KAHLER CR > JOHN DAY R - AT MOUTH	0%
MUDDY CR > JOHN DAY R - AT MOUTH	15%
PARRISH CR > JOHN DAY R - AT MOUTH	23%
PINE CR > JOHN DAY R - AT MOUTH	0%
PINE HOL > JOHN DAY R - AT MOUTH	0%
RHODES CAN > JOHN DAY R - AT MOUTH	0%
ROCK CR > JOHN DAY R - AB WALLACE CAN	10%
ROCK CR > JOHN DAY R - AT MOUTH	13%
ROWE CR > JOHN DAY R - AT MOUTH	15%
SERVICE CR > JOHN DAY R - AT MOUTH	23%
SHOOFLY CR > JOHN DAY R - AT MOUTH	1%
SOREFOOT CR > JOHN DAY R - AT MOUTH	0%
THIRTYMILE CR > JOHN DAY R - AT MOUTH	3%
W BR BRIDGE CR > BRIDGE CR - AT MOUTH	21%

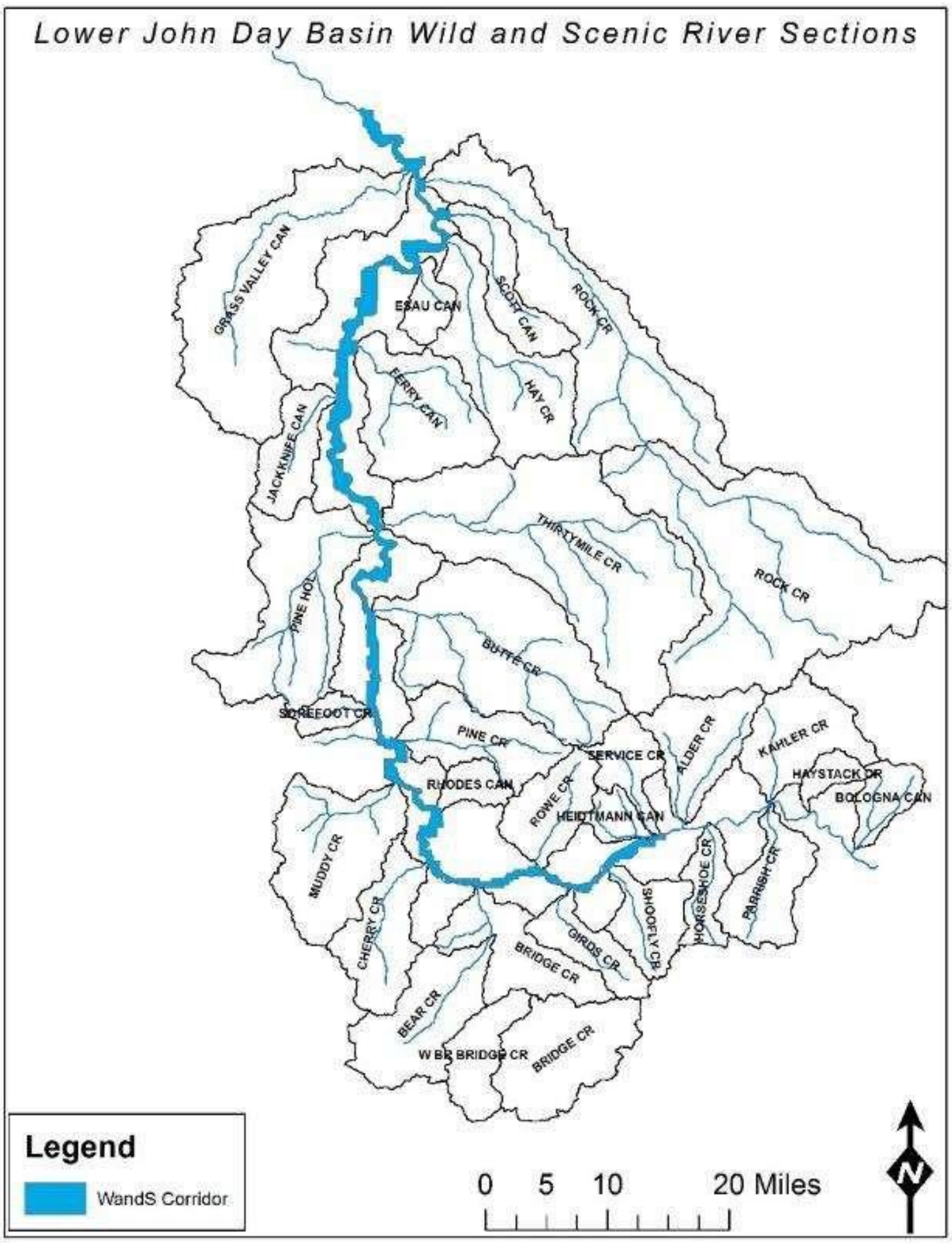
F. Instream Flow Protections

The Department of Environmental Quality (DEQ), Oregon State Parks and Recreation (OSPR), and

Oregon Department of Fish and Wildlife (ODFW) have been able to apply for instream water rights for fish, wildlife, and environmental needs. In addition, some instream water rights were created through conversion of "minimum perennial streamflows" that were adopted as administrative rules before 1987. Instream water rights may or may not represent the minimum flow needs for fish, wildlife and/or other instream uses.

Permanent instream water rights currently exist for the Lower Mainstem River and a small subset of tributaries (Rock and Bridge Creek Basins). As noted in Section 3 of this report, the majority of the Lower Mainstem River is classified as a State Scenic Waterway and also has associated instream flow recommendations (500 cfs from Jul.-Jan., 1000 cfs in Feb., 2000 cfs Mar.-Jun.).

Figure 54: Wild and Scenic River Sections in Lower John Day



The Mainstem Service Creek and McDonald Ferry instream water rights, which were created through conversion of minimum perennial streamflows adopted in 1962, are static throughout the year, 30 cfs and 20 cfs every month respectively. As shown in Figure 55, the Lower Bridge right has a seasonality component to it, varying from 6-40 cfs over the course of the year. Streamflow data exist for both the mainstem river locations as well as the Bridge Creek site. This streamflow data shown in Table 21 and Table 22 show how the instream water rights compare to median monthly flows. In general, the Mainstem John Day instream rights are nearly always met. Since 1989 when the mainstem rights came into effect, there have been less than 30 days at each site when instream flows were not maintained. These instances have all occurred in August and September. Roughly 97.5% of the time, August flows meet the instream water rights.

Figure 55: Stream Reaches with Permanent Instream Water Rights

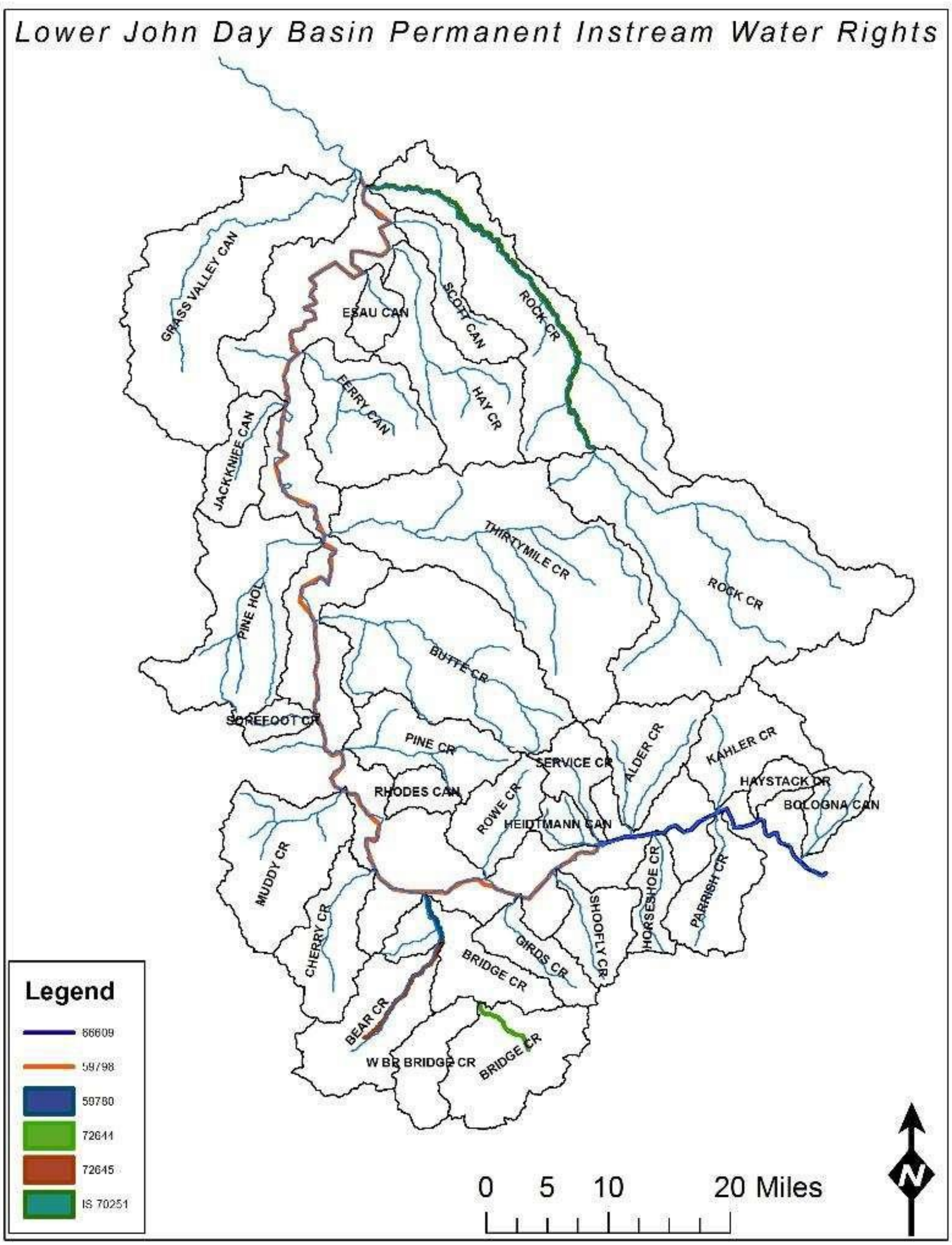


Table 21: Measured Flows to Instream Water Right on John Day River at Service Creek

