FINAL GREEN RIVER COMPREHENSIVE MANAGEMENT PLAN

Prepared for the Utah Department of Natural Resources, Division of Forestry, Fire & State Lands

JANUARY 2020

SWCA ENVIRONMENTAL CONSULTANTS | CRSA

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Prepared for

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ABBREVIATIONS

%g	percentage of gravity
°C	degrees Celsius
BLM	U.S. Bureau of Land Management
BMP	best management practices
CBC	Christmas Bird Count
cfs	cubic feet per second
CWA	Clean Water Act
CWMA	cooperative weed management areas
DOGM	Utah Division of Oil, Gas and Mining
DPS	distinct population segment
DOE	U.S. Department of Energy
DSPR	Utah Division of State Parks and Recreation
DWQ	Utah Division of Water Quality
DWR	Utah Division of Wildlife Resources
DWRe	Utah Division of Water Resources
DWRi	Utah Division of Water Rights
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FFSL	Utah Division of Forestry, Fire & State Lands
FGTWG	Flaming Gorge Technical Working Group
GCMRC	USGS Grand Canyon Monitoring and Research Station
GIS	global information system
GRCMP	Green River Comprehensive Management Plan
HMP	hazard mitigation plan
IBA	important bird area
kg	kilograms
m	meter
mm	millimeters
NFIP	National Flood Insurance Program
NPDES	National Pollutant Discharge Elimination System
NPS	U.S. National Park Service
NRCS	National Resources Conservation Service
NRHP	National Register of Historic Places
NSO	no surface occupancy
OHWM	ordinary high water mark
PDF	portable document format
PFYC	Potential Fossil Yield Classification
RDCC	Resource Development Coordinating Committee
RM	river mile
RMP	resource management plan
ROE	right-of-entry

SGCN	species of greatest conservation need
SHPO	Utah State Historic Preservation Office
SITLA	State of Utah School and Institutional Trust Lands Administration
SPC	Utah wildlife species of concern
SWCA	SWCA Environmental Consultants
SWReGAP	Southwest Regional Gap Analysis Project
The Tribe	The Ute Indian Tribe
TL	total length
UDAF	Utah Department of Agriculture and Food
UDEQ	Utah Department of Environmental Quality
UDOT	Utah Department of Transportation
UGS	Utah Geological Survey
UPDES	Utah Pollution Discharge Elimination System
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator coordinate system
WIA	walk-in access
WMA	wildlife management areas
WSRA	Wild and Scenic Rivers Act

1.1 Project Vision and Goals

The Utah Department of Natural Resources, Division of Forestry, Fire & State Lands (FFSL) has developed the 2020 *Green River Comprehensive Management Plan* (GRCMP) to prescribe management goals and objectives for sovereign lands along the Green River in Emery, Grand, Uintah, and Wayne Counties, Utah (Figure 1.1).[1] The GRCMP has also been developed to ensure that navigation, fish and wildlife habitat, aquatic beauty, public recreation, and water quality (Public Trust values; Utah Administrative Code R652-2-200) are given due consideration and balanced with the benefits to be derived from any proposed use, pursuant to Utah Administrative Code R652-2.

Primary management responsibility for the river's resources lies with FFSL, according to Title 65A of the Utah Code, which governs management of all state lands under the jurisdiction of FFSL. Utah Code 65A-2-1 states that "[t]he division [FFSL] shall administer state lands under comprehensive land management programs using multiple-use, sustained-yield principles." Briefly summarized, the overarching management objectives of FFSL are to balance and sustain the use of the Public Trust resources and to provide for reasonable beneficial uses of those resources consistent with their long-term protection and conservation.

FFSL's vision for this GRCMP planning process is as follows:

> *The State of Utah, through the Equal Footing doctrine, claims fee title ownership of the bed and banks of the Green River. FFSL has direct management jurisdiction over lands lying below the ordinary high-water mark (i.e., the top of bank) of navigable bodies of water at statehood. FFSL recognizes the importance of the Green River ecosystem and its natural, cultural, recreational, agricultural, and aesthetic amenities, including those resource values and uses that extend beyond its banks and affect or are affected by actions on sovereign lands. Accordingly, FFSL considers it imperative that management of the Green River include coordination in planning and actions with other agencies having jurisdictional and management responsibility over these resources.*

The Green River is a valuable ecosystem of statewide importance. Sustainable management in the context of multiple use of the Green River will ensure that the ecological health (e.g., water quality, bank stability, riparian areas, aquatic organisms, wildlife, and wetlands), scenic attributes, recreation opportunities (e.g., boating, fishing, hunting, and birding), and irrigation are maintained into the future. FFSL will ensure that the management of this resource is based on a holistic view—including the use of adaptive management, as necessary—to ensure long-term sustainability. Responsible stewardship of the Green River's resources will provide a lasting benefit to the Public Trust.

[1] Certain segments of the Green River in Emery, Grand, Uintah, and Wayne Counties are not considered sovereign lands because they were not navigable bodies of water at the time of statehood.

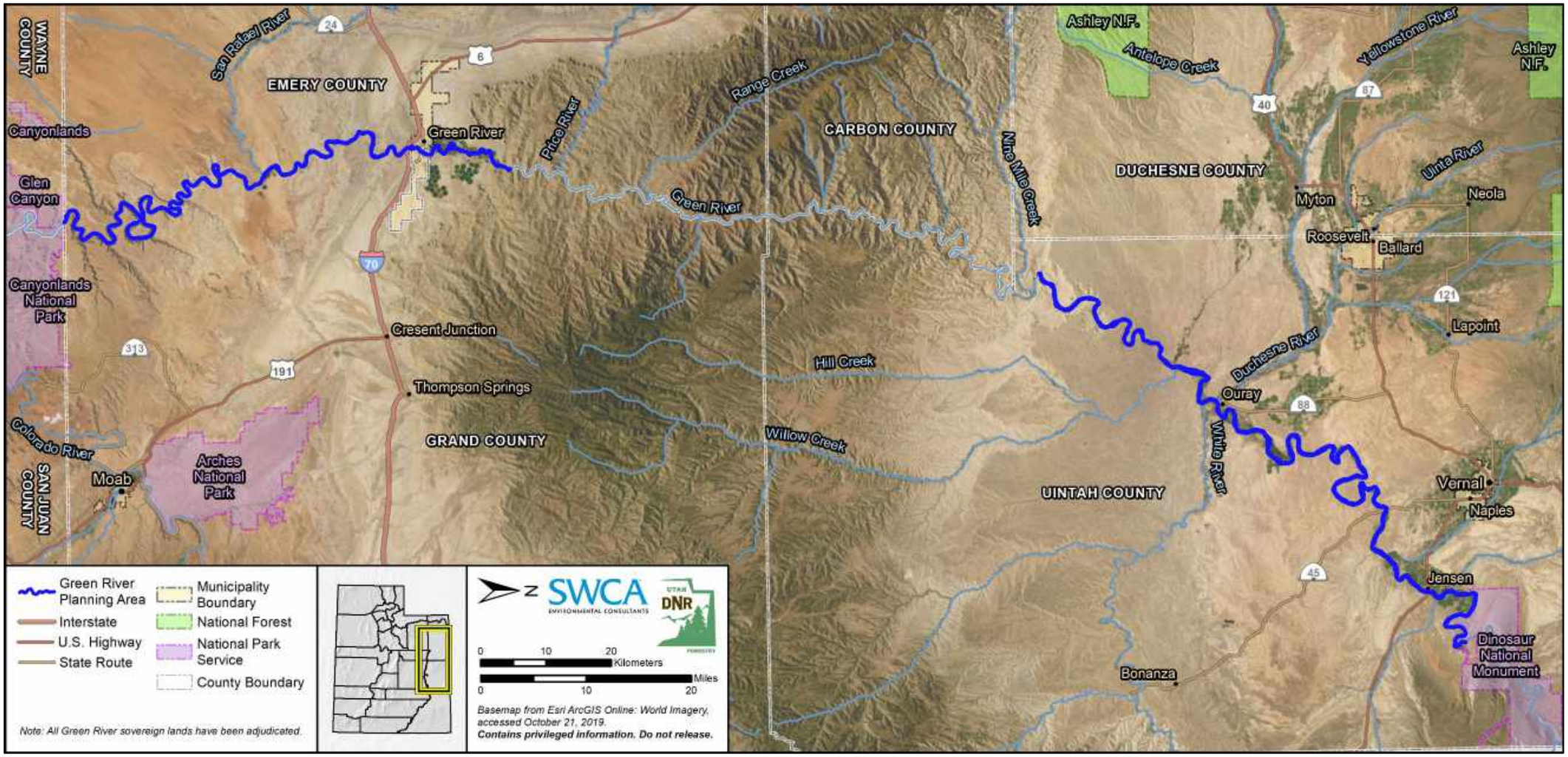


Figure 1.1. Green River sovereign lands (the planning area).

To meet land management mandates, FFSL's goal for the GRCMP is to ensure that FFSL maintains clear and consistent guidance regarding management direction and proper coordination, permitting requirements, and best management practices (BMPs) for implementing projects that may affect Green River sovereign lands. Specifically, the objectives for the GRCMP process are as follows:

- Create the first comprehensive management plan for Green River sovereign lands (i.e., the planning area).
- Ensure that sovereign lands management remains consistent with Public Trust obligations.
- Incorporate principles of multiple use while conserving ecosystem, water, mineral, and community resources.
- Integrate existing information, data, public involvement, and scientific research that have been developed on the Green River into clear and consistent management practices.
- Coordinate with Utah Department of Natural Resource divisions, Utah Department of Environmental Quality (UDEQ) divisions, federal agencies, local government, tribes, stakeholders, and other interested parties regarding management, permitting, maintenance, planning, and research on the Green River.

Drafting the Plan

Existing information and previously established management practices for the Green River were reviewed to inform the development of the GRCMP. This review allowed the GRCMP to be built on previously compiled data sources and current management strategies.

In addition to existing data, development of the GRCMP relied on feedback from the public, counties, municipalities, federal agencies, and other stakeholders, as per Utah Administrative Code R652-90-600. The public outreach process for the GRCMP was combined with that of the *Colorado River Comprehensive Management Plan* (SWCA Environmental Consultants [SWCA] et al. 2020), which was developed concurrently. For a summary of the public outreach process and a summary of FFSL's responses to public comments, see Appendix A. Several individuals from consulting firms were involved in preparing the GRCMP, including the project managers, resource specialists, graphic designers, technical editors, and formatters. A list of these individuals is provided in Appendix B.

Other state agencies contributed to the development of the GRCMP by providing data, technical information, insight into management and jurisdictional roles, and oversight of content. Representatives from these entities formed the GRCMP planning team. A list of planning team members involved in finalizing the GRCMP is provided in Table 1.1.

Table 1.1. Green River Comprehensive Management Plan Planning Team

First Name	Last Name	Representing	Title
Mike	Allred	Utah Division of Water Quality	Environmental scientist
Laura	Ault	Utah Division of Forestry, Fire & State Lands	Sovereign lands program manager
Roger	Barton	Utah Department of Agriculture and Food	Conservation district coordinator
Hollie	Brown	Utah Division of Oil, Gas and Mining	Information specialist
Skyler	Buck	Utah Division of Water Resources	Water resources engineer
Amy	Dickey	Utah Division of Water Quality	Environmental scientist
Chris	Fausett	State of Utah School and Institutional Trust Lands Administration	Deputy assistant director
Darrell	Gillman	Utah Department of Agriculture and Food	Conservation district coordinator
Scott	Hacking	Utah Department of Environmental Quality	District engineer
Makeda	Hanson	Utah Division of Wildlife Resources	Regional habitat manager
Daniel	Hinckley	Utah Department of Transportation	Region 4, Moab
Ty	Hunter	Utah Division of State Parks and Recreation	Boating program manager
Chris	Keleher	Utah Division of Wildlife Resources	Species recovery program director
Naomi	Kisen	Utah Department of Transportation	Natural resources/National Environmental Policy Act program
Scott	McGettigan	Utah Division of Water Resources	Water resources engineer
Chris	Merritt	State Historic Preservation Office	Program specialist
Marc	Stilson	Utah Division of Water Rights	Regional engineer
Matthew	Thayn	Utah Division of Wildlife Resources	Lead construction specialist
Laura	Vernon	Utah Division of Forestry, Fire & State Lands	Sovereign lands planner
Carissa	Watanabe	Utah Department of Transportation	Environmental performance manager
Grant	Willis	Utah Geological Survey	Mapping program manager
Brody	Young	Utah Division of State Parks and Recreation	Assistant boating program manager

The GRCMP is intended to be revised approximately every 10 years. However, the plan can be updated or amended more frequently as issues arise during implementation, as statute or rules change, or to accommodate new information. In accordance with Utah Administrative Code, the revision process is open to the public for comment.

How to Use the Plan

The GRCMP is intended to facilitate access to data, river use class information, permitting processes, and BMPs to assist stakeholders in planning and implementing projects that may affect Green River sovereign lands. This introductory chapter provides an overview of the regulatory environment and sets the stage for the management plan and how it applies to different management scenarios, including a description of the authorizing and permitting processes. The map book at the end of this chapter (Figure 1.8 [maps 1–32]) provides an accessible visual reference of the river's use classes as prescribed in Utah Administrative Code R652-70-200. Chapter 2 summarizes the current conditions of the river and focuses on ecosystem, water, geology and mineral, and community resources. This, in combination with public outreach, provides the basis for Chapter 3, which discusses desired future conditions, management goals and objectives, and BMPs that may apply to ongoing management and permitting decisions for projects proposed by state government agencies, local governments, stakeholders, adjacent landowners, private entities, and others. Throughout the GRCMP, colored boxes called "Further Reading" are used to refer the reader to other Green River–related documents or websites. These include primary documents, information, and management practices that were used in the planning process or that may be helpful or interesting to reference. Chapter 4 provides a list of literature cited for the plan. Unless otherwise stated, all photographs and graphics in the plan are courtesy of FFSL or were provided by the authors of the plan.

Information in the GRCMP is supported by three online resources: 1) a GRCMP interactive portable document format (PDF), 2) a GRCMP Esri story map, and 3) a geographic information system (GIS) spatial data viewer. All of these resources are found on the FFSL website and provide supplemental formats with which to view the GRCMP, understand the regulatory context behind the GRCMP, and visualize available data used to make management decisions. Although the interactive PDF will remain the same until the plan is updated, both the Esri story map and GIS spatial data viewer can be modified as new data and other information become available for the Green River. These three online resources are discussed further below.