Service Creek			
Month	Q-Target Median [cfs]	Days Target not Met	Fraction of Days Target not Met
1	867	0	0.000
2	1550	0	0.000
3	3325	0	0.000
4	4300	0	0.000
5	3990	0	0.000
6	1670	0	0.000
7	343.5	0	0.000
8	81	23	0.026
9	84	0	0.000
10	300	0	0.000
11	416	0	0.000
12	557	0	0.000

Table 22: Measured Flows to Instream Water Right on John Day River at McDonald Ferry

McDonald Ferry			
Month	Q-Target Median [cfs]	Days Target not Met	Fraction of Days Target not Met
1	920	0	0.000
2	1790	0	0.000
3	3500	0	0.000
4	4490	0	0.000
5	4220	0	0.000
6	1865	0	0.000
7	380	0	0.000
8	91	19	0.025
9	81.5	10	0.013
10	293	0	0.000
11	426	0	0.000
12	598	0	0.000

Instream water rights are much less frequently met in Lower Bridge Creek than on the mainstem river. Rates of achievement range from 0-78% monthly. For summer months, targets are not met from 55-78% of the time. Figure 56 shows that targets are met most infrequently during November and December.

Table 23: Comparison of Measured Flows to instream Water Right for Bridge Creek

Lower Bridge Creek			
Month	Q-Target Median [cfs]	Days Target not Met	Fraction of Days Target not Met
1	-7.8	228	0.67
2	-6	190	0.61
3	3.9	163	0.46
4	15.05	80	0.22
5	25.25	109	0.29
6	-1.9	189	0.53
7	-1.14	203	0.55
8	-2.8	244	0.66
9	-3.12	282	0.78
10	0.63	155	0.44
11	-16.285	329	1.00
12	-12.5	285	0.84

Figure 56: Comparison of Instream Water Right and Median Daily Flow for Bridge Creek

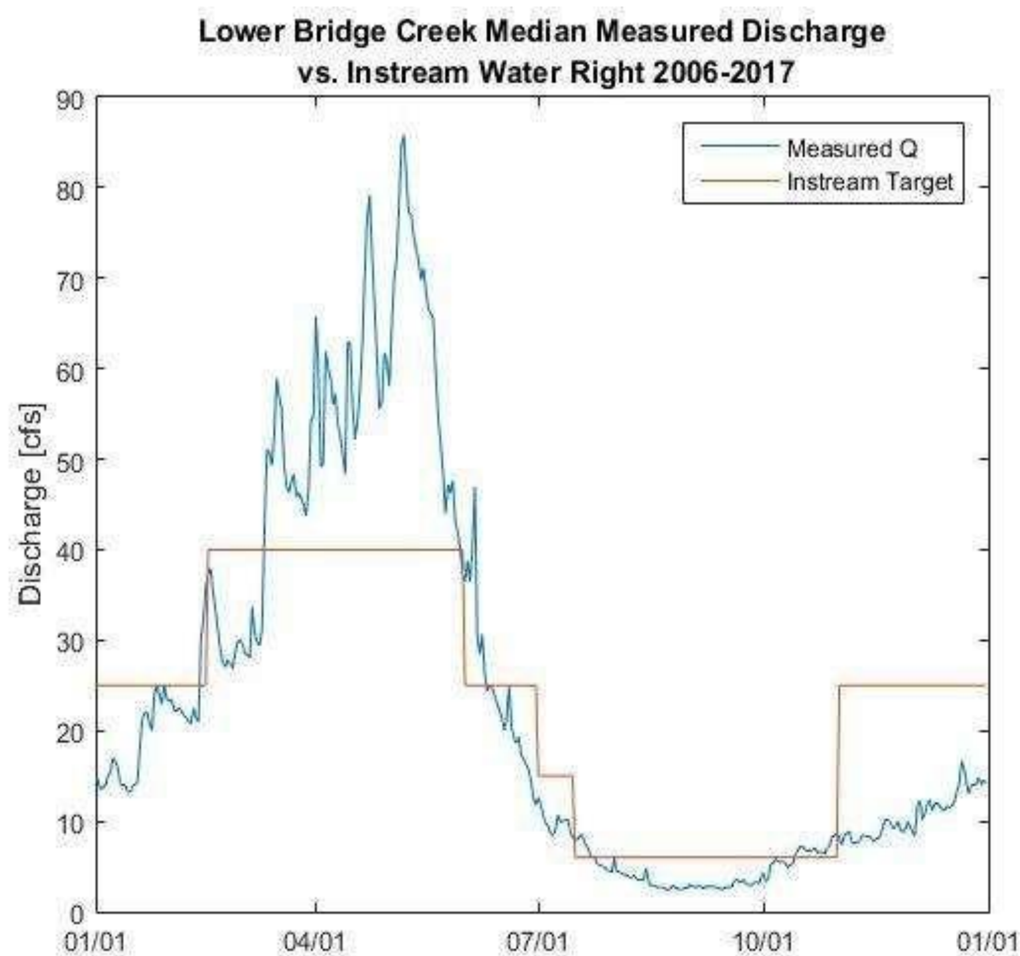


Table 24 represents a study by ODFW that assessed optimum and minimum monthly flows for a handful of streams in the Basin, including the mainstem river (Lauman, 1977). The recommendation for the mainstem river again does not have a seasonality component, but the suggested minimum flow is 390 cfs, relative to the 30 cfs currently in place. Between the ODFW study and the existing instream non-mainstem water rights, there currently are only 6 of 31 tributary WABs with instream established targets/rights.

Table 24: Recommended Instream Flows for Fish and Wildlife: A. Minimum, B. Optimum

A

Recommended minimum stream flows for fish life, John Day Basin													
Stream	Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
John Day River	Below North Fork John Day R.	390	390	390	390	390	390	390	390	390	390	390	390
Bridge Creek	Below Bear Cr.	25	25/40	40	40	40	25	15/6	6	6	6	25	25
Bridge Creek	Above West Branch	10	10/15	15	15	15	10	7/3	3	3	3	10	2510
Bear Creek	Mouth	10	10/15	15	15	15	10	7/3	3	3	3	10	10
Alder Creek	Mouth	8	8/12	12	12	12	8	4/1	1	1	1	8	8
Kahler Creek	Mouth	8	8/12	12	12	12	8	4/1	1	1	1	8	8

B

Recommended optimum stream flows for fish life, John Day Basin													
Stream	Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
John Day River	Below North Fork John Day R.	500	500	500	500	500	500	500	500	500	500	500	500
Bridge Creek	Below Bear Creek	40	40/68	68	68	68	40	25	25	25	25	40	40
Bridge Creek	Above West Branch	15	15/25	25	25	25	15	10	10	10	10	15	15
Bear Creek	Mouth	15	15/25	25	25	25	15	10	10	10	10	15	15
Alder Creek	Mouth	12	12/20	20	20	20	12	8	8	8	8	12	12
Kahler Creek	Mouth	12	12/20	20	20	20	12	8	8	8	8	12	12

The instream leasing program administered by OWRD is a means of increasing instream flows by transferring water rights instream for ecological benefits. The duration of the transfer can last from 1 year to perpetuity. The program is voluntary and is classified as a beneficial use by the water department, thus avoiding any forfeiture issues. Often, third-party entities compensate irrigators for curtailing their diversions for specific water rights. The water right is leased instream and protected from other users based on priority date by district water masters. Figure 57 depicts the locations of all water rights involved in past instream leases, and Figure 58 shows the count of all water rights involved in instream leases by WAB . To date, the John Day mainstem at Mouth, Bridge Creek above West Branch, Pine Creek, and Lower Rock Creek WABs have had the greatest number of water rights enrolled in the instream leasing program.