- Interactive PDF: This electronic document, viewable in Adobe Reader, is identical to a hard copy of the GRCMP; however, this format provides the reader with hyperlinks to additional reading, a nimble Table of Contents to navigate from one section to another, and the ability to make electronic notes in the document and print copies without concern for browser or word processing differences.
- Esri story map: This format combines the text and graphics in the plan with geospatial data to create maps that guide users along the Green River and provide important information such as river use classes and current conditions. Resource maps are static but do allow the user to zoom in to a specific area of interest. The Esri story map is organized by tabs and includes background and resource information. Along the left side of each tab is a bar that includes a selection of text and graphics taken from the GRCMP.
- GIS spatial data viewer: To view all GIS spatial data compiled and catalogued for the GRCMP, users can operate this GIS data viewing tool without support from GIS professionals or a background in this field. To better understand current conditions, users can turn data layers (there are more than 60) on and off, which allows a unique perspective and virtual tour of the Green River. Combining existing authorization locations, river use class, and stream alteration permit information can help municipalities plan the next utility crossing or bank restoration project. Similarly, reviewing boater access locations can allow boaters to prepare for their next float trip down the Green River. GIS data layers are found in colored boxes throughout the plan.

1.2 Ownership, Regulatory, and Management Context

Green River Bed and Bank

Because segments of the Green River were adjudicated and determined to be navigable at statehood in 1896, the State of Utah claims fee title ownership to the bed and banks of those segments of the river by virtue of the Equal Footing Doctrine (Slade et al. 1997). Exceptions may exist in certain locations where unique title issues are present, and nothing in the plan is intended to represent an adjudication of ownership of any particular tract. The GRCMP is created for FFSL's planning purposes, and FFSL recognizes that certain title and boundary questions may have to be addressed on a case-by-case basis in the future. The State of Utah considers its bed and banks of the Green River as "sovereign land." The Utah State Legislature defines sovereign land as "those lands lying below the ordinary high water mark [OHWM] of navigable bodies of water at the date of statehood and owned by the state by virtue of its sovereignty" (Utah Code 65A-1-1). As noted in this definition, the state's ownership extends to the OHWM; however, knowing exactly where the OHWM was located at statehood is challenging. For this reason, and because the OHWM has not been mapped continuously along the Green River, a case-by-case demarcation of the OHWM may be undertaken as part of a permit authorization process.

Green River Title Adjudication

The longitudinal scope and extent of Utah's ownership of the bed of the Green River were formally adjudicated in decisions issued by the United States Supreme Court in 1931[2] and in 1965.[3] The 1931 decision decreed the Labyrinth Canyon segment of the Green River to be navigable

> where the river crosses the township line between townships 23 and 24 south, range 17 east, Salt Lake Base and Meridian, to the confluence of the Grand (Colorado) River, is now and at all times on and after January 4, 1896, has been, a navigable river, and the title to the bed thereof vested in the State of Utah upon its admission to the Union. (283 U.S. 801 [1931]).

The complicated history surrounding the expanding and retracting boundaries of the Uintah and Ouray Indian Reservation along the Green River prompted more litigation, and the 1965 decision provided certainty regarding tribal and state ownership of the upper Green River. The 1965 decision adjudicated the longitudinal length of the Green River on a segment-by-segment basis. The District Court determined the segments of the Green River located in Dinosaur National Monument and in Desolation and Gray Canyons to be non-navigable. However, the Green River was determined to be navigable as it flowed out of Dinosaur National Monument (river mile [RM] 312 above the confluence of the Green and Colorado Rivers in Canyonlands National Park [The Confluence]) and across the Uinta Basin to Sand Wash (RM 212.7 above The Confluence), and as it emerged from Gray Canyon (RM 129 above The Confluence) across the San Rafael Desert to RM 95. All sovereign lands on the Green River have therefore been adjudicated.

Green River Mineral Leasing

For purposes of mineral leasing, the relevant river segment is the Green River section flowing across the Uinta Basin (from RM 312 to the mouth of Sand Wash) because the shale formations in the basin are experiencing increased oil and gas development prompted by advances in directional drilling and hydraulic fracturing techniques. Along this segment of the Green River, the State of Utah, through FFSL, has been properly issuing mineral leases for the state lands and corresponding mineral estate under the riverbed of the Green River.[4] FFSL intends to continue issuing no surface occupancy leases along the navigable Uinta Basin segment of the Green River while consulting and cooperating with the Ute Indian Tribe on any subsequent mineral leases involving state lands.

Green River Sovereign Land Boundaries

The boundary of sovereign land underlying a river is intrinsically more difficult to define than that of a lake because rivers are more susceptible to substantial geographic movement and shifts in location over time. A thorough examination of the laws of water boundaries, particularly as they pertain to rivers, is complex and beyond the scope of this management plan. However, there are a few basic concepts that are important in understanding the management of rivers as sovereign lands.

Most rivers meander over time unless human-made or natural barriers exist to prevent such movement. As the course of the river changes, natural and artificial processes of erosion, reliction, avulsion, and accretion[5] may affect landownership. Generally, the gradual processes of accretion, reliction, and erosion change the property boundaries between private and public ownership. An adjacent, upland landowner may obtain title to any dry land added by accretion or reliction and/or may lose title to dry land eroded and now covered by water.

[2] *United States v. State of Utah,* 283 U.S. 801 (1931).

[3] Civil No. C-201-62 (D. Ut. 1965) (unpublished decision).

[4] In addition to the 1965 decision adjudicating title to the State of Utah on the navigable stretches of the Green River, Utah's ownership of those sections flowing over the Uintah and Ouray Indian Reservation is further supported by the United States Supreme Court decision in *Montana v. United States*. 450 U.S. 544 (1981), which holds that creation of the Crow Indian Reservation pre-statehood did not trump the strong presumption against title to the Big Horn River vesting with the state upon admission to the Union.

[5] *reliction* = gradual recession of water, leaving land permanently uncovered; *avulsion* = rapid abandonment of a river channel and the formation of a new river channel; *accretion* = the gradual deposition of sediment along the edge of a channel.

For the purposes of sovereign land management, state ownership of the riverbed generally follows the movement of the river over time as it naturally meanders because of erosion, reliction, and accretion processes. However, landownership remains fixed following sudden avulsive events. Avulsive events can result from natural occurrences such as flash floods or from human-made causes such as channel straightening or artificial channel relocation.

Currently, FFSL is not planning to initiate a boundary settlement process for the Green River as it has done at Utah Lake and Bear Lake. FFSL has settled boundaries of other sovereign land resources with some adjacent upland landowners on a case-by-case basis and plans to continue with this approach as boundary issues along the Green River arise.

The Public Trust Over Sovereign Lands

The Public Trust Doctrine is a legal principle derived from English common law. It provides that Public Trust lands, waters, and living resources in a state are held by the state in trust for the benefit of all people (Slade et al. 1997). The doctrine establishes the right of the public to use Public Trust resources, and also establishes the responsibilities of the states when managing Public Trust assets (Slade et al. 1997). In general, Public Trust waters consist of the navigable waters in a state, whereas Public Trust lands are the lands beneath those waters up to the OHWM at statehood. The living resources (e.g., fish, aquatic plants and wildlife) inhabiting these lands and water are also subject to the Public Trust Doctrine (Slade et al. 1997).

The roots of the Public Trust Doctrine date back to the Institutes of Justinian and the accompanying Digest, compiled in the sixth century, which collectively formed Roman civil law. Under Roman law, the air, sea, shores of the sea, and running waters were held in common by all citizens. The rights of fishing, navigation, and public use of the banks of a river or shore were common to all (Slade et al. 1997). These principals of Roman civil law were adopted, for the most part, by English common law, which recognized public rights in all tidewaters (i.e., navigable waters) and the lands beneath. English common law, in turn, became the law of the 13 original states (Slade et al. 1997).

The Equal Footing Doctrine is the principle of United States constitutional law that mandates that new states be admitted to the Union as equals to the original 13 states. The Equal Footing Doctrine perpetuated the Public Trust Doctrine from the 13 original states to each of the 37 new states. As each new state entered the Union, it received in trust those lands beneath navigable waters for the citizens of the new state (Slade et al. 1997).

The State of Utah has recognized and declared that the bed and banks of navigable waters within the state are owned by the state and are among the basic resources of the state, and that there exists, and has existed since statehood, a Public Trust over and upon these waters (Utah Administrative Code R652-2-200). Segments of the Green River are included in this category of navigable waters and are managed by FFSL for public benefit consistent with the Public Trust Doctrine.

Historically, the common law rights in Public Trust lands and waters were directly related to navigation, fishing, and commerce. As society has evolved, the public's use of trust lands and waters has changed. The Public Trust Doctrine has expanded from preserving the public's right to use trust lands and waters for navigation, fishing, and commerce to include recreation, environmental protection, and the preservation of scenic beauty (Slade et al. 1997). Recognition of this evolution in the Public Trust Doctrine is found in the following text from Utah Administrative Code R652-2: "It is also recognized that the public health, interest, safety, and welfare require that all uses on, beneath or above the beds of navigable lakes and streams of the state be regulated, so that the protection of navigation, fish and wildlife habitat, aquatic beauty, public recreation, and water quality will be given due consideration."

Green River Management

The Utah State Legislature has designated FFSL as the executive authority for the management of sovereign lands in Utah, including the Green River. Because the precise location of the OHWM at the time of statehood is not known for the entire Green River, FFSL generally manages the river from the top of bank to the top of the opposite bank, as illustrated in Figure 1.2. The top-of-bank-to-top-of-bank management boundary along the entire river allows FFSL to provide consistent management of this state sovereign land.

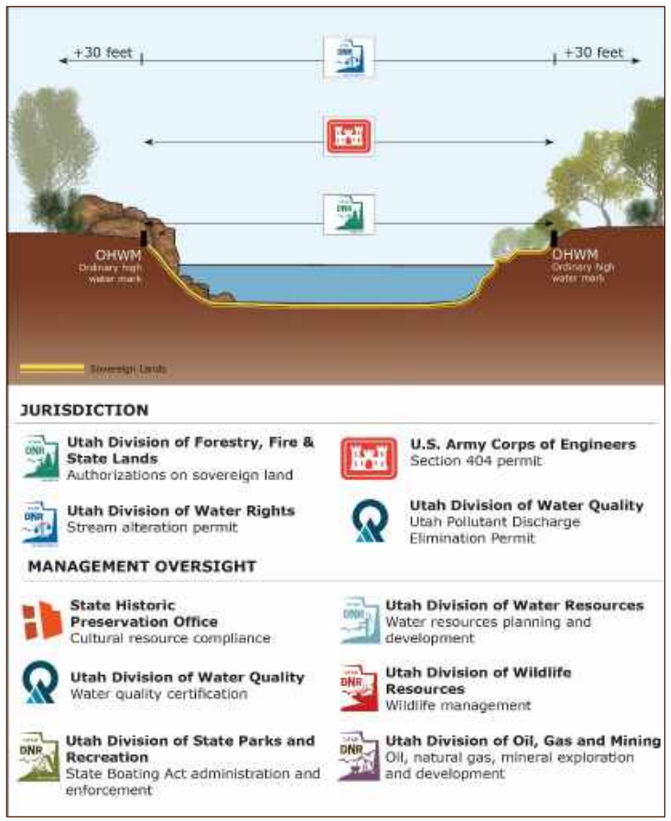


Figure 1.2. Green River cross section showing agency management jurisdiction for the river.

FFSL supports partnerships and collaborations with other entities that have jurisdiction and/or management authority on the Green River (see Figure 1.2 and Sections 1.3, 1.4, and 1.5), as well as with interested stakeholders, to improve overall river management and decision-making.

Multiple-Use Approach

FFSL administers state lands using multiple-use, sustained-yield principles as required by Utah Code 65A-2-1 and Utah Administrative Code R652-90-800. There is no particular hierarchy of uses on sovereign lands. FFSL recognizes that protection of **navigation, fish and wildlife habitat, aquatic beauty, public recreation, and water quality** must be given due consideration and balanced against the need for, justification of, or benefit from any proposed use (Utah Administrative Code R652-2-200). Implementation of multiple-use policies must avoid substantial impairment of Public Trust resources. As a trustee, FFSL must also strive for an appropriate balance among compatible and competing uses on the Green River.

River Mile System and River Segments

One method of identifying features along rivers is by using RMs as reference points. The RMs used in the plan are based on the *Guide to the Colorado & Green Rivers in the Canyonlands of Utah & Colorado* (Martin and Whitis 2016). The starting point (RM 0) on the Green River is The Confluence. From The Confluence, the RMs for the Green River increase in the upstream direction. Commonly used river segment names, associated with RMs, are used throughout the plan (Table 1.2). RMs in the plan may be slightly edited from Martin and Whitis (2016) for continuity between river segments. Where applicable (and with the exception of Table 1.2), RMs are rounded to the nearest 0.5 mile.

Table 1.2. Green River Comprehensive Management Plan River Segments and Associated River Miles

River Segment	River Miles	Segment Identification	Description (length)
Uinta Basin	317.7 to 215.8	G-1-UB	Border of Dinosaur National Monument to Sand Wash (101.9 miles)
Green River Valley	132.2 to 120.1	G-2-GRV	Swasey's rapid to Green River State Park (12.1 miles)
Labyrinth Canyon	120.1 to 46.7	G-3-LC	Green River State Park to the border of Canyonlands National Park (73.4 miles)

Note: RM references are for management purposes only and may not represent precisely the ownership interests and/or fee title claimed by the State of Utah.

Special Designations

Wild and Scenic Rivers Act

The Wild and Scenic Rivers Act (WSRA) was passed by Congress in 1968. The WSRA's purpose was to set aside "certain selected rivers of the Nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations" (16 United States Code 1271 et seq.). Rivers must be both eligible ("free-flowing" with one or more "outstandingly remarkable values") and suitable (whether designation is the best way to manage or protect the eligible river corridor) in order to be designated as wild and scenic. Depending on the type and degree of human development associated with the river and adjacent lands (e.g., impoundments, shoreline development), eligible rivers are preliminarily classified as wild, scenic, or recreational.

After the eligibility and suitability determinations are complete, federal agencies can formally recommend designation to the National Wild and Scenic Rivers System. Congress must approve any rivers recommended by federal agencies for designation. A river authorized for study by Congress receives statutory protection under Public Law 90-542 Section 7(b), water resources projects; Section 8(b), land disposition; and Section 9(b), mining and mineral leasing. A river identified for study through a federal agency is not protected under the WSRA. Rather, protection of its outstanding remarkable values and other characteristics occurs through other agency decisions.