Figure 57: All Recorded Past Instream Leases

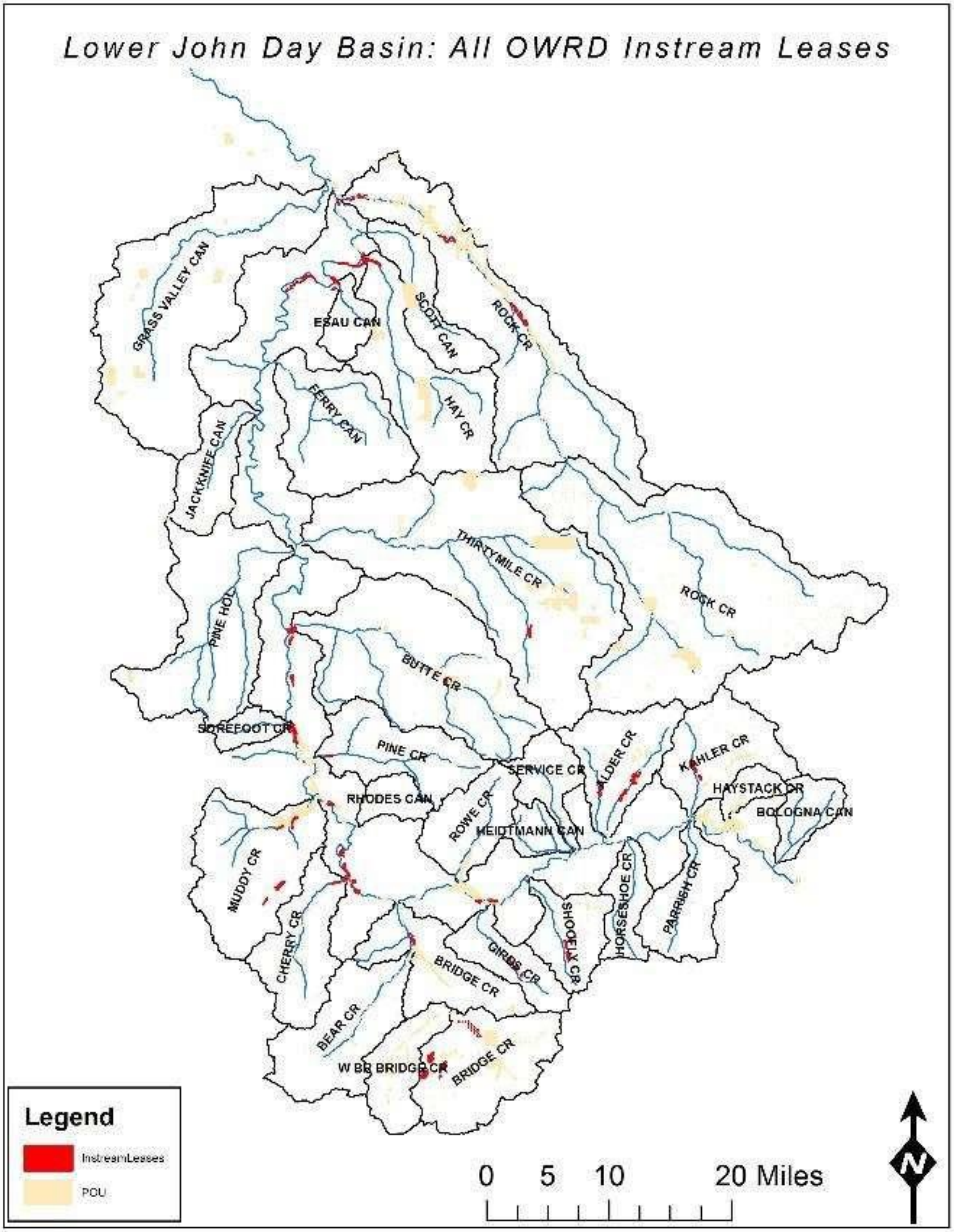
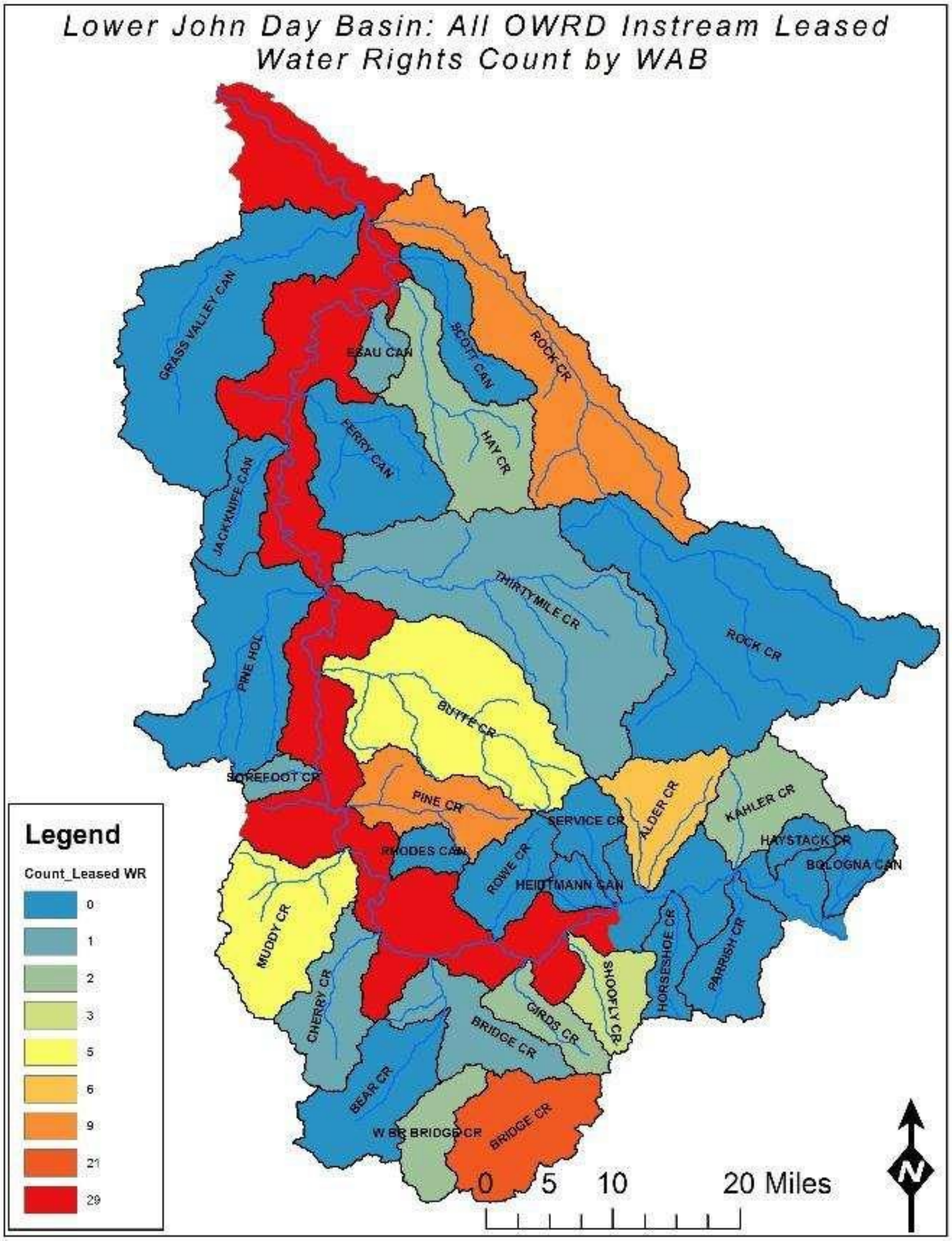


Figure 58: Count of Water Rights Involved in Instream Leases by WAB



G. Fish

The John Day Basin is home to numerous fish species, including some listed under the endangered species act (ESA) or listed as a species of concern. Mid-Columbia summer steelhead (Oncorhynchus mykiss), listed under the ESA, make use of nearly the entire Lower John Day Basin. Unlike spring Chinook (Oncorhynchus tshawytscha) that primarily use the mainstem river as a migration corridor, steelhead also make extensive use of Lower Basin tributaries for spawning and rearing.

Per ODFW data, Figure 59, Figure 60, and Table 25 illustrate the miles of historic steelhead habitat per WAB, and then density of stream miles per WAB. As would be expected, the larger WABs tend to have the greatest amount of steelhead river miles (e.g. Rock Creek and Thirtymile). The density measurement identifies those WABs that have the greatest amount of steelhead stream miles per unit area. Bridge Creek WABs, Kahler Basin, Lower Rock, Service Creek and others are identified as having the greatest density of steelhead river miles.

Altered hydrology is frequently identified as a primary limiting factor for steelhead recovery in the John Day Basin. The Lower Basin is characterized by hot, precipitation-free summers and cold, but relatively dry winters. This natural combination of minimal annual precipitation input and long warm dry-seasons naturally results in conditions that can be problematic for cold-water fish. Coupled with surface water withdrawals, summertime conditions in Lower John Day tributary streams can easily become inhospitable.