In March 2019, the President signed Senate Bill 47, the John D. Dingell, Jr. Conservation, Management, and Recreation Act, into law. The Emery County Public Land Management Act of 2018 (the Emery County Act) was incorporated into this law. The Emery County Act amends the WSRA to include the following portions of the Green River: the 5.3-mile segment from the boundary of the Uintah and Ouray Indian Reservation south to the Nerfertiti boater access point, as a wild river; the 8.5-mile segment from the Nerfertiti boater access point south to Swasey's Landing boater access point, as a recreational river; and the 49.2-mile segment from Bull Bottom south to the county line between Emery and Wayne Counties, as a scenic river. Of these three segments, a small portion (less than 0.5 RM) of the Green River north of Swasey's Landing boater access point (the Green River Valley segment near RM 132) and the segment from Bull Bottom south to the county line (the Labyrinth Canyon segment from approximately RM 47 to RM 93) are sovereign lands that have been adjudicated and were determined by the Supreme Court to be owned by the State of Utah.

The 2019 federal National Wild and Scenic River designations create implications for FFSL management of the sovereign lands lying below the Green River, especially in the Labyrinth Canyon segment. However, FFSL intends to work with the U.S. Bureau of Land Management (BLM), Grand County, and Emery County to define management roles, the sovereign land boundary along the river, and any other boundaries associated with the scenic designation. It is FFSL's position that the state retains complete ownership and managerial control over the bed of the Green River in the scenic Labyrinth Canyon segment.

In addition, the BLM has identified a portion of the Uinta Basin segment as suitable for recommendation into the National Wild and Scenic Rivers System with a classification of "scenic." This portion of the planning area extends from approximately RM 216 to RM 241 (see GIS spatial data viewer for additional detail). Other portions of the Uinta Basin, Green River Valley, and Labyrinth Canyon segments have been determined eligible for "recreational" or "scenic" designation, which is an initial step in the river assessment process prior to the determination of suitability. These areas can also be viewed on the GIS spatial data viewer.

The Wilderness Act

The Wilderness Act was passed by Congress in 1964 and established the National Wilderness Preservation System. The Wilderness Act's purpose was to assure than an increasing population, accompanied by expanding settlement and growing mechanization, does not occupy and modify all areas within the United States and its possessions, leaving no lands designated for preservation and protection in their natural condition (16 United States Code 1131 et seq.).

Wilderness is defined by the Wilderness Act as "an area where the earth and its community of life are untrammeled by man" and as "an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation (16 United States Code 1131 et seq.). Under the Wilderness Act, wilderness characteristics include having outstanding opportunities for solitude or a primitive and unconfined type of recreation; having at least 5,000 acres of land or sufficient size to make practicable its preservation and use in an unimpaired condition; and having ecological, geological, or other features of scientific, educational, scenic or historical value.

The Wilderness Act initially immediately placed 54 areas into the National Wilderness Preservation System. The process for adding new lands to the National Wilderness Preservation System involves the Secretary of the Interior's classification of new lands and review of suitability before these findings are reported to the President. The President must then advise Congress of his/her recommendations with respect to the designation of new wilderness. Each recommendation of the President for designation as wilderness becomes effective by an act of Congress.

The Emery County Act discussed in the previous section designated 54,643 acres of land adjacent to the Labyrinth Canyon segment as wilderness and added it to the National Wilderness Preservation System. The new Labyrinth Canyon Wilderness will be managed by the BLM. The Desolation Canyon Wilderness was also added to the National Wilderness Preservation System under the Emery County Act. This designation includes 142,996 acres adjacent to the Green River, also to be managed by the BLM. Both wilderness areas are withdrawn from mineral entry on the date of wilderness designation, subject to valid existing rights. The new wilderness areas can be viewed on the GIS spatial data viewer.

1.3 Utah Department of Natural Resources Management Responsibilities

Utah Division of Forestry, Fire & State Lands

The State of Utah claims fee title ownership of the sovereign lands of the bed of the Green River. FFSL has direct management jurisdiction from top of bank to top of bank of the river (see Figure 1.2) and manages the river under the Public Trust Doctrine for the use and enjoyment by the public. To ensure effective implementation of Utah's multiple-use approach, FFSL strives to assure public access to navigable waters for commerce, navigation, fishing, swimming, and recreational boating, while also working to preserve the ecological and cultural values of Green River sovereign lands. Other sovereign lands connected to or close to the Green River are two separate segments of the Colorado River. Holistic management of the Green and Colorado Rivers is recommended because the Green River flows into and influences the Colorado River.

Utah Division of Oil, Gas and Mining

The mission of the Utah Division of Oil, Gas and Mining (DOGM) is to "regulate the exploration and development of coal, oil and gas, and other minerals in a manner that encourages responsible reclamation and development; protects correlative rights; prevents waste and protects human health and safety, the environment and the interest of the state and its citizens" (Utah Department of Natural Resources 2018). The Board of Oil, Gas, and Mining is the policy-making body for DOGM. DOGM's coal program is responsible for providing permits to coal companies, site inspections, and oversight of the reclamation and bond release process. DOGM's oil and gas program regulates the exploration and development of oil and natural gas resources, and the minerals program regulates exploration and development of all non-coal mineral resources (e.g., copper, gold, and silver). Coal and mineral deposits, including oil, gas, and hydrocarbon resources, in state-owned lands are reserved to the state. DOGM may permit the exploration and development of these resources from beneath sovereign lands with permission from FFSL.

Utah Division of State Parks and Recreation

Title 79-4 of the Utah Code establishes the Utah Division of State Parks and Recreation (DSPR) and the Board of Parks and Recreation and sets forth their responsibilities. Under Utah Code 79-4-802, the DSPR has the discretion to give grants to local governments and state agencies for riverway enhancement projects with funds appropriated by the Utah State Legislature for that purpose. Grants for riverway enhancement projects must be for rivers or streams that are impacted by high-density populations or are prone to flooding, and these grants must include a plan to provide employment opportunities for youth, including at-risk youth.

The DSPR also is required to administrate and enforce the State Boating Act (Utah Code 73-18), which includes duties such as ensuring the safety of vessels and persons on the water, registering boats, zoning certain waters of the state for non-motorized use, regulating commercial operators, and regulating waterway markers and other permanent objects in waters of the state.

Utah Division of Water Resources

The mission of the Utah Division of Water Resources (DWRe) and the Board of Water Resources is to plan, conserve, develop, and protect Utah's water resources, pursuant to Title 73 of the Utah Code. DWRe conducts studies and planning for water use in the Green River watershed. The Board of Water Resources has divided the State of Utah into eight river districts for management purposes. The planning area is primarily in the Green River District and in the Upper Colorado River District.

Utah Division of Water Rights

The Utah Division of Water Rights (DWRi) regulates the appropriation and distribution of water in the state of Utah, pursuant to Title 73 of the Utah Code. The State Engineer, who is the director of DWRi, gives approval for the diversion and use of any water, regulates the alteration of natural streams such as the Green River, and has the authority to regulate dams to protect public safety. All projects within twice the width of the Green River active channel up to 30 feet are regulated by DWRi under the Stream Alteration Program (see Figure 1.2). DWRi has authority to regulate dam safety and inspects the Pariette East Dike, located adjacent to the Green River on the Pariette Draw tributary southwest of the community of Ouray in Uintah County.

FFSL does not adjudicate water rights in Utah, and nothing in the plan is intended to, nor shall it be construed to, revoke, cancel, suspend, limit, modify, regulate, affect, or impair any existing appropriated, decreed, contracted, or other water right approved by DWRi that is owned by the holder of a permit issued under the GRCMP. In addition, nothing in the plan is intended to affect any right or interest of the permittee under any such water right, including the right to impound, store, divert, and use water as authorized under any such regulation or affect any vested water right. When FFSL requests that a person obtain a permit for a water diversion structure or other encroachment on sovereign land, it is exercising authority only as a property owner where it has jurisdiction.

Utah Division of Wildlife Resources

Title 23 of the Utah Code establishes the Utah Division of Wildlife Resources (DWR) and the Wildlife Board and sets forth their duties and powers. Utah Code 23-14-1 states that "The Division of Wildlife Resources is the wildlife authority for Utah and is vested with the functions, powers, duties, rights and responsibilities provided in this title and other law." DWR also manages lands and access areas along the Green River for the benefit of the public. As part of its responsibility, DWR implements restoration projects to enhance fish and wildlife habitat and to increase fish and wildlife population numbers.

Utah Geological Survey

The Utah Geological Survey (UGS) was established to survey, investigate, and provide information on the geology, topography, paleontology, and mineral resources of the state (Utah Code 79-2), including geologic hazards such as earthquakes and faults. The Board of Utah Geological Survey is the policy-making body for the UGS. A permit is required from UGS before excavating for critical paleontological resources on lands owned or controlled by the state.

1.4 Other State and Local Entities Management Responsibilities

State of Utah School and Institutional Trust Lands Administration

The State of Utah School and Institutional Trust Lands Administration (SITLA) manages 3.4 million acres of land in Utah held in trust for 12 state institutions. SITLA works with private businesses to generate revenue from these lands (through surface and subsurface development and real estate transactions), which is deposited into permanent endowments for each beneficiary. SITLA is an adjacent landowner along Green River sovereign lands.

Utah Department of Agriculture and Food

The Utah Department of Agriculture and Food's (UDAF) mission is to promote the healthy growth of Utah agriculture, conserve natural resources, and protect the food supply. It accomplishes this through administration of Utah's agricultural laws that mandate a variety of activities such as inspections, loan issuance, pest and disease control, and public information programs. Especially relevant to Green River sovereign lands are UDAF's grazing improvement, noxious weed detection and control, environmental stewardship certification, and agricultural land preservation programs. Utah conservation districts, local groups created to improve and protect natural resources for public benefit, are under the purview of UDAF.

Utah Department of Transportation

The Utah Department of Transportation (UDOT) plans, designs, and implements transportation projects (e.g., bridges, roads, bike lanes, and public transit) while adhering to state and federal environmental laws and regulations. Transportation infrastructure may cross the Green River or parallels its banks. Although there are no specific UDOT guidelines or regulations regarding the Green River, the agency is required to prepare environmental analysis and documentation for federally funded and state-funded transportation projects and implement measures to minimize harm to the environment.

Utah Division of Water Quality

The UDEQ Division of Water Quality (DWQ) and the Utah Water Quality Board are responsible for maintaining, protecting, and enhancing the quality of Utah's surface and groundwater resources. Title 19, Chapter 5 of the Utah Code charges the board and division to develop programs for the prevention and abatement of water pollution. The board is also responsible for establishing water quality standards throughout the state; enforcing technology-based, secondary treatment effluent standards or other more stringent discharge limits to meet instream standards; reviewing plans, specifications, and other data relative to wastewater disposal systems and municipal separate stormwater systems; and establishing and conducting a continuing planning process for control of water pollution. DWQ also administers the Water Quality Certification Program under Section 401 of the Clean Water Act (CWA) and the Nonpoint Source Management Program under Section 319 of the CWA.

Utah State Historic Preservation Office

The Utah State Historic Preservation Office (SHPO) within the Utah Division of State History provides review, comment, and guidance to agencies needing to comply with cultural resource regulations. Utah Code 9-8-404 requires that state agencies consider their actions on historic properties and provide the Utah SHPO with an opportunity to comment on those actions. Section 106 of the National Historic Preservation Act (codified in Title 54 of the United States Code) applies similarly in cases where there is a federal undertaking (money, land, permitting, etc.); the federal agency is required to consult with SHPO. Generally, for both state and federal actions, a historic property is something that is more than 50 years old; retains integrity; and is eligible for, or listed on, the National Register of Historic Places (NRHP). The Utah SHPO does not have regulatory authority over state or federal projects, but instead offers advice and comment on a proposed undertaking to hopefully avoid or minimize effects to a historic property. Under federal statute, the Utah SHPO is the central clearinghouse for historical and archaeological information for Utah, including federal, state, and private lands. Architectural information is available freely to the

public; however, archaeological site information is protected by federal law (Archaeological Resources Protection Act) and state law (Government Records Access and Management Act), whereby only approved archaeologists can view the sensitive information. Outside the formal compliance process, the Utah SHPO can provide advice on how to manage historic properties and can offer potential funding opportunities in certain cases.

Local Government

Counties and cities with jurisdiction over lands abutting the Green River have important management responsibilities, are river stakeholders, and are partners with FFSL in ongoing and future projects. Local government performs functions related to public safety, education, recreation, tourism, land use and planning, and weed management among other subjects.

General Public

FFSL manages Green River sovereign lands for the benefit of the general public in accordance with the Public Trust. Feedback from the public is always welcome. Community involvement in ongoing sovereign lands management (e.g., service projects involving restoration or education) is encouraged, assuming efforts are coordinated with and approved by FFSL.

1.5 Federal Agencies Management Responsibilities

Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) administers the National Flood Insurance Program (NFIP), which is fundamental to reducing flood losses. In this program, floodplain management is defined to include all actions that states and communities can take to minimize damage to new and existing buildings and infrastructure. Communities along the Green River, such as Jensen, may incorporate NFIP requirements into their zoning codes, subdivision ordinances, and/or building codes or adopt special-purpose floodplain management ordinances. The NFIP requirements apply to areas mapped as the 100-year flood on Flood Insurance Rate Maps issued by FEMA. Local officials are responsible for administering and enforcing local floodplain management regulations within their jurisdiction (see Figure 1.2).

Federal Energy Regulatory Commission

The Federal Energy Regulatory Commission (FERC) is an independent agency that regulates the interstate transmission of electricity, natural gas, and oil. Of most relevance to the Green River is FERC's responsibility to license and inspect private, municipal, and state hydroelectric projects.

Natural Resources Conservation Service

The Natural Resources Conservation Service (NRCS) provides farmers and ranchers with financial and technical assistance to apply conservation practices "on the ground" that not only help the environment but also agricultural operations, including those in the GRCMP planning area. In Utah, the NRCS administers Farm Bill programs such as Agricultural Conservation Easement and Small Watershed, as well as the Emergency Watershed Protection Program, which provides technical and financial assistance to communities affected by natural disasters such as floods. Through the Emergency Watershed Protection Program, the NRCS sponsored the rehabilitation of the Tusher Diversion Dam (also known as the Green River Diversion), located near RM 128 on the Green River.

U.S. Army Corps of Engineers

Under Section 404 of the CWA, the U.S. Army Corps of Engineers (USACE) is responsible for regulating placement of fill material in the nation's waters, including the Green River (see Figure 1.2). USACE's management responsibilities under the CWA are to protect the nation's aquatic resources from unnecessary adverse impacts.

U.S. Bureau of Land Management

The BLM manages approximately 245 million acres of public surface land and 700 million acres of subsurface mineral estate (BLM n.d. [2019]). The BLM's mission directs the agency to manage public land for multiple uses while conserving natural, historical, and cultural resources. Multiple uses on BLM lands include renewable energy development (e.g., solar, wind), conventional energy development (e.g., oil and gas, coal), livestock grazing, hard rock mining (e.g., gold, silver), leasable and saleable minerals (e.g., phosphate), timber harvesting, and outdoor recreation (e.g., camping, rafting). The conservation side of BLM's mission includes preserving specially designated landscapes, such as National Conservation Lands (e.g., national monuments, wilderness areas). The BLM is an adjacent landowner along Green River sovereign lands.

U.S. Bureau of Reclamation

The U.S. Bureau of Reclamation (USBR) manages, develops, and protects water and water-related resources in an environmentally and economically sound manner for the American public. It operates 338 reservoirs and is the nation's largest wholesale water supplier (USBR 2018). The USBR operates the Flaming Gorge Dam on the Green River, north of sovereign lands approximately 26 RMs downstream of the Utah-Wyoming state line.

U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency (EPA) develops and enforces regulations to protect human health and the environment. The EPA works to ensure that the public has clean air, land, and water, and supports national efforts to reduce environmental risks based on best available scientific information. In addition, the EPA gives grants to state environmental programs, nonprofits, educational institutions, and others. The EPA is also involved in the development of area contingency plans for oil spills that could threaten waters of the United States, including the Green River.

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) is responsible for protecting flora and fauna, including fish and migratory birds; complying with the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act; and protecting threatened, endangered, and candidate species found in and near the Green River as required by the Endangered Species Act (ESA). The USFWS also conducts scientific investigations to document and remedy contaminant-related problems for fish and wildlife and monitors long-term contaminant trends. In addition, the USFWS manages Ouray National Wildlife Refuge, located along the Green River near Ouray, Utah, and engages in adaptive management of habitat, invasive species, and native plants in the refuge.

U.S. National Park Service

Since 1916, the U.S. National Park Service (NPS) has been the management agency for the National Park System. The mission of the NPS is to preserve unimpaired natural and cultural resources and values of the national parks for the enjoyment, education, and inspiration of current and future generations. Two national park units are located adjacent to Green River sovereign lands: Dinosaur National Monument and Canyonlands National Park.

1.6 Tribal Management Responsibilities

Ute Indian Tribe of the Uintah and Ouray Indian Reservation

The Ute Indian Tribe (the Tribe) has a membership of 2,970 individuals, more than half of whom live on the Uintah and Ouray Indian Reservation (Ute Indian Tribe 2013). The Tribe is composed of three recognized bands of Utes: the Whiteriver Band, Uncompahgre Band, and Uintah Band. The Uintah and Ouray Indian Reservation covers approximately half of Uintah and Duchesne Counties, and also extends into Carbon, Grand, and Wasatch Counties. The Tribe operates its own tribal government and has several agencies that manage natural

resources, including an air quality department, recreation department, and fish and wildlife department. The Uinta Basin segment of the Green River runs through the Uintah and Ouray Indian Reservation.

1.7 County and Municipal Zoning

The Green River borders one municipality and four counties. Each municipality and county entity along the river has the authority to authorize land uses up to the OHWM. However, the natural resources and ecological systems of the Green River do not observe property boundaries. Management decisions made by FFSL regarding the river will affect and are affected by the land uses and associated activities on adjacent lands.

The priority for FFSL's management of the riverbed is to continue protecting and sustaining the Public Trust resources of the Green River while recognizing that local governments need to provide services to their constituents that may have an impact on the natural environment (e.g., transportation, utilities, and recreation infrastructure). For these reasons, it is important to understand the types of land uses and projects authorized by each municipality and county's general plan and zoning ordinance. Coordination regarding "greenbelts" and development patterns should be an ongoing discussion for the well-being of adjacent residents and for the river. Population growth and infrastructure development in and around municipalities and towns could place increasing pressure on the river corridor.

The GRCMP recognizes FFSL's commitment to maintaining environmental quality for Utah citizens and specifically to minimizing impacts to the environment. However, the GRCMP and FFSL have no authority over regulations on any lands adjacent to the river.

The counties and municipality use their own land use zoning designations to indicate the allowed uses for properties adjacent to the Green River. In addition to the current zoning maps and ordinances, future land use maps and general plans portray expected and anticipated uses, which may differ from the current zoning and/or existing land uses in place. A summary of the current zoning for land uses in each county is provided in the following sections. Please refer to the GIS spatial data viewer available on the FFSL website to view the zoning per county.

Emery County

Approximately 82 miles of the planning area river corridor is in Emery County (this portion of the river corridor is also shared with Grand County as it defines the counties' borders). One municipality in the county has jurisdiction over land uses adjacent to sovereign lands: the city of Green River. Of the 82 miles of river corridor in Emery County, approximately 1.37 miles is in the city of Green River.

The city of Green River has zoned some of the land adjacent to the planning area as Agricultural, Residential, Open Space, and Commercial. Emery County has zoned land adjacent to the planning area as Mining and Grazing, and Agriculture.

Grand County

The west boundary of Grand County (and east boundary of Emery County) is delineated by the Green River. Approximately 85 miles of the planning area river corridor is in Grand County. There are no municipalities adjacent to these sovereign lands.

Grand County has zoned some of the land adjacent to the planning area as Multiple Use (range, resource, and recreation).

Uintah County

Approximately 103 miles of the planning area river corridor is in Uintah County. There are no municipalities adjacent to these sovereign lands.

Uintah County has zoned some of the land adjacent to the planning area as Mining and Grazing, Agriculture, Industrial, and Commercial.

Wayne County

Approximately 0.06 mile of the planning area river corridor is in Wayne County. There are no municipalities adjacent to these sovereign lands.

Wayne County has not designated any zoning on land adjacent to the planning area; all land adjacent to sovereign lands is under federal ownership.

1.8 Collaborative Management Groups

The Green River flows through two states and is an important water supply for agriculture, industry, municipalities, recreation, and wildlife. A number of collaborative groups provides multi-stakeholder management efforts on the Green River. Several key groups are discussed below.

Flaming Gorge Technical Working Group

The purpose of the Flaming Gorge Technical Working Group (FGTWG) is to propose specific flow and temperature targets for each year of Flaming Gorge Dam operations based on current year hydrological conditions and the conditions of endangered fish. The FGTWG also integrates flow requests from the Upper Colorado River Endangered Fish Recovery Program where possible. Members of the FGTWG include personnel from the USBR, USFWS, and the Western Area Power Administration. Flow and temperature targets proposed by the FGTWG affect downstream conditions on FFSL segments of the Green River.

Upper Colorado River Endangered Fish Recovery Program

The Upper Colorado River Endangered Fish Recovery Program is a partnership of local, state (including Utah), and federal agencies; water and power interests; and environmental groups working to recover four species of endangered fish in the Colorado River basin (which includes the Green River), while allowing for water development. The recovery program involves restoring and managing stream flows and habitat; boosting wild, endangered fish populations with hatchery-raised fish; and reducing negative interactions with some species of nonnative fish. The recovery program sets goals to provide measurable criteria for downlisting (change in status from endangered to threatened) and delisting (removal from ESA protection) the endangered fish in the Colorado River. Recovery program efforts can affect Green River sovereign lands. DWR is a member of this group.

1.9 Adjacent Land Management Plans

Interagency coordination and communication are essential to ensuring the sustainability of Public Trust values on Green River sovereign lands. Approximately 34% of the adjacent landownership within 50 feet of the river banks is federally owned (BLM, NPS, and USFWS) and approximately 51% is state owned. The types of management plans already in place for these lands are discussed below.

Bureau of Land Management Resource Management Plans

The Federal Land Policy and Management Act of 1976 directs the BLM to develop and periodically revise resource management plans (RMPs) to guide management of BLM-administered lands under the principals of multiple use and sustained yield. RMPs provide a comprehensive, long-term framework for the allocation of present and future resources and for management decisions that balance uses with resource protection. Land use planning goals, objectives, and management actions are established in an RMP. The BLM Vernal, Price, Moab, and Richfield Field Offices all have RMPs in place that cover lands near the planning area.

National Park Service Foundation Documents

The NPS is required to develop a foundation document for each national park unit to outline the purpose and significance of the park unit, interpretive themes, fundamental resources and values, and special mandates and administrative commitments. The foundation document provides the underlying guidance for planning decisions in a park unit. Individual park units may also develop separate plans for the management of particular resources, such as noxious species. Foundation documents have been developed for Dinosaur National Monument and Canyonlands National Park.

County Resource Management Plans

Utah Code 17-27a-401 requires counties to include a county RMP for public lands as part of their general plan. The county RMP must address 28 topics, including livestock grazing, agriculture, fire management, noxious weeds, water rights, ditches and canals, water quality and hydrology, floodplains and river terraces, wetlands, riparian areas, wildlife, fisheries, recreation, and mineral resources. The county RMP establishes findings pertaining to each topic or resource, describes defined objectives, and outlines general policies and guidelines on how objectives should be accomplished. County RMPs have been developed for the four counties with Green River sovereign lands.

1.10 Utah Division of Forestry, Fire & State Lands Authorization Process

FFSL is the executive authority for the management of sovereign lands and is required to prescribe standards and conditions for the authorization and development of surface resources on sovereign lands. Authorizations (easements, general permits, and rights-of-entry [ROE]) issued by FFSL must be in compliance with state law, administrative rules, and the Public Trust Doctrine and must adhere to multiple-use, sustained-yield principles. Each authorization (easement, general permit, or ROE) must also comply with this GRCMP. Figure 1.3 demonstrates FFSL's most commonly used authorization processes (processes are subject to change depending on the proposed activity and permit), and Figure 1.4 provides a standard authorization checklist. FFSL's authorization processes are governed by applicable laws. Unpermitted actions violate state laws and are subject to a civil penalty. Without a CMP, the authorization process requires site-specific planning.

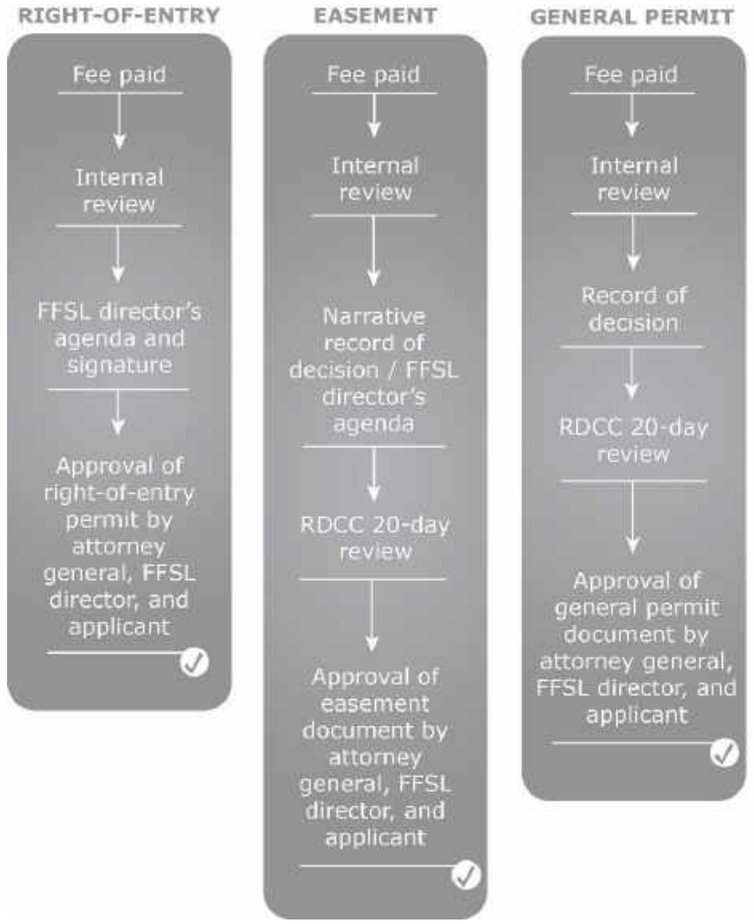


Figure 1.3. Authorization process diagram.[6]

[6] This diagram is for illustrative purposes only. FFSL follows all applicable legal doctrines, statutes, and regulations for authorizations.

Figure 1.4. Application checklist.[6]

Types of Authorizations

Easements

An easement (Utah Administrative Code R652-40) across the Green River may be issued by FFSL for bridges, above- and below-grade utility lines, or pipelines. Easement fees are based on determined rates, which may include linear rate or appraised value. Easements are granted for no more than a term of 30 years and are subject to a 20-day review by the state's Resource Development Coordinating Committee (RDCC).

General Permits

General permits are issued for public or private use of sovereign lands. Public use may include roads, bridges, recreation areas, dikes, or flood-control structures. Private use may include agricultural uses that are constructed adjacent to upland private property or facilities for the launching, docking or mooring of boats constructed for the use of the adjacent upland owner. An adjacent upland owner is defined as any person who owns adjacent upland property which is improved with, and used solely for, a single-family dwelling. General permits are issued for no more than 30 years and are subject to a 20-day review by the RDCC.

Rights-of-Entry

An ROE (Utah Administrative Code R652-41) allows non-exclusive, non-permanent, or occasional commercial or non-commercial use of sovereign lands for a short-term period of generally no more than 1 year. ROEs are generally issued for filming, commercial recreation ventures, research, organized events, and non-commercial ventures lasting more than 15 days.

Authorization Renewals

The permittee should submit a written request to FFSL to be considered for a permit renewal. This should be done at least 3 months prior to the expiration date of the current permit, unless otherwise directed. Permit renewals are then evaluated by FFSL based on current use and regulations.

1.11 River Use Class System and Maps

According to Utah Administrative Code R652-70-200, sovereigns lands should be classified based on their current and planned uses. Table 1.3 lists and describes the river use classes that guide management and use on the Green River. River use classes are applied to specific locations along the Green River based on county and municipal zoning adjacent to the river and on other parameters such as existing authorizations, environmental factors, adjacent landownership and uses, and established deed restrictions or conservation easements. Table 1.3 also describes the specific parameters used to designate river use classes along the Green River. The distribution of river use classes by river segment in percentages is found in Chapter 2, Table 2.1.