Figure 59: Total Steelhead River Miles per WAB

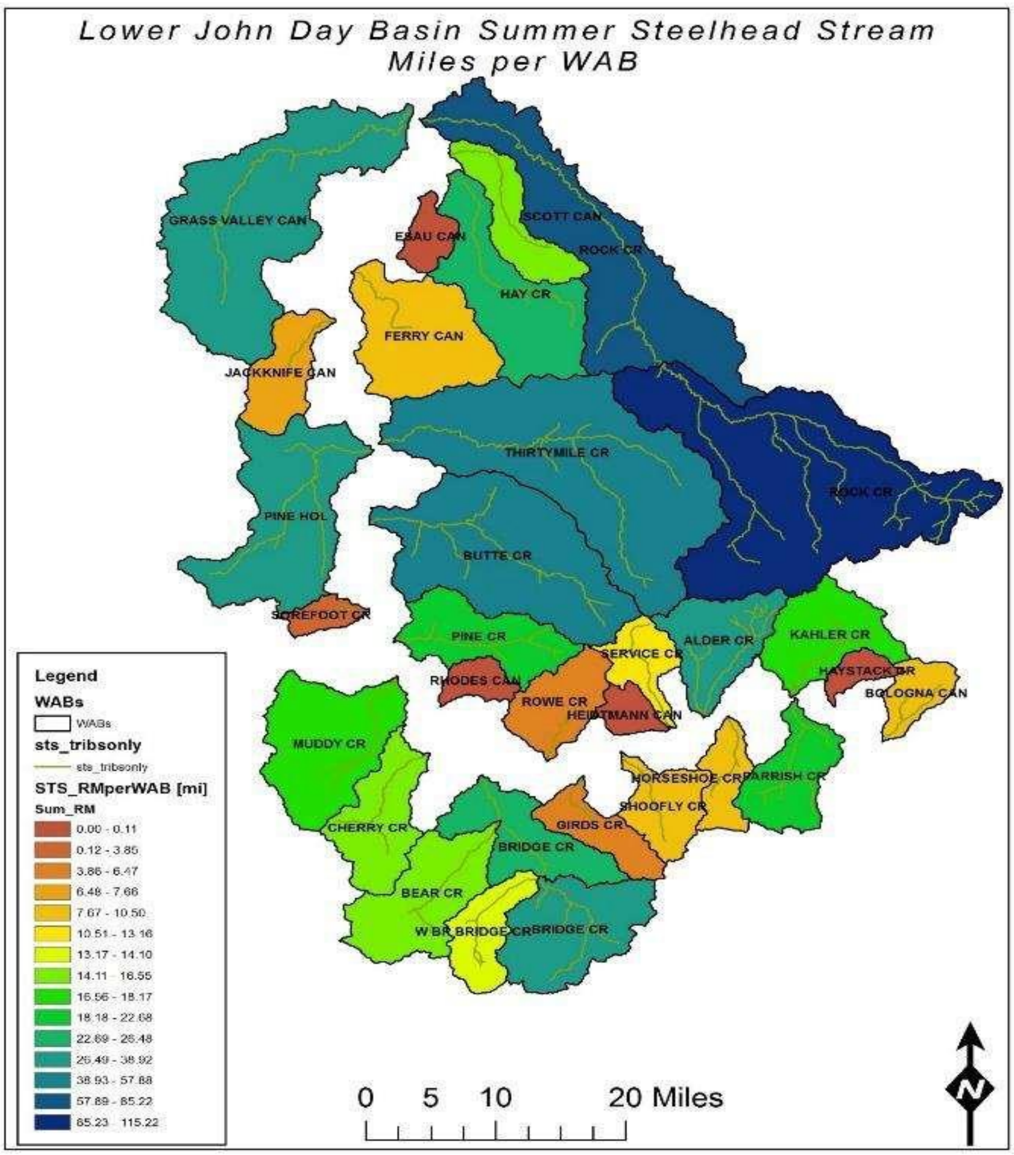


Figure 60: Steelhead River Miles per Acre per WAB

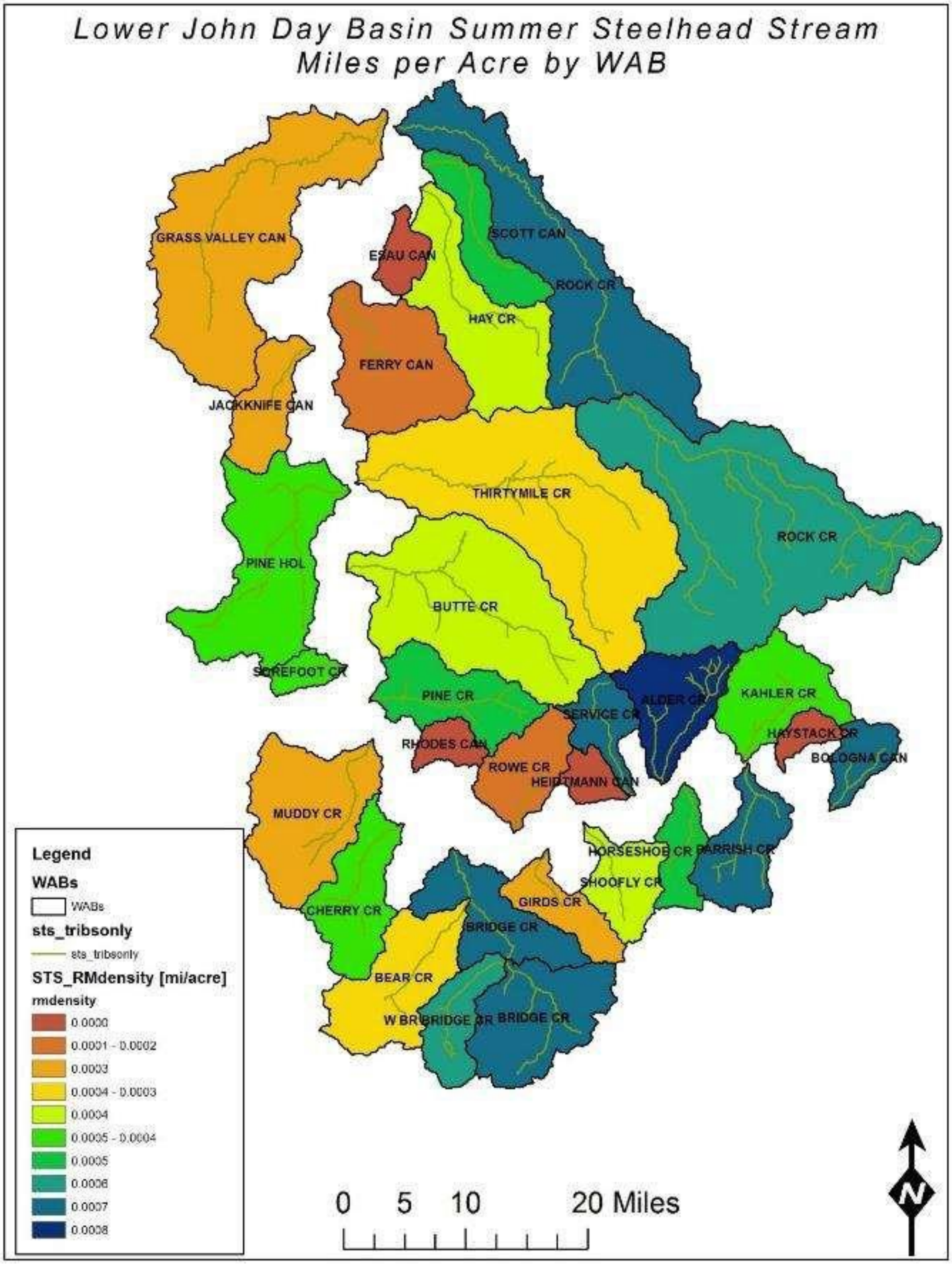


Table 25: Steelhead River Miles and Density Data

WAB NAME	Sum_RM [mi]	Rmdensity [mi/acre]
ALDER CR > JOHN DAY R - AT MOUTH	32.6	0.0008
PARRISH CR > JOHN DAY R - AT MOUTH	22.7	0.0007
ROCK CR > JOHN DAY R - AT MOUTH	85.2	0.0007
SERVICE CR > JOHN DAY R - AT MOUTH	13.2	0.0007
BRIDGE CR > JOHN DAY R - AB W BR BRIDGE CR	35.8	0.0007
BRIDGE CR > JOHN DAY R - AT MOUTH	26.5	0.0007
BOLOGNA CAN > JOHN DAY R - AT MOUTH	10.5	0.0007
ROCK CR > JOHN DAY R - AB WALLACE CAN	115.2	0.0006
W BR BRIDGE CR > BRIDGE CR - AT MOUTH	14.1	0.0006
HORSESHOE CR > JOHN DAY R - AT MOUTH	9.6	0.0005
SCOTT CAN > JOHN DAY R - AT MOUTH	16.0	0.0005
PINE CR > JOHN DAY R - AT MOUTH	21.9	0.0005
PINE HOL > JOHN DAY R - AT MOUTH	36.9	0.0004
KAHLER CR > JOHN DAY R - AT MOUTH	17.2	0.0004
SOREFOOT CR > JOHN DAY R - AT MOUTH	3.9	0.0004
CHERRY CR > JOHN DAY R - AT MOUTH	16.5	0.0004
SHOOFLY CR > JOHN DAY R - AT MOUTH	10.5	0.0004
BUTTE CR > JOHN DAY R - AT MOUTH	44.3	0.0004
HAY CR > JOHN DAY R - AT MOUTH	25.1	0.0004
THIRTYMILE CR > JOHN DAY R - AT MOUTH	57.9	0.0003
BEAR CR > BRIDGE CR - AT MOUTH	15.9	0.0003
GRASS VALLEY CAN > JOHN DAY R - AT MOUTH	38.9	0.0003
GIRDS CR > JOHN DAY R - AT MOUTH	6.5	0.0003
MUDDY CR > JOHN DAY R - AT MOUTH	18.2	0.0003
JACKKNIFE CAN > JOHN DAY R - AT MOUTH	7.7	0.0003
ROWE CR > JOHN DAY R - AT MOUTH	6.0	0.0002
FERRY CAN > JOHN DAY R - AT MOUTH	10.5	0.0002
HAYSTACK CR > JOHN DAY R - AT MOUTH	0.1	0.0000
ESAU CAN > JOHN DAY R - AT MOUTH	0.0	0.0000
RHODES CAN > JOHN DAY R - AT MOUTH	0.0	0.0000
HEIDTMANN CAN > JOHN DAY R - AT MOUTH	0.0	0.0000

H. Recreational Flows

As discussed in the Basin Overview section of this report, recreation is a growing component of the Lower John Day landscape. Kayaking, canoeing, and rafting are common in the region. Published information on necessary recreation flows for the basin are not available. However, based on interviews with staff at the Service Creek Station, target flows for on-water recreation were estimated. Figure 61 depicts the median daily discharge of the John Day River at Service Creek and the suggested minimum flows for varied boat types (see Table 26 as well). In addition, Craig Lacy, a long-time guide on the Lower John Day, estimates flows of 750-800 cfs are needed to navigate the lower river in a drift boat.

Boater permit data provided by BLM is shown in Figure 62. Since 1998 there has been a steady increase in permits issued for the Lower John Day (roughly a 30% increase in the past 20 years). In 2017, the BLM recorded over 28,000 boater-use-days between Kimberly and Tumwater Falls. According to the BLM, which administers the permit program, "The amount of use is tied to water flows." (Email from Heidi Mottl, April 19, 2018.)

Figure 61: Discharge Vs. Recommended Recreation Flows, John Day at Service Creek

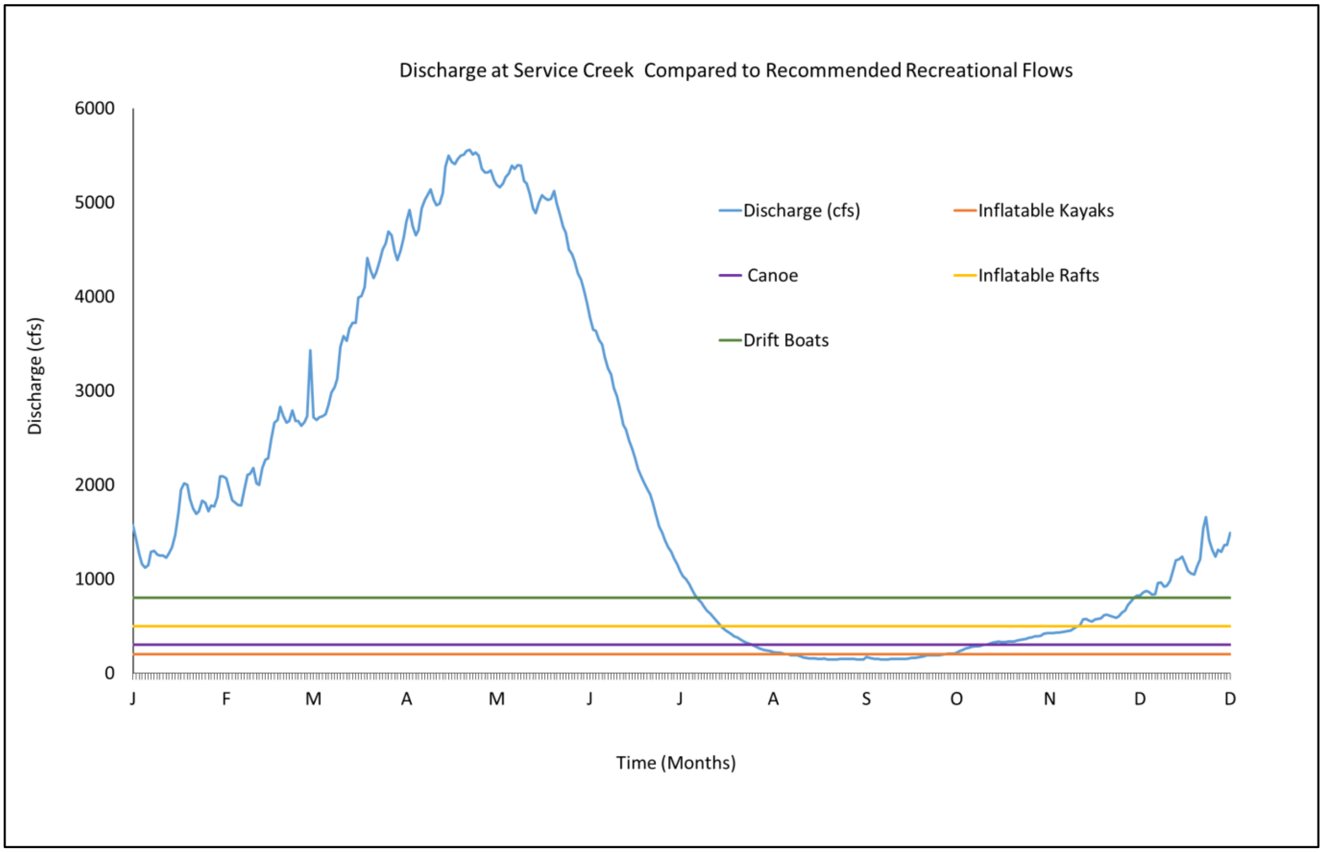
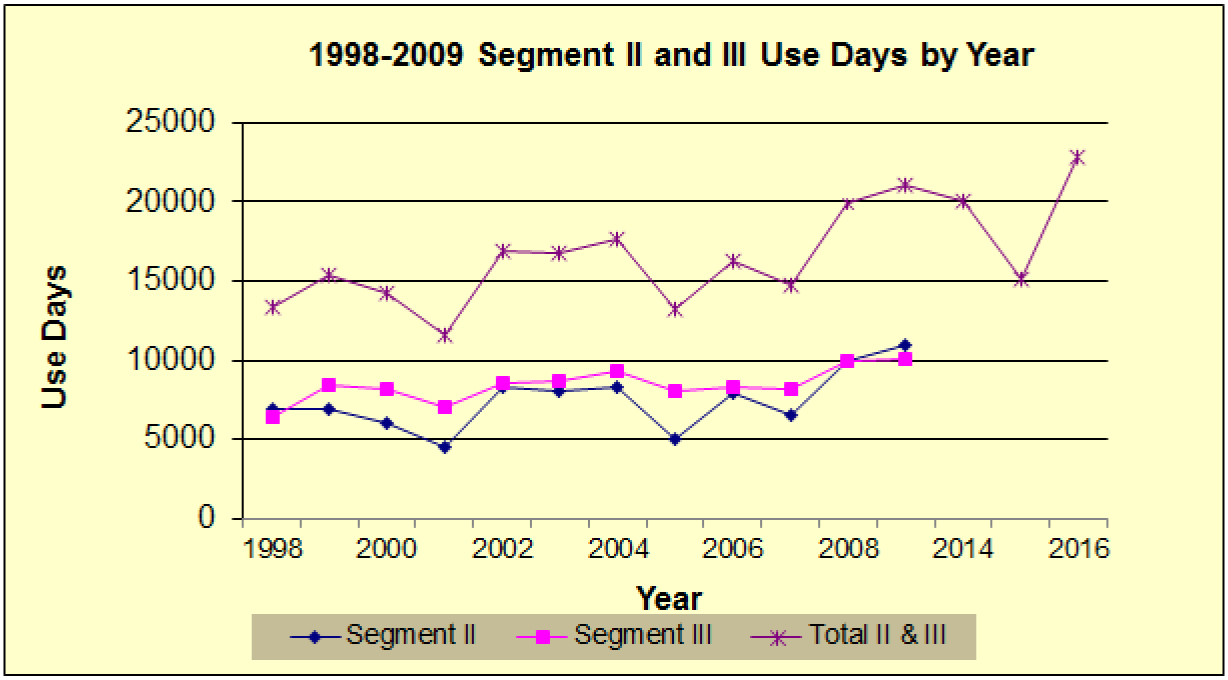


Table 26: Days Recreation Target Met, John Day at Service Creek

	Inflatable Kayaks	Canoe	Inflatable Rafts	Drift Boats
Target (cfs)	**200**	**300**	**500**	**800**
Days Target Met	**303**	**282**	**230**	**NA**

Figure 62: BLM Boater Permit Data



Segment II = Clarno to Cottonwood

Segment III = Service Creek to Clarno

9. Water Quality

A. Total Maximum Daily Load and Water Temp

As discussed in the Basin Overview, many streams in the basin are on the Clean Water Act 303(d) list, particularly for water temperature. Temperature, sedimentation, flow modification, and habitat modification are the leading causes of impairment. Table 27 provides the pollutants of concern in each WAB. Table 28 provides the number of impairments per pollutant. Figure 63 depicts stream impairments in the basin.

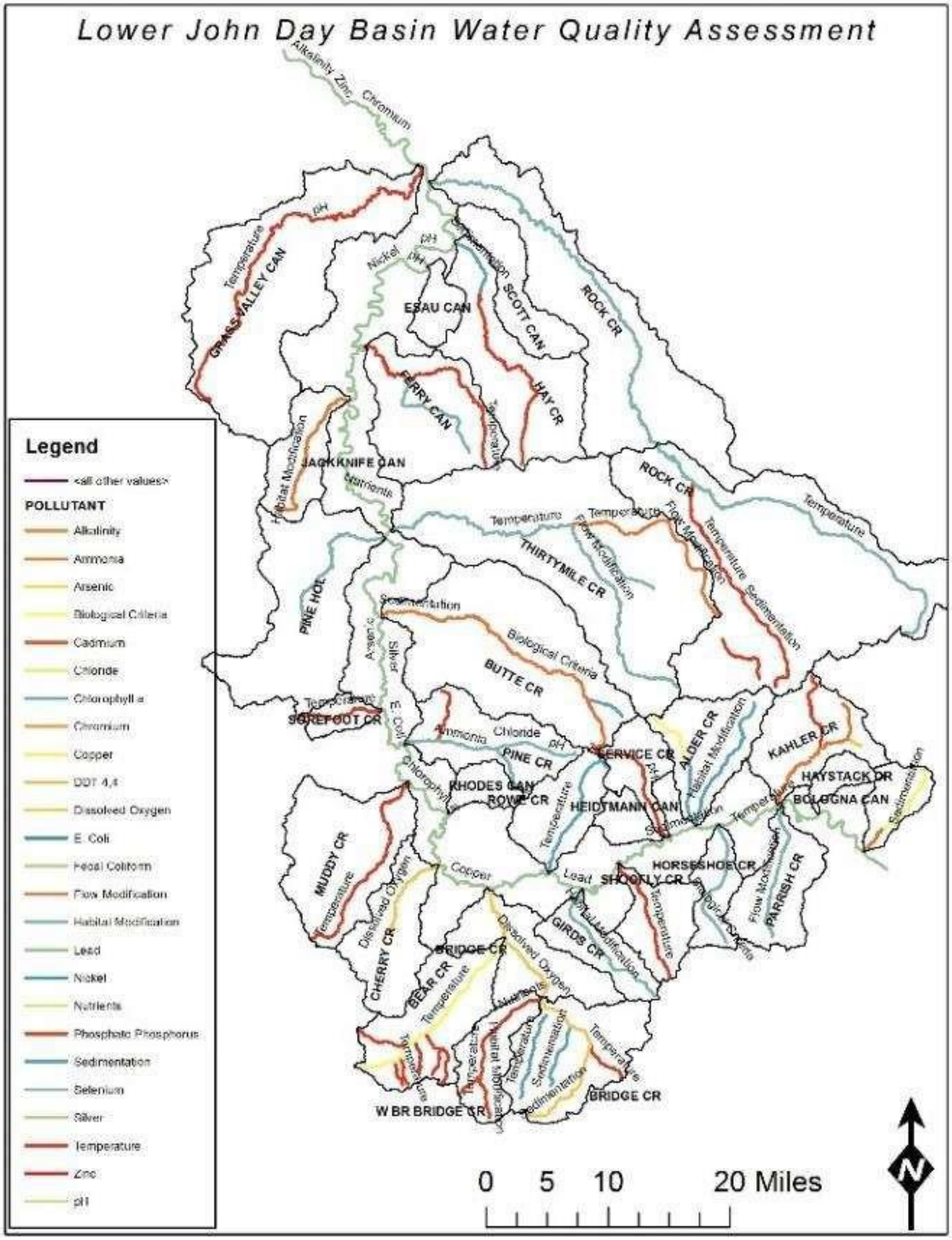
Table 27: Lower John Day Pollutants by Stream