Table 1.3. Classification of Sovereign Lands along the Green River

River Use Class*	Description*	Example along the Green River	Percentage Based on Acreage of each Class	Parameters
Class 1	Manage to protect existing resource development uses	Tusher Diversion Dam; authorized boater access points and bridges	2%	Areas with existing authorizations Areas with existing development
Class 2	Manage to protect potential resource development options	None	0%	Established, permanent structures without a current easement from FFSL
Class 3	Manage as open for consideration of any use	Areas in the City of Green River that are zoned commercial and residential	33%	Areas zoned for commercial, industrial, residential, or development Areas zoned for mining and grazing Areas adjacent to a tribal reservation
Class 4	Manage for resource inventory and analysis	Class 4 is not applied to the GRCMP planning area.		
Class 5	Manage to protect potential resource preservation options	Areas zoned agriculture near the Town of Jensen	50%	Conservation of agricultural uses BLM land Areas zoned open space Potential wild and scenic river corridors Wilderness study areas
Class 6	Manage to protect existing resource preservation uses	Areas adjacent to Dinosaur National Monument and Ouray National Wildlife Refuge	15%	Local, county, state, or federal conservation protection areas Parcels holding conservation easements Conservation of cultural resources such as national scenic and historic trails

* Data from Utah Administrative Code R652-70-200.

Examples of how specific classes and uses were assigned to the river system based on current and potential use are found on Figures 1.5 and 1.6, respectively. For example, areas along the river with existing, permitted utilities, boater access points, roads, and diversion canals (items 1, 6, 12, and 15 on Figure 1.6) are considered Class 1 reaches of the river. Segments of the river that are adjacent to private land or may have commercial or industrial uses are considered Class 3 areas (item 13 on Figure 1.6). Finally, reaches of the river associated with agricultural uses or zoned open space (items 3, 4, and 5 on Figure 1.6) and that warrant protection of cultural resources or are afforded legal conservation protection (items 9 and 10 on Figure 1.6) are considered Class 5 and Class 6 areas, respectively. For the purposes of illustration, Figures 1.5 and 1.6 show multiple river use classes and uses in a small area. In practice, river use classes and uses are usually not this condensed.

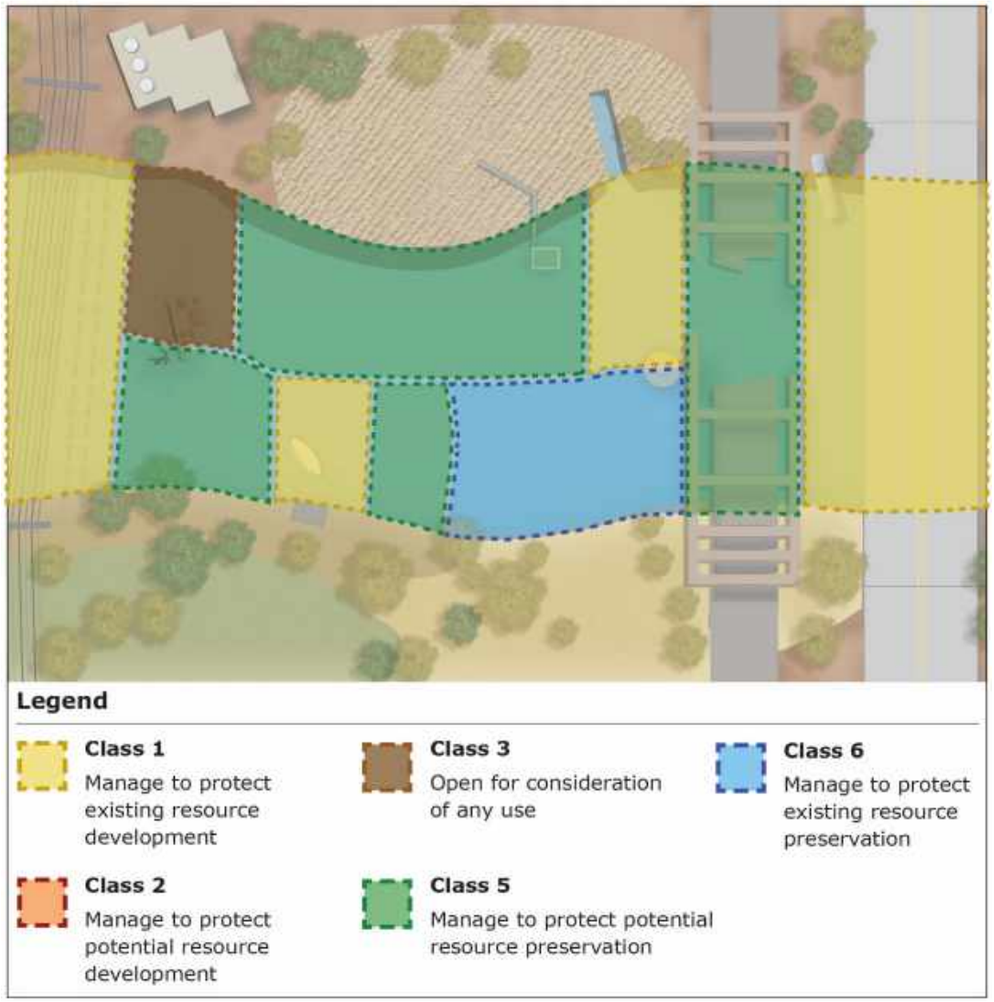


Figure 1.5. Green River plan view showing conceptual river use classes.

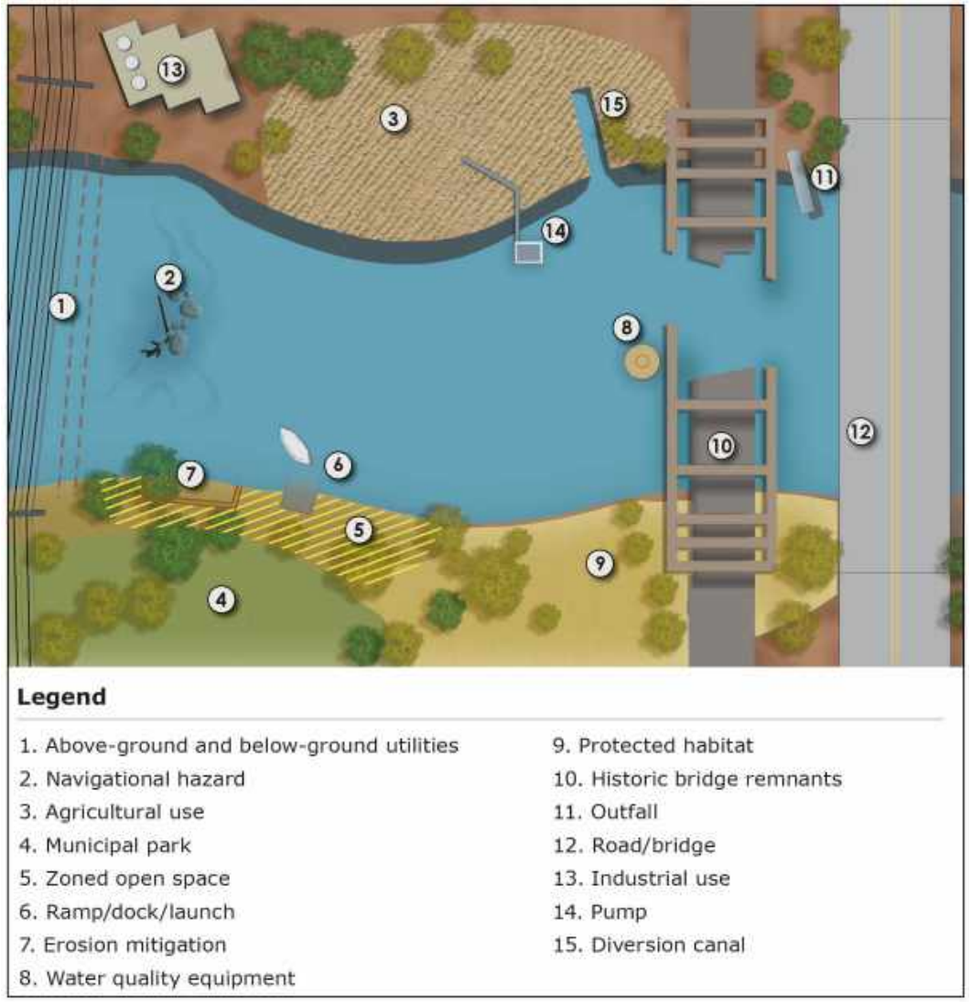


Figure 1.6. Green River plan view showing conceptual river uses.

Segments of the river that are associated with agriculture are zoned Class 5 and are managed to protect potential resource (agriculture) preservation options. This classification was selected because agriculture is a key economic activity; is of regional and state-wide importance; and informs the history, lifestyle, and culture of particular areas (e.g., Green River). In addition, zoning agricultural areas as Class 5 helps protect important habitat for wildlife species.

Where Table 1.3 lists the river use classes, Figure 1.8—a map book of the Green River made up of 32 individual maps—shows the reader the specific locations of these river use classes along the sovereign land segments of the Green River. Figure 1.7 provides a map book index showing the entire planning area. Note: Some river use class locations, e.g., Class 1, can be difficult to see because of their width and the scale at which the map book is made. For the most accurate view of all river use class locations, please use the GIS spatial data viewer available on the FFSL website.

Further Reading

Colorado River Comprehensive Management Plan (SWCA Environmental Consultants et al. 2020)

Guide to the Colorado & Green Rivers in the Canyonlands of Utah & Colorado (Martin and Whitis 2016)

Putting the Public Trust Doctrine to Work. The Application of the Public Trust Doctrine to the Management of Lands, Waters and Living Resources of the Coastal States (Slade et al. 1997)

GIS Data Layers

FFSL Authorizations, Landownership, Political Boundaries, River Miles, River Segments, River Use Classes, Sovereign Lands of the Green River, Zoning

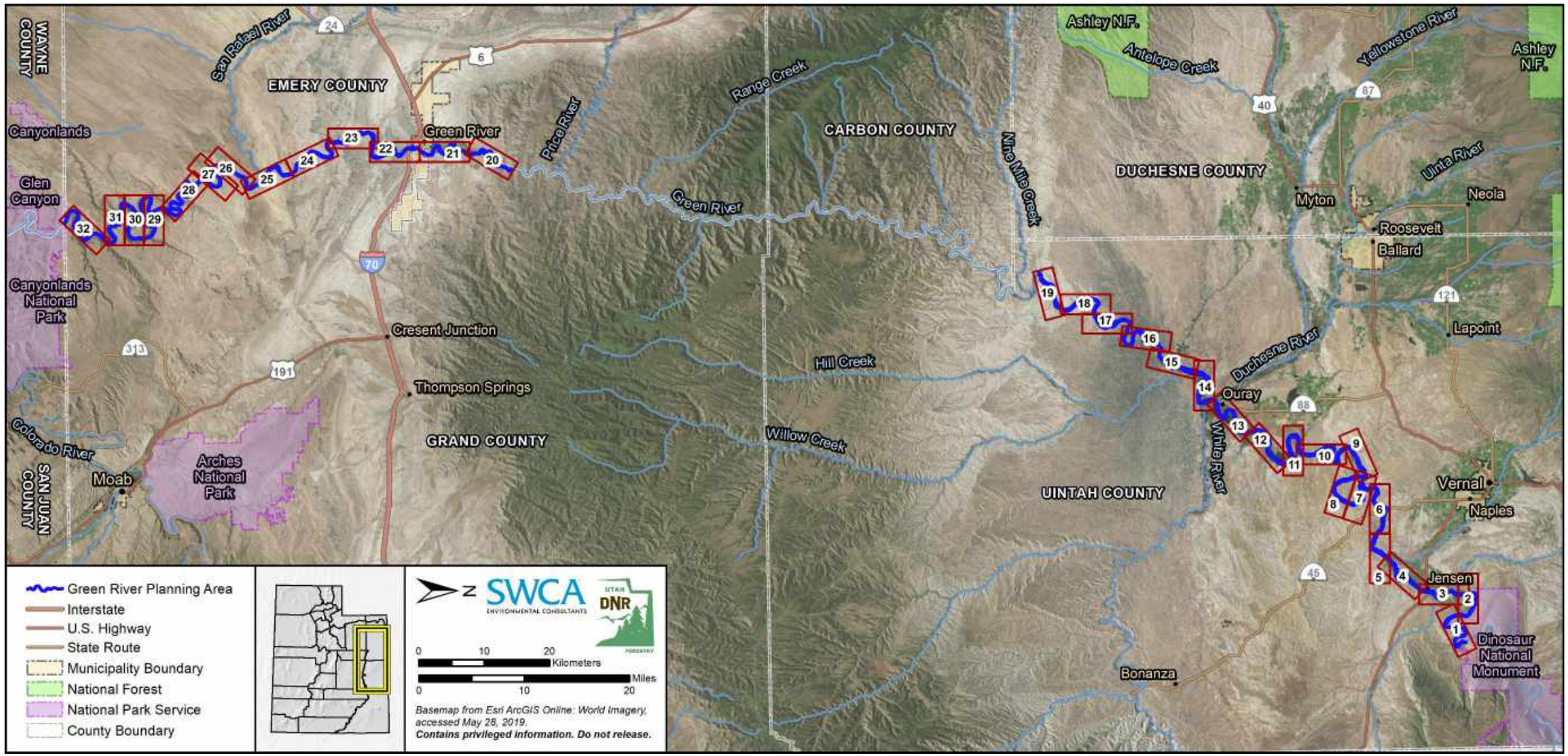


Figure 1.7. River use classes map book index for the Green River Comprehensive Management Plan planning area.