STREAM	Pollutant 1	Pollutant 2	Pollutant 3	Pollutant 4	Pollutant 5	Pollutant 6	Pollutant 7	Pollutant 8	Pollutant 9	Pollutant 10	Pollutant 11
Alder Creek	Flow Modification	Habitat Modification	Temperature	Sedimentation							
Bear Creek	Temperature	Habitat Modification	Temperature	Flow Modification	Sedimentation	Biological Criteria					
Bologna Canyon	Temperature	Flow Modification									
Bridge Creek	Habitat Modification	Sedimentation	Temperature	Flow Modification	Biological Criteria	Sedimentation	Temperature	Dissolved Oxygen			
Brown Creek	Sedimentation	Biological Criteria	Temperature								
Butte Creek	Sedimentation	Sedimentation	Habitat Modification	Biological Criteria	Temperature	Flow Modification					
Cherry Creek	Habitat Modification	Sedimentation	Flow Modification	Temperature	Dissolved Oxygen						
Cougar Creek	Temperature										
Cove Creek	Sedimentation	Flow Modification	Habitat Modification	Temperature							
Dodds Creek	Temperature										
East Bologna Canyon	Sedimentation	Biological Criteria									
East Fork Thirtymile Creek	Habitat Modification	Temperature	Flow Modification								
Ferry Canyon	Habitat Modification	Temperature									
Gable Creek	Flow Modification	Temperature	Sedimentation								
Girds Creek	Sedimentation	Temperature	Flow Modification	Habitat Modification							
Grass Valley Canyon	pH	Temperature									
Hay Creek	Flow Modification	Temperature	Habitat Modification	Sedimentation							
Heflin Creek	Temperature										
Henry Creek	Temperature										
Horseshoe Creek	Sedimentation	Biological Criteria	Habitat Modification								
Indian Spring Canyon	Habitat Modification										
Jackknife Creek	Habitat Modification	Temperature	Flow Modification								
Johnson Creek	Temperature										
Kahler Creek	Temperature	Dissolved Oxygen	Dissolved Oxygen	Habitat Modification	Flow Modification						
Lake Creek	Biological Criteria	Sedimentation									
Lamberson Canyon	Habitat Modification										
Lone Rock Creek	Flow Modification	Dissolved Oxygen	Biological Criteria	Temperature							
Muddy Creek	Sedimentation	Habitat Modification	Flow Modification	Temperature							
Nelson Creek	Temperature	Biological Criteria	Sedimentation	Sedimentation							
North Fork Bear Creek	Temperature	Ammonia	Biological Criteria	pH							
OKelly Creek	Alkalinity	Chloride	Phosphate Phosphorus								
Parrish Creek	Temperature	Sedimentation	Flow Modification	Habitat Modification							
Pine Creek	Phosphate Phosphorus	Temperature	pH	Sedimentation	Chloride	Alkalinity	Ammonia	Flow Modification	Dissolved Oxygen	Biological Criteria	Habitat Modification
Pine Hollow	Temperature	Flow Modification	Habitat Modification								
Rail Creek	Temperature										
Robinson Canyon	Temperature	Flow Modification	Habitat Modification								
Rock Creek	Sedimentation	Biological Criteria	Temperature	Sedimentation	Flow Modification	Habitat Modification					
Rowe Creek	Temperature	Biological Criteria	Sedimentation	Sedimentation							
Scotty Creek	Temperature										
Service Creek	pH	pH	Sedimentation	Flow Modification	Temperature						
Shoofly Creek	Habitat Modification	Flow Modification	Temperature								
Sorefoot Creek	Temperature										
Stahl Canyon	Temperature										
Straw Fork	Sedimentation	Biological Criteria	Temperature	Sedimentation							
Tamarack Creek	Dissolved Oxygen										
Thirtymile Creek	Sedimentation	Flow Modification	Biological Criteria	Temperature	Habitat Modification						
Trail Fork Canyon	Habitat Modification										
West Branch Bridge Creek	Sedimentation	Nutrients	Flow Modification	Habitat Modification	Temperature						

Table 28: Number of 303(d) Listings per Pollutant

Row Labels	Count of POLLUTANT
Temperature	43
Sedimentation	31
Flow Modification	26
Habitat Modification	25
Biological Criteria	16
pH	10
Dissolved Oxygen	8
Fecal Coliform	4
Alkalinity	3
Ammonia	3
Nutrients	3
Phosphate Phosphorus	3
Chloride	2
Chlorophyll a	2
Copper	2
E. Coli	2
Arsenic	1
Cadmium	1
Chromium	1
DDT 4,4	1
Lead	1
Nickel	1
Selenium	1
Silver	1
Zinc	1

Figure 63: Lower John Day Impaired Streams



Water temperature is a major concern for cold-water fish and the ubiquitous elevated water temperatures during summer pose serious risks to the long-term viability of many species. Figure

64 shows the temperature standards for basin streams. Tributary WABs in the basin have a temperature standard of 18˚C for salmon and trout rearing and migration, and the mainstem John Day has a standard of 20˚C as a migration corridor. The NorWeST dataset provides measured and modeled water temperature data for the John Day River Basin and can be used to forecast the distribution of suitable future cold-water fish habitat based on climate change projections.

Figure 64: Lower John Day Temperature Standards

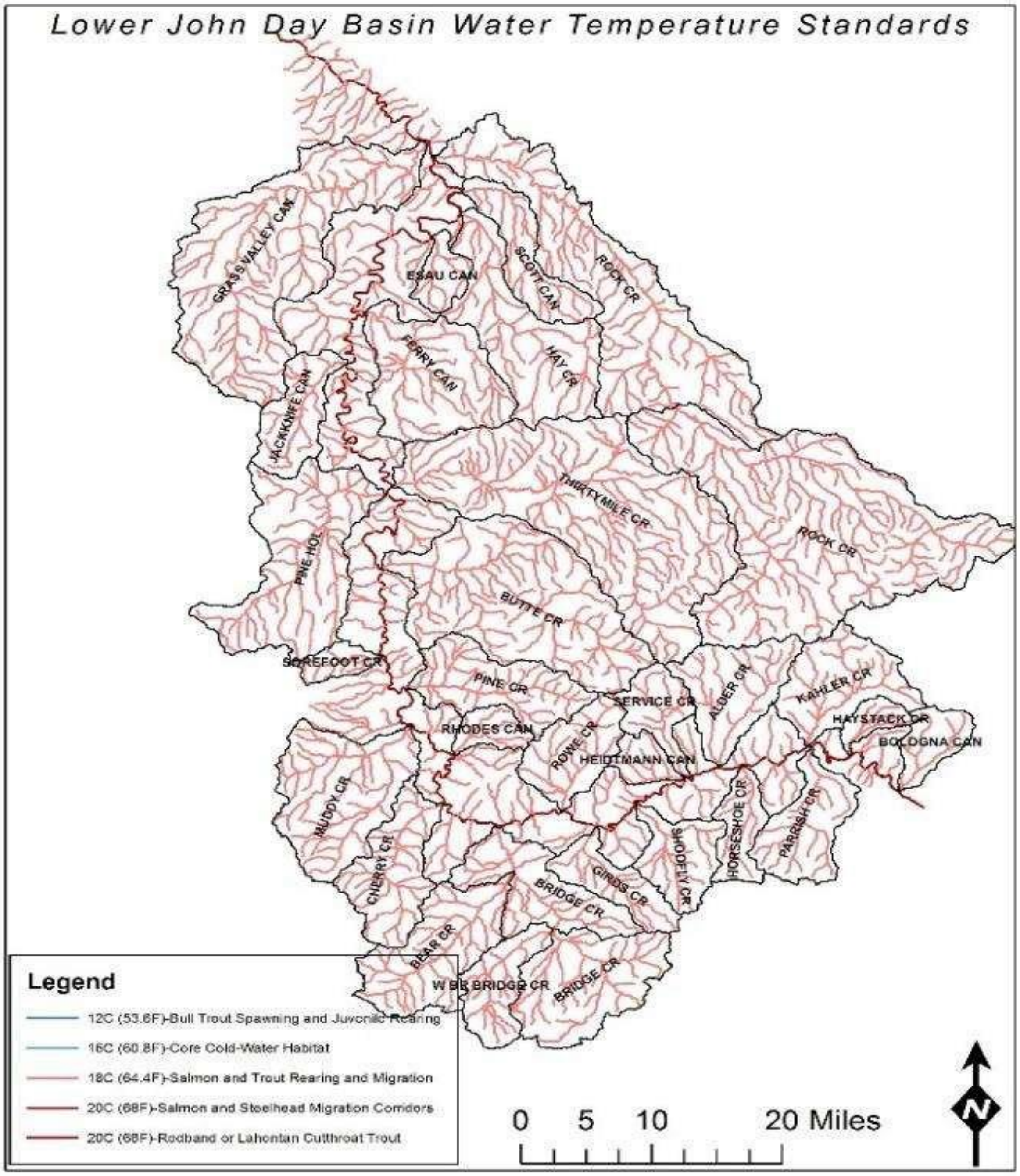
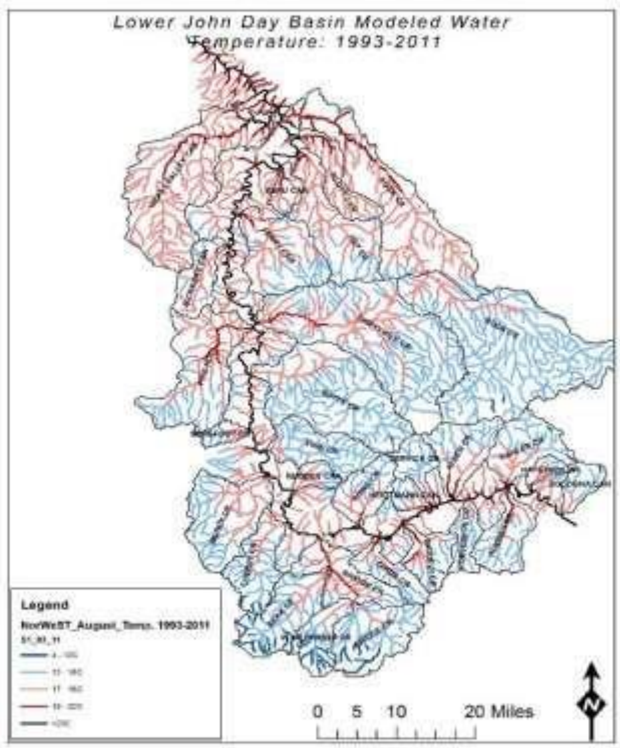