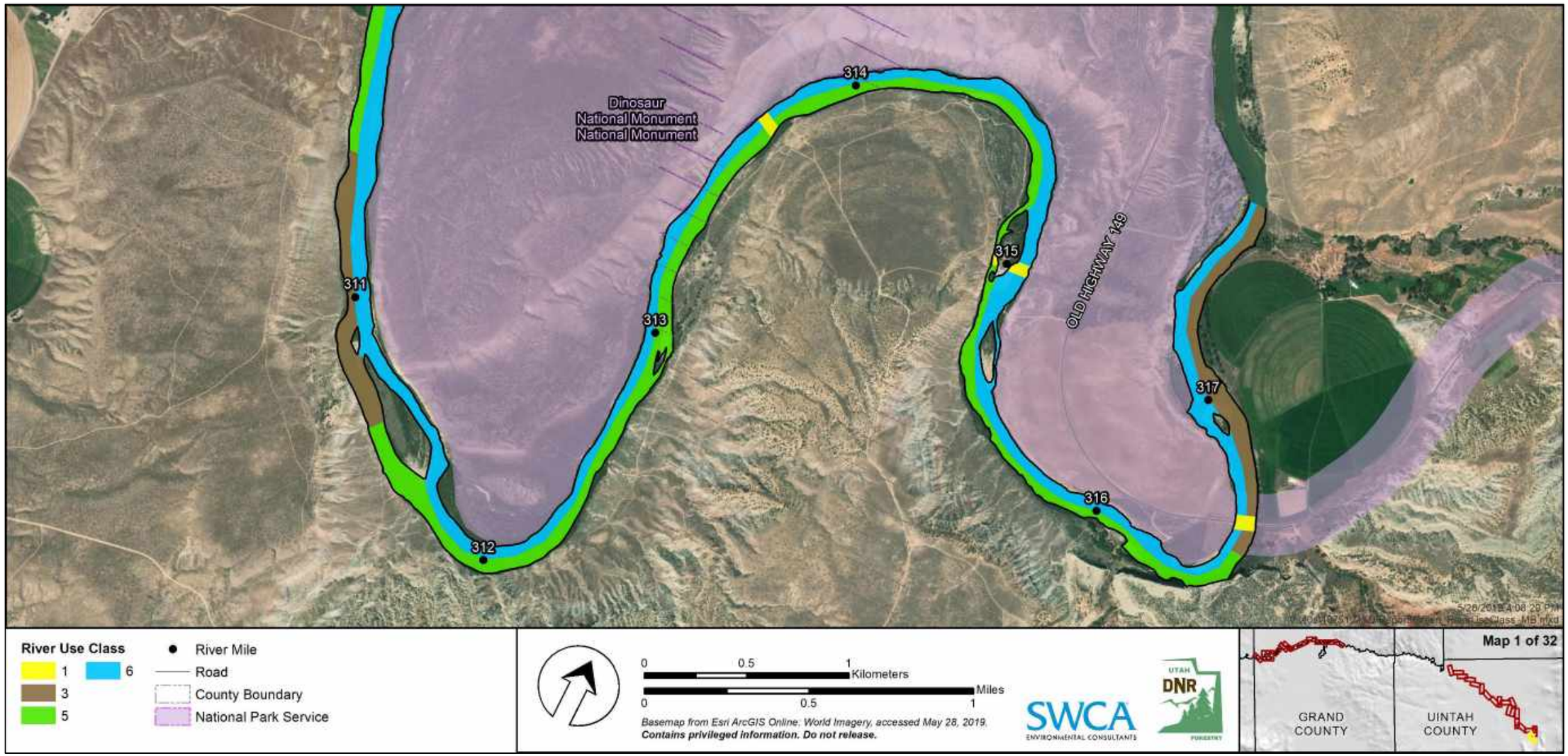


Figure 1.8. River use classes for the Green River, Map 1 of 32.

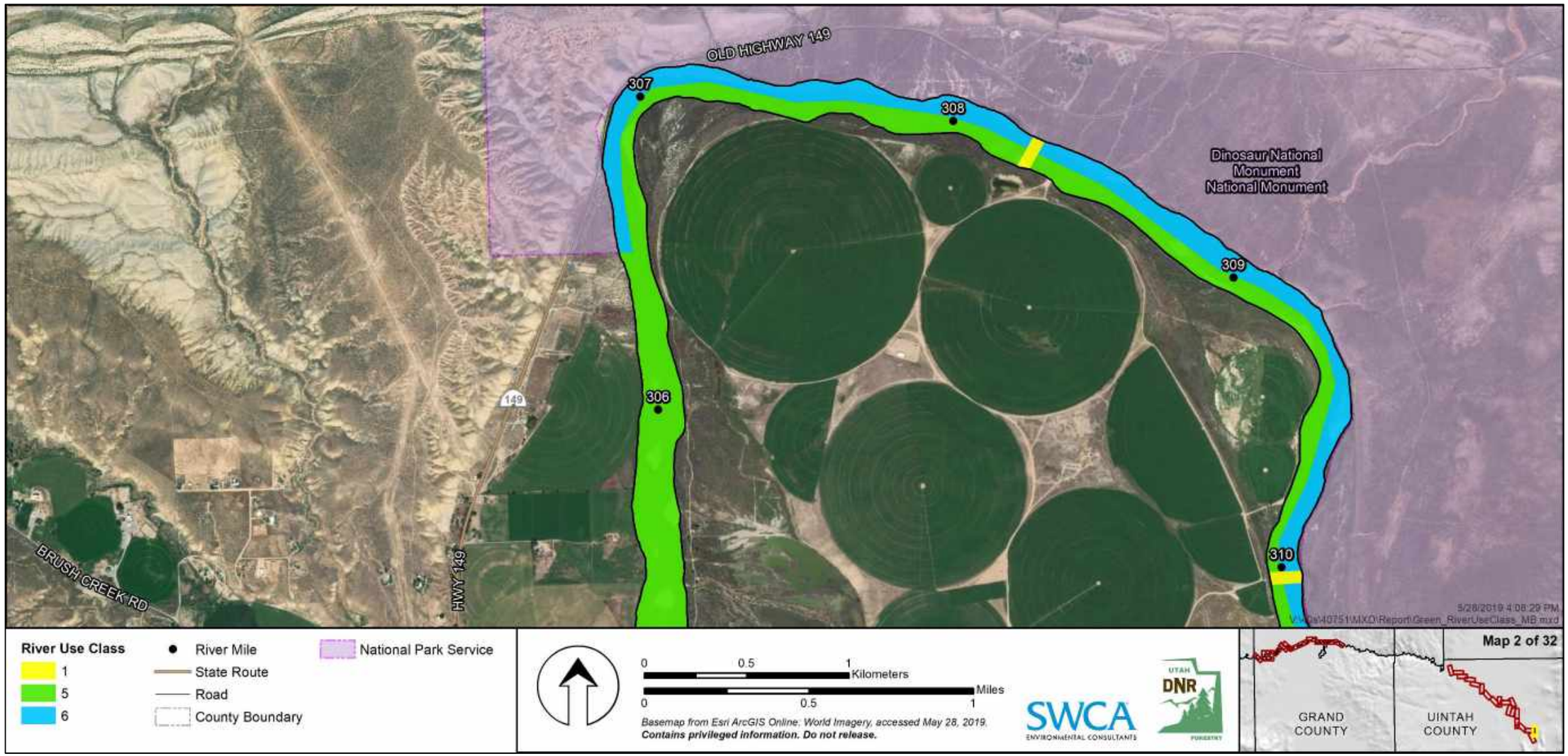


Figure 1.9. River use classes for the Green River, Map 2 of 32.

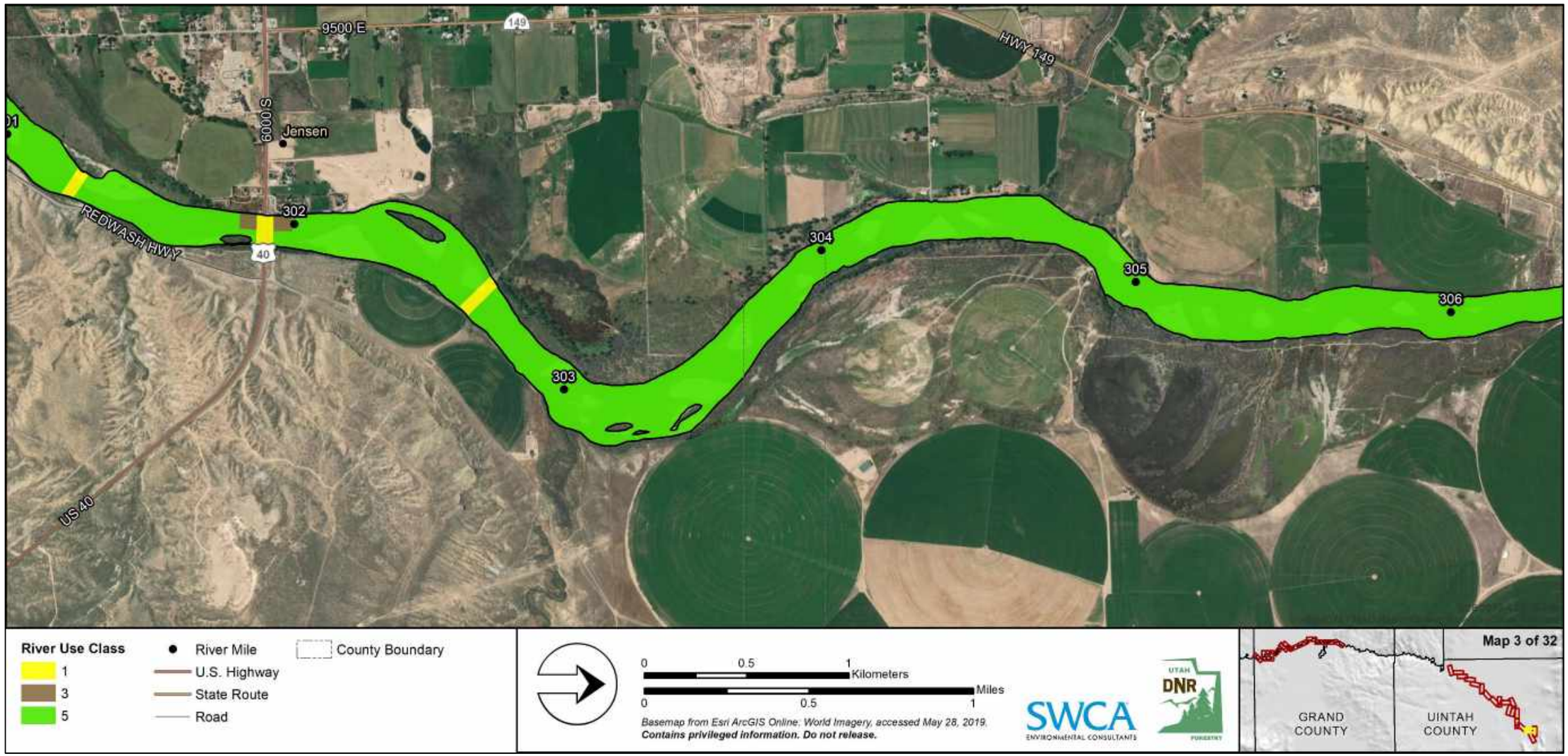


Figure 1.10. River use classes for the Green River, Map 3 of 32.

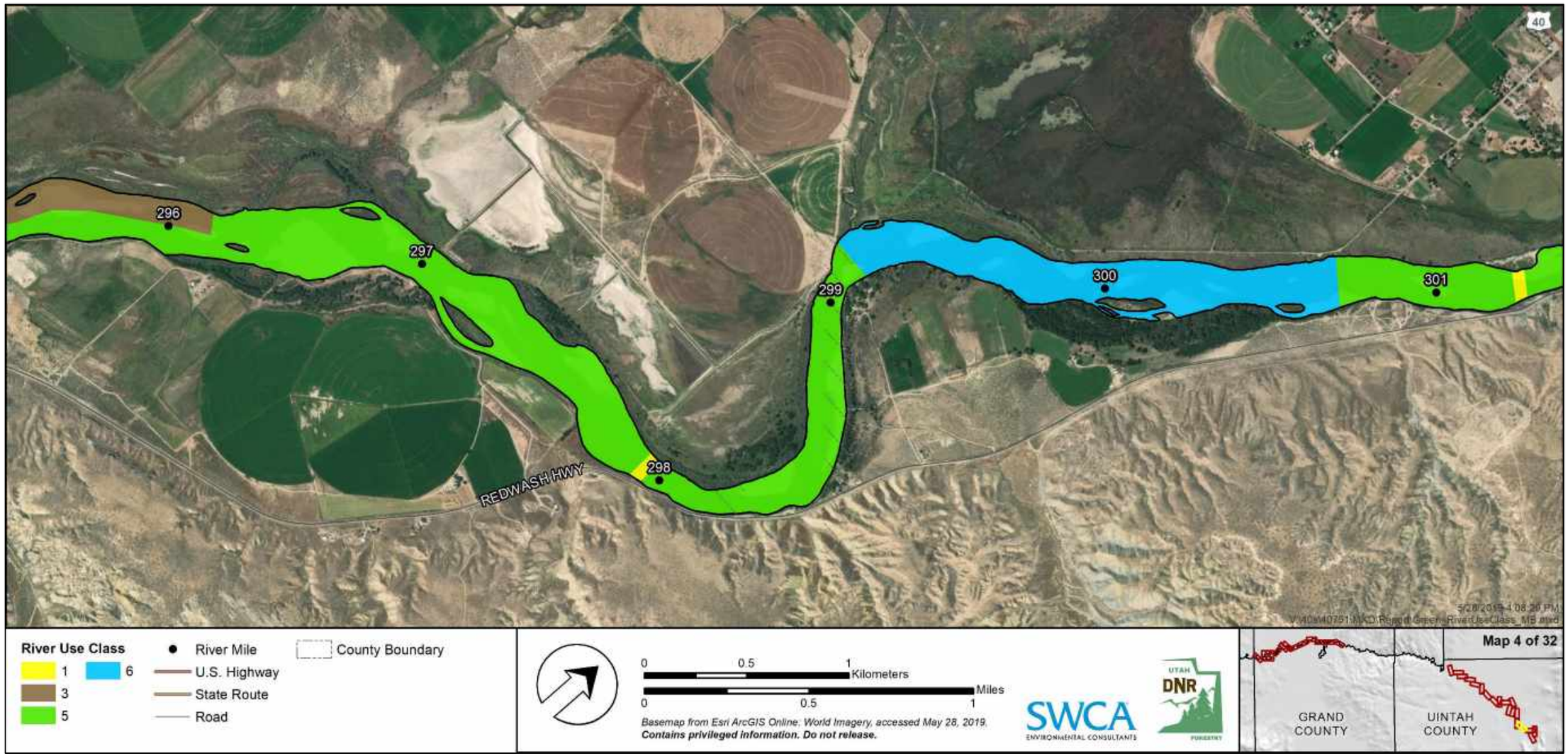


Figure 1.11. River use classes for the Green River, Map 4 of 32.

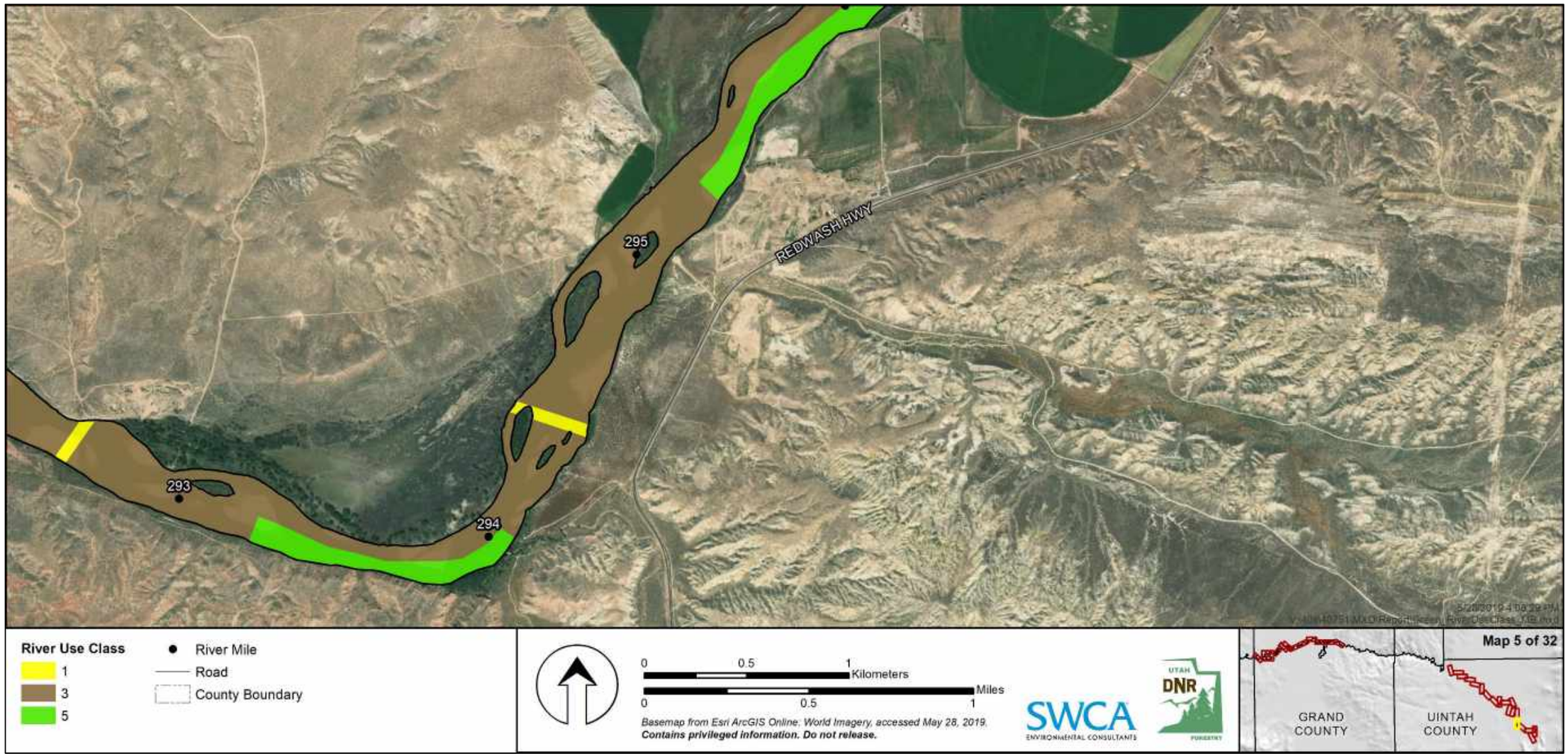


Figure 1.12. River use classes for the Green River, Map 5 of 32.

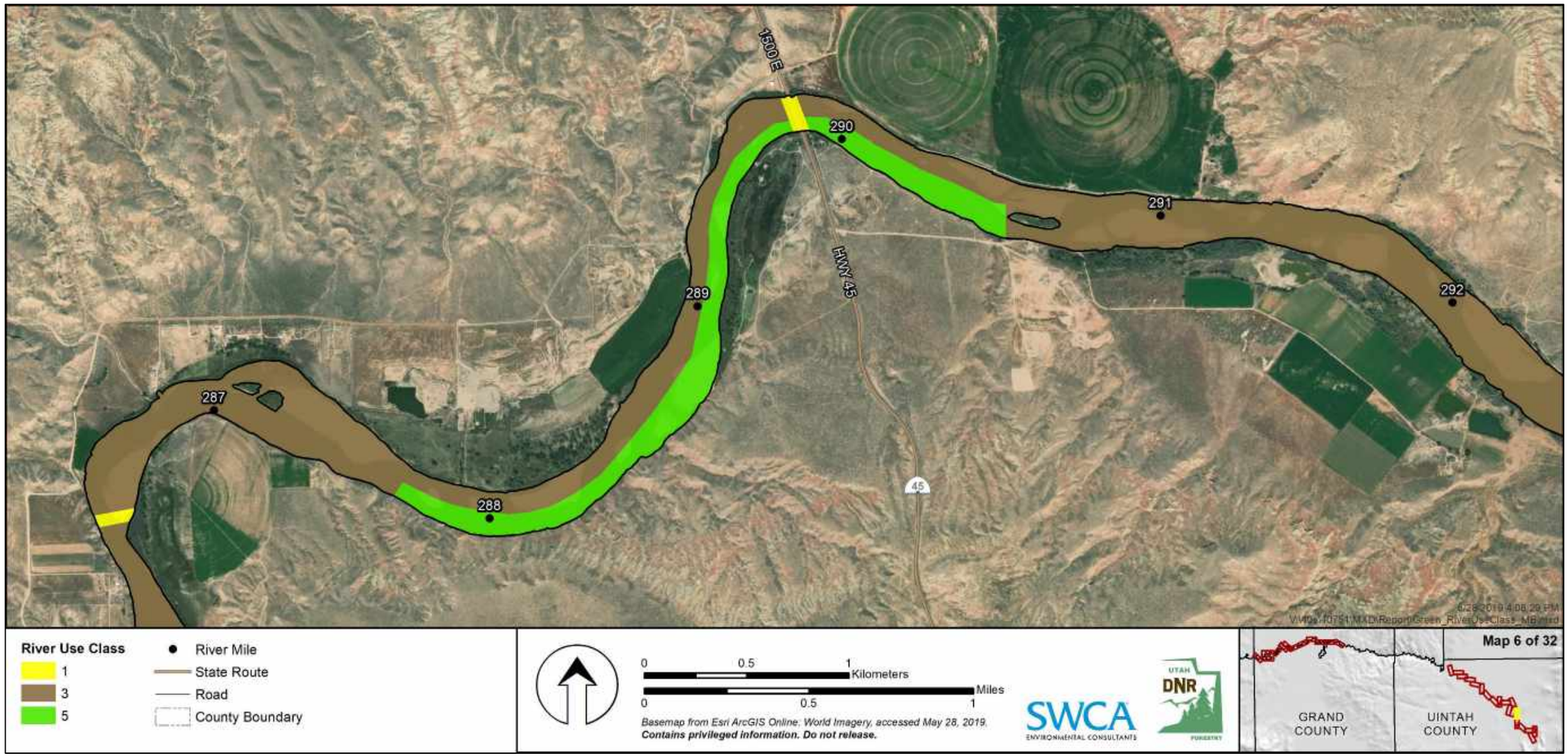


Figure 1.13. River use classes for the Green River, Map 6 of 32.

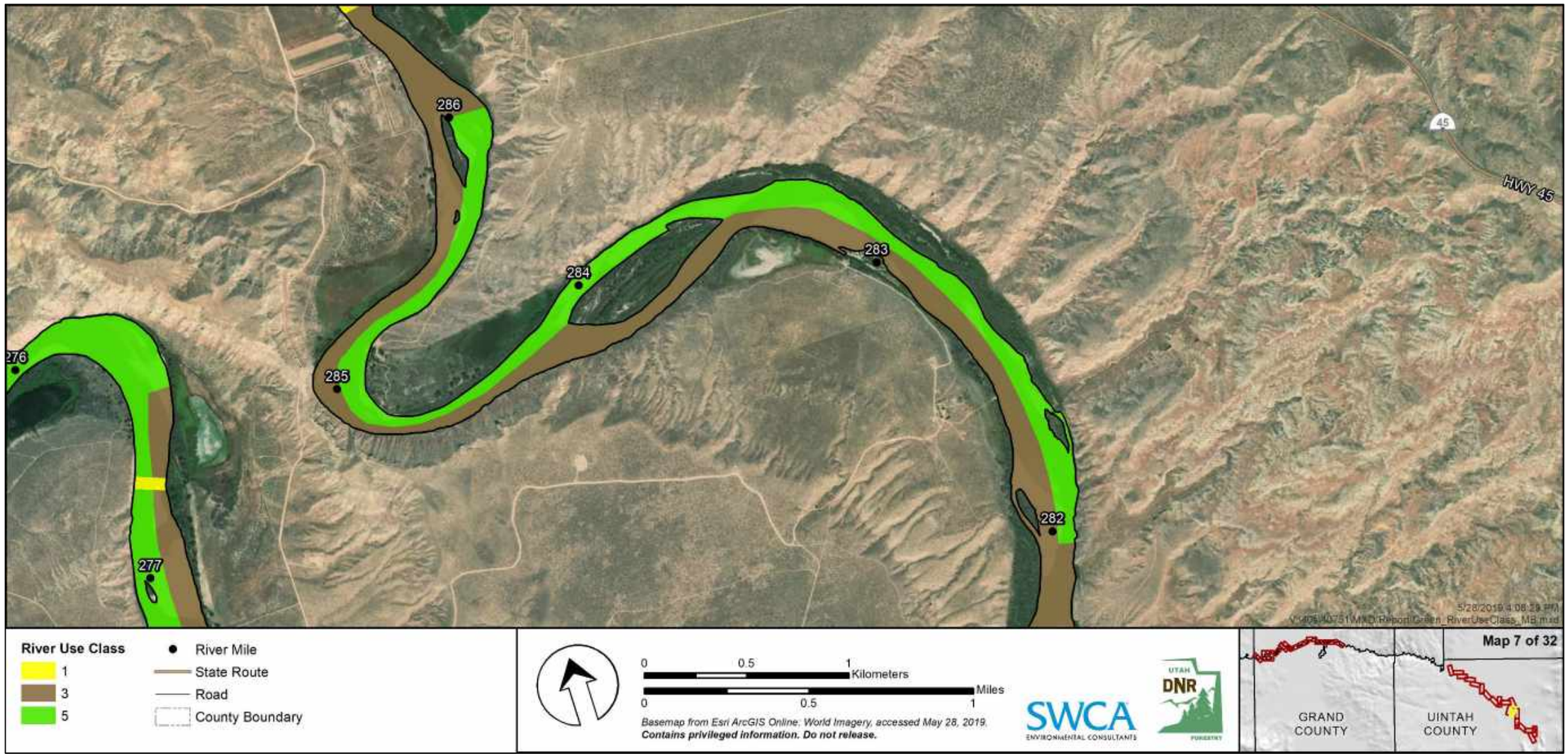
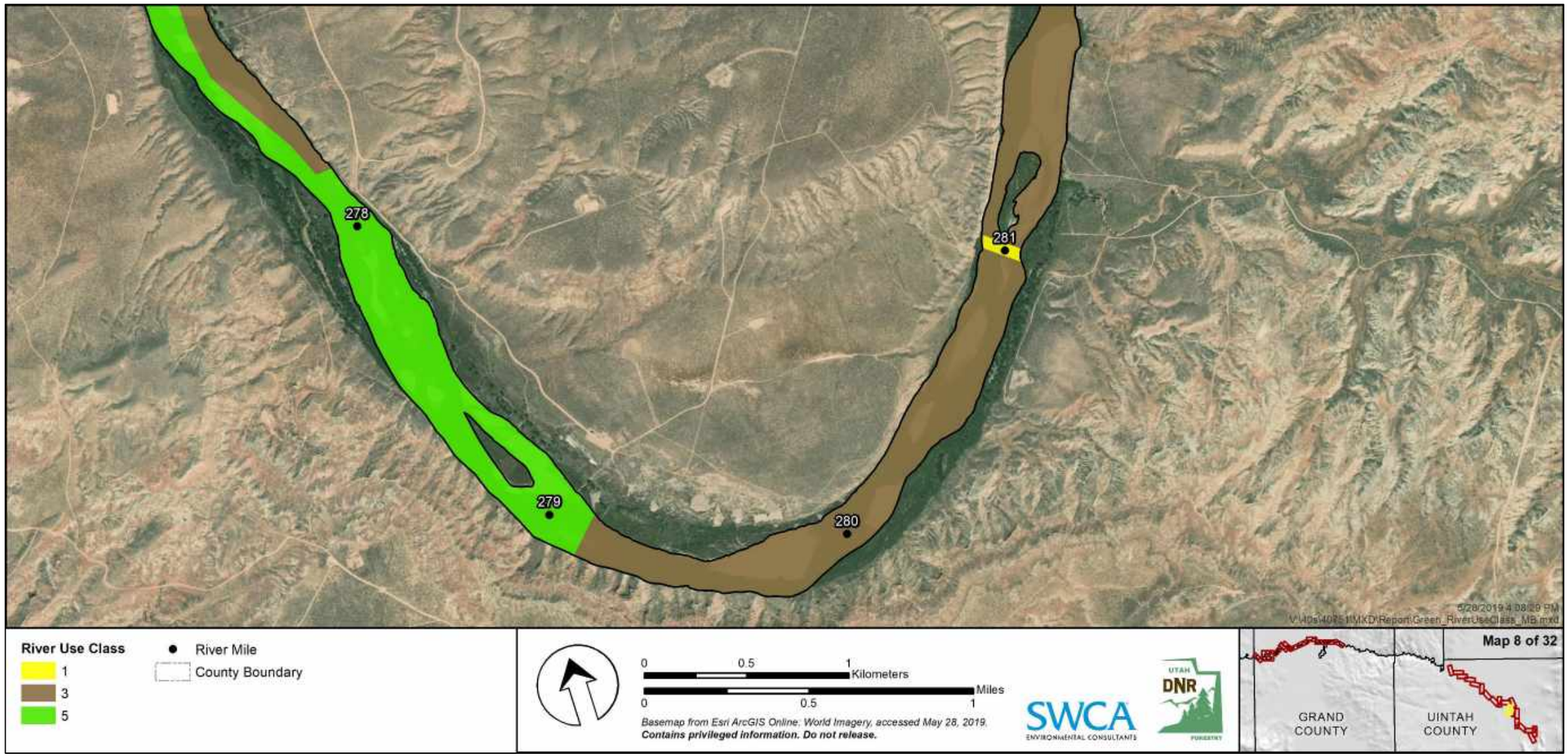


Figure 1.14. River use classes for the Green River, Map 7 of 32.