Figure 65 depicts modeled mean August water temperatures for 1993-2011. Figure 66 shows the same for the period 2070-2099. A visual comparison of the figures indicates a pronounced increased in August water temperatures over this timeframe.

Figure 65: Lower John Day Modeled Temperature, 1993 - 2011



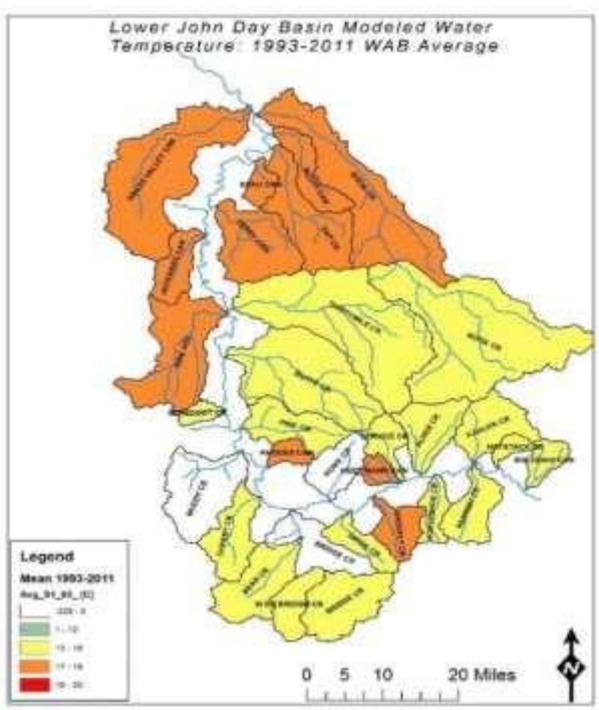
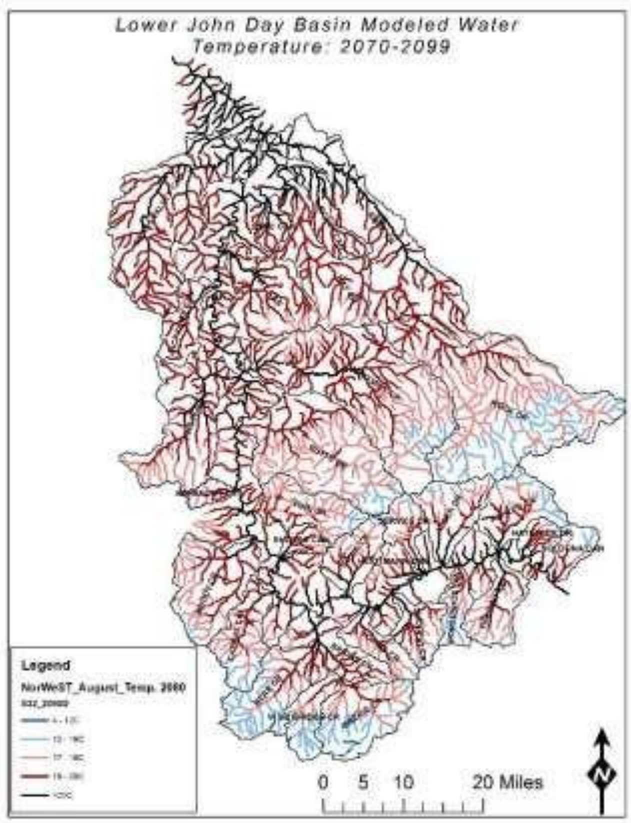


Figure 66: Lower John Day Modeled Temperature, 2070 - 2099



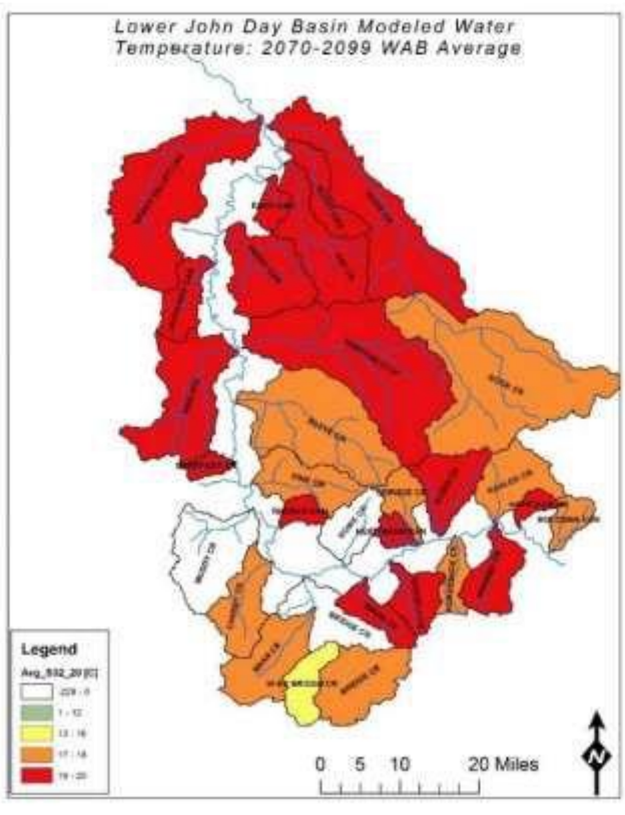


Figure 67 illustrates reaches with August water temperatures less than or equal to the temperature target of 18˚C for two periods. Similar to figures above, there is a definite upgradient advancement of increased water temperature. By 2070-2099, stream reaches with mean August temperatures less than or equal to 18˚C are primarily limited to lower-order higher-elevation subwatershed tributaries. When overlaid with an historic steelhead presence spatial dataset, the potential impact of this warming on available mid-summer steelhead habitat becomes very apparent (Figure 68). Table 29 and Table 30 show miles by all streams and by WAB that are projected to support steelhead based on temperature data. In summary, it is estimated that total steelhead-bearing stream miles with water temperature conditions less than or equal to 18˚C will reduce by 60% from the period 1993-2011 to the period 2070-2099. WABs with the greatest amount of suitable stream miles under future conditions include: Upper Rock, Butte, Pine, and the Bridge Creek Basin.

Figure 67: Stream Reaches with August Water Temperatures Less Than or Equal To 18˚C

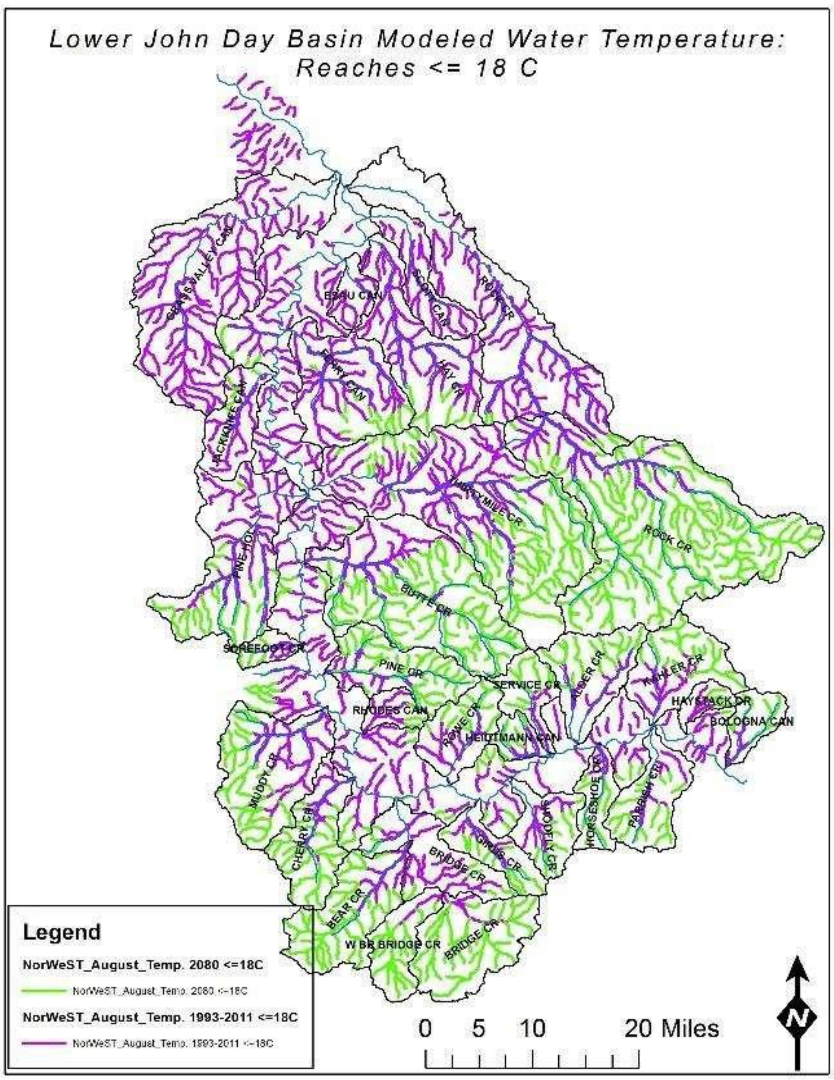


Figure 68: Stream Reaches with Fish Present and Water Temperature Less Than or Equal To 18˚C