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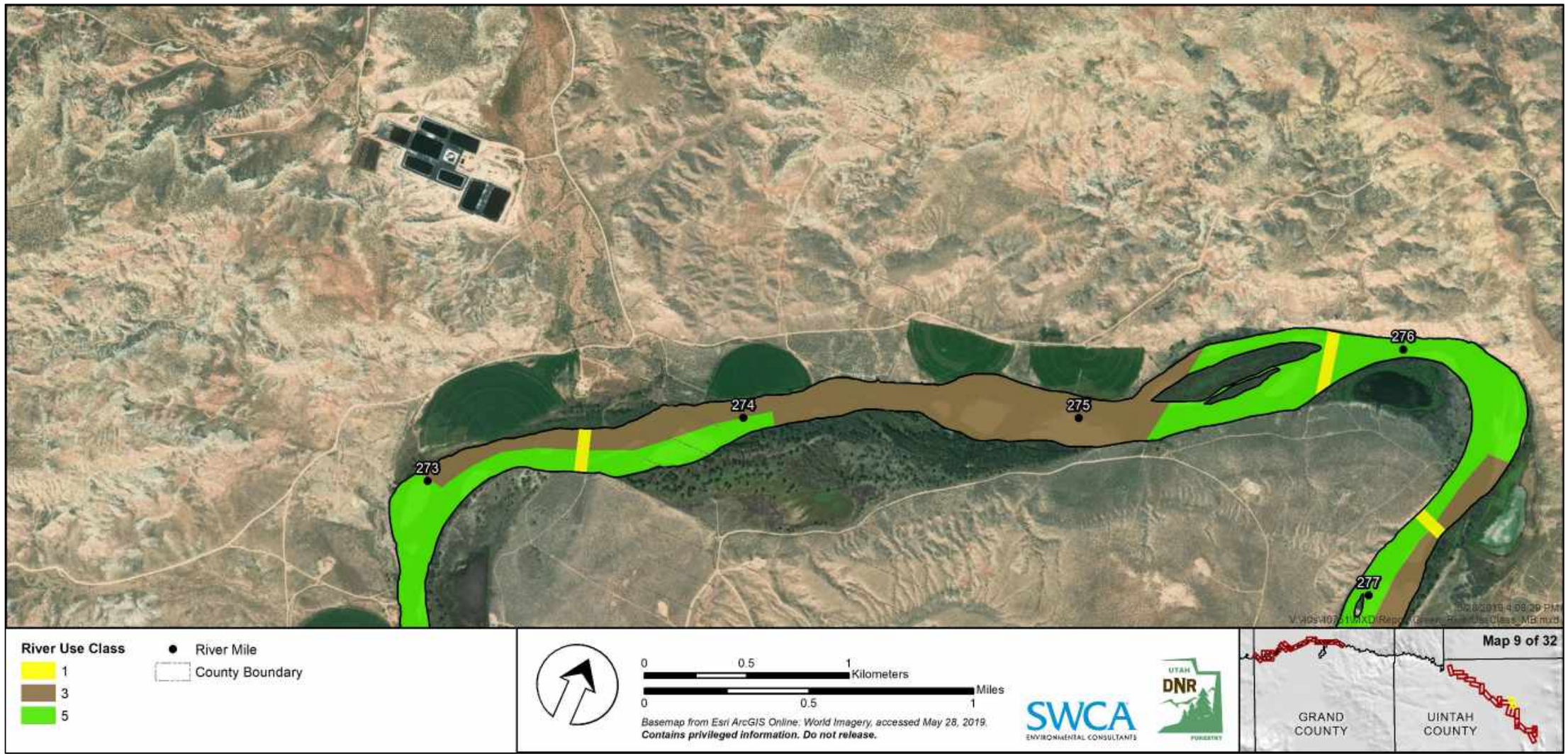

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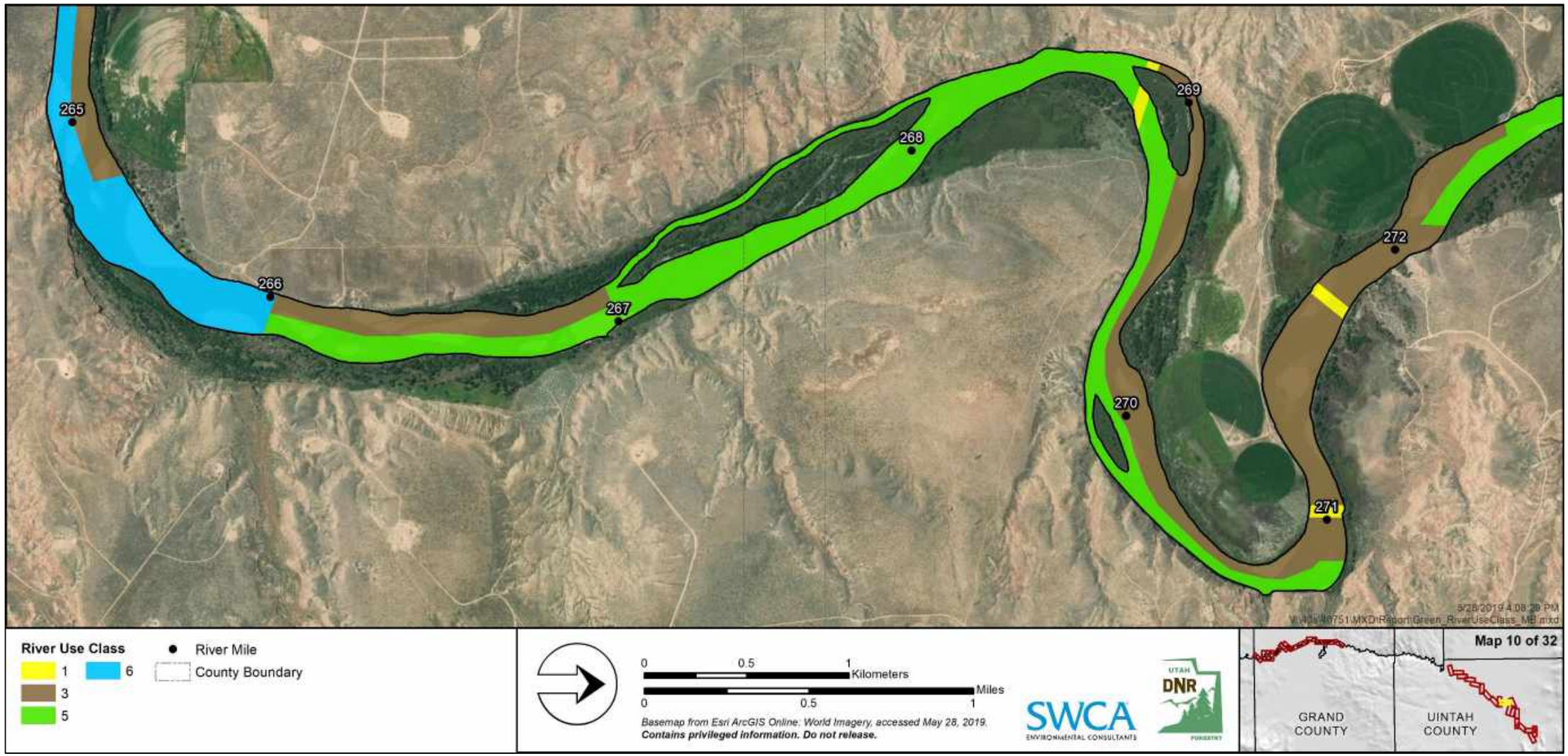
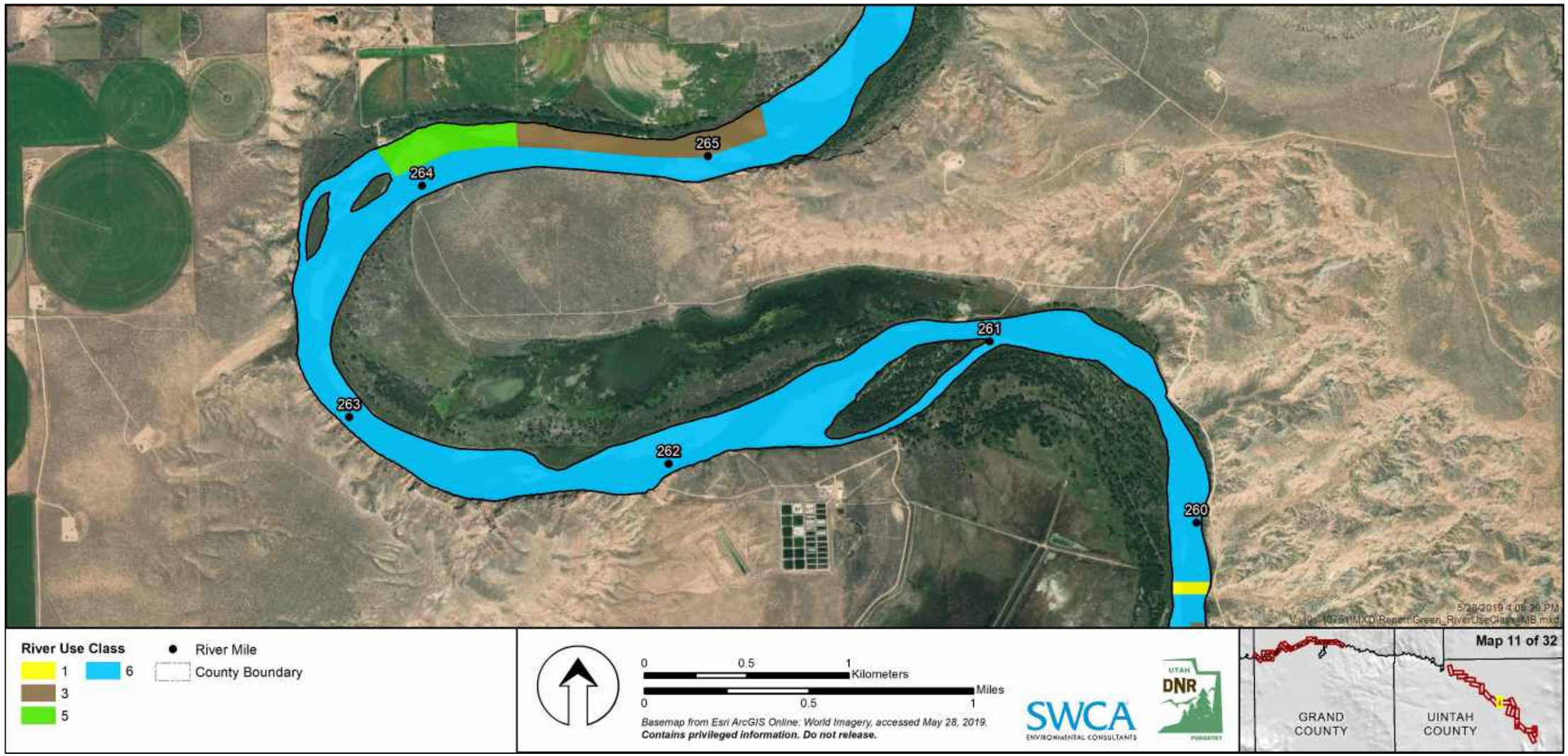


Figure 1.17. River use classes for the Green River, Map 10 of 32.



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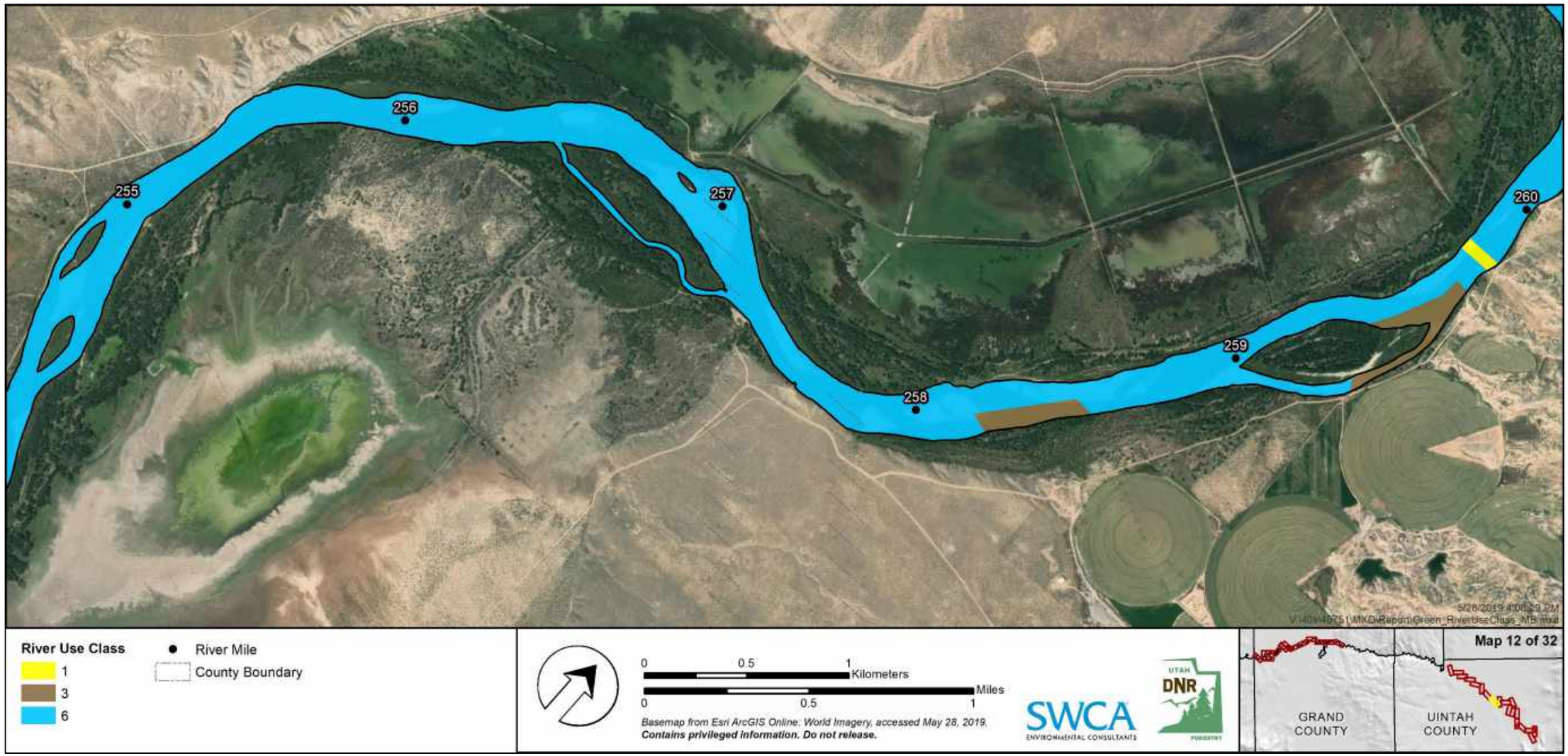