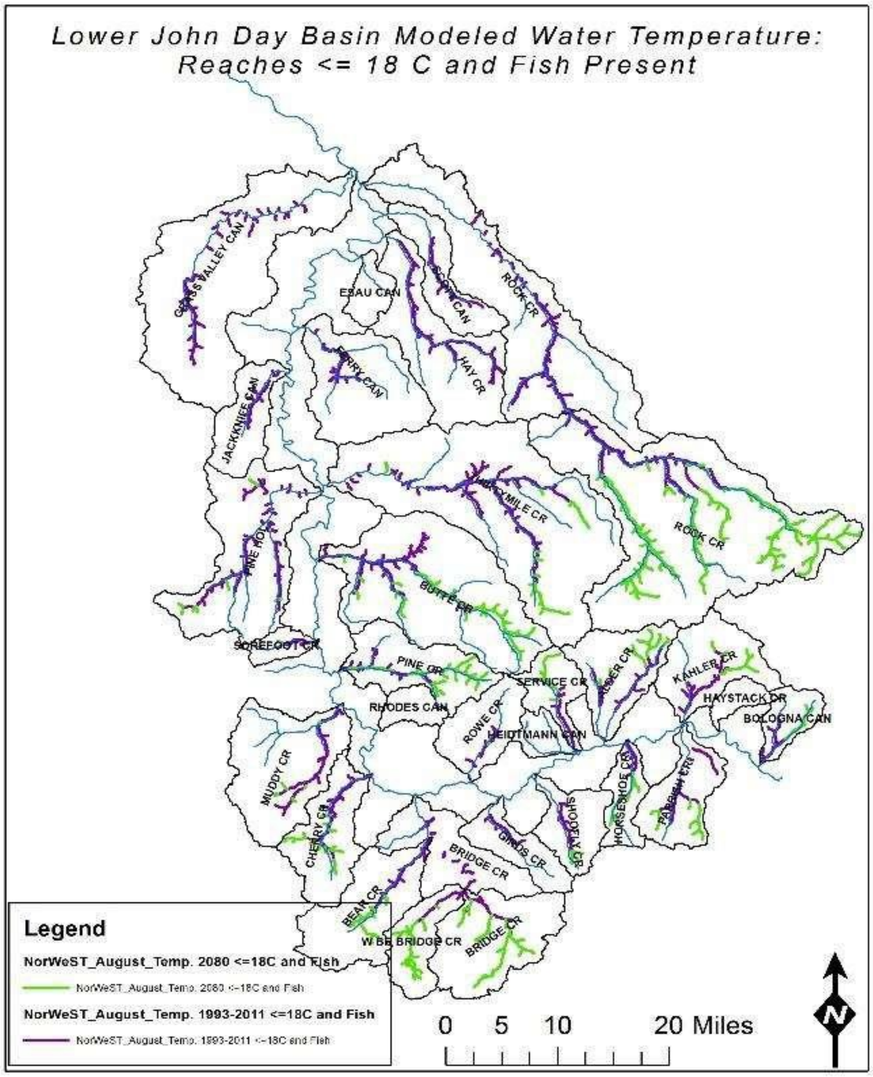


Table 29: Sum of all River Miles in Lower John Day with: Mean August Water Temps <=18˚C; Historical Fish Presence & Mean August Water Temps <=18˚C for Periods During Period 2070 - 2099

Model Period	River Miles <=18 ˚C [mi]	River Miles <=18 ˚C and Historic Fish Presence [mi]
Norwest 1993-2011	3088	790
Norwest 2070-2099	1342	308
% Reduction	57%	61%

Table 30: Sum of River Miles in Lower John Day Basin WABs With Mean August Water Temps <=18° C; Historical Fish Presence and Projected Mean August Water Temps <= 18° C for Periods During Period 2070-2099

WAB	Sum of River Miles [mi]
ROCK CR > JOHN DAY R - AB WALLACE CAN	109.5
BUTTE CR > JOHN DAY R - AT MOUTH	34.3
PINE CR > JOHN DAY R - AT MOUTH	26.6
BRIDGE CR > JOHN DAY R - AB W BR BRIDGE CR	22.5
W BR BRIDGE CR > BRIDGE CR - AT MOUTH	16.7
THIRTYMILE CR > JOHN DAY R - AT MOUTH	14.9
ALDER CR > JOHN DAY R - AT MOUTH	12.2
CHERRY CR > JOHN DAY R - AT MOUTH	11.8
BEAR CR > BRIDGE CR - AT MOUTH	9.6
PARRISH CR > JOHN DAY R - AT MOUTH	9.1
HORSESHOE CR > JOHN DAY R - AT MOUTH	8.6
SERVICE CR > JOHN DAY R - AT MOUTH	8.0
KAHLER CR > JOHN DAY R - AT MOUTH	7.8
BOLOGNA CAN > JOHN DAY R - AT MOUTH	5.3
PINE HOL > JOHN DAY R - AT MOUTH	5.2
SHOOFLY CR > JOHN DAY R - AT MOUTH	2.9
MUDDY CR > JOHN DAY R - AT MOUTH	2.8
SOREFOOT CR > JOHN DAY R - AT MOUTH	0.6
ROWE CR > JOHN DAY R - AT MOUTH	0.2
BRIDGE CR > JOHN DAY R - AT MOUTH	0.0
ROCK CR > JOHN DAY R - AT MOUTH	0
GRASS VALLEY CAN > JOHN DAY R - AT MOUTH	0
SCOTT CAN > JOHN DAY R - AT MOUTH	0
HAY CR > JOHN DAY R - AT MOUTH	0
ESAU CAN > JOHN DAY R - AT MOUTH	0
FERRY CAN > JOHN DAY R - AT MOUTH	0
JACKKNIFE CAN > JOHN DAY R - AT MOUTH	0
HAYSTACK CR > JOHN DAY R - AT MOUTH	0
RHODES CAN > JOHN DAY R - AT MOUTH	0
HEIDTMANN CAN > JOHN DAY R - AT MOUTH	0
GIRDS CR > JOHN DAY R - AT MOUTH	0

10. DATA GAPS

Several important data gaps were identified by the Working Group's Data Committee. These current gaps include:

1. Municipal water use,
2. Impacts of cropping and vegetation (juniper removal, forest treatment) changes,
3. Instream targets and needs for all WABs with fish presence.
4. Further impacts of climate change.
5. Quantifying groundwater supply.

11. CONCLUSIONS

The below is a categorized summary of conclusions found in the Step 2 Plan.

Where is water coming from in the basin?

Most of the water, by unit area, is coming from the smaller, southern basins (groundwater and surface water). Specific examples include Upper Rock, Thirtymile, Butte, Bridge, and Bear Creeks.

Where is later summer streamflow coming from?

Rock above Wallace Canyon, Bridge above west Branch, Thirtymile, Butte, Rock at mouth, and Bear Creeks account for nearly 60% of all mid-summer natural surface outflow.

There is minimal surface water contribution from the Lower Basin between Service Creek and McDonald Ferry (100-200 cfs during high flow periods and -3-10 during late summer)

How significant is the production of water from the lower basin?

The lower basin produces only 5.6 percent of the total annual surface water yield, despite covering 40% of the overall John Day basin.

What do different components of the water budget look like?

Of the total amount of water coming into the basin, 84% is lost to evapotranspiration (ET), 7% to surface water, and 9% to groundwater.

Where are the main consumptive uses?

Surface water use -> Mainstem, Rock Creek, Butte Creek, and Muddy Creek WABs contain 83% of SW consumption.

Groundwater use -> Some WABs with water right rates greater than estimated groundwater recharge. The Grass Valley Canyon, Scott Canyon, and Lower Rock WABs have pumping rates significantly greater than estimated within-basin groundwater production.

How reliable are water rights in the basin?

When comparing lands with irrigation rights and lands actively utilizing the irrigation rights in the mid to late season, it appears that approximately 24% of the total amount authorized by existing water rights is being used. This is believed to be due to limited water availability and may also be due to other factors including on-farm management decisions.

What are current instream protections?

Static instream rights are not consistent with ecological needs, only 6 of 31 tributary WABs with instream established targets/rights.

Is surface water available for future appropriation?

Water is not likely available for new surface water appropriations from July through October. Water may be available for appropriation from January through May.

What is risk to future instream use?

Available steelhead-bearing stream miles may reduce 60% by 2070-2099.

Suitable future habitat is most likely available in Upper Rock, Butte, pine, and Bridge Creeks.

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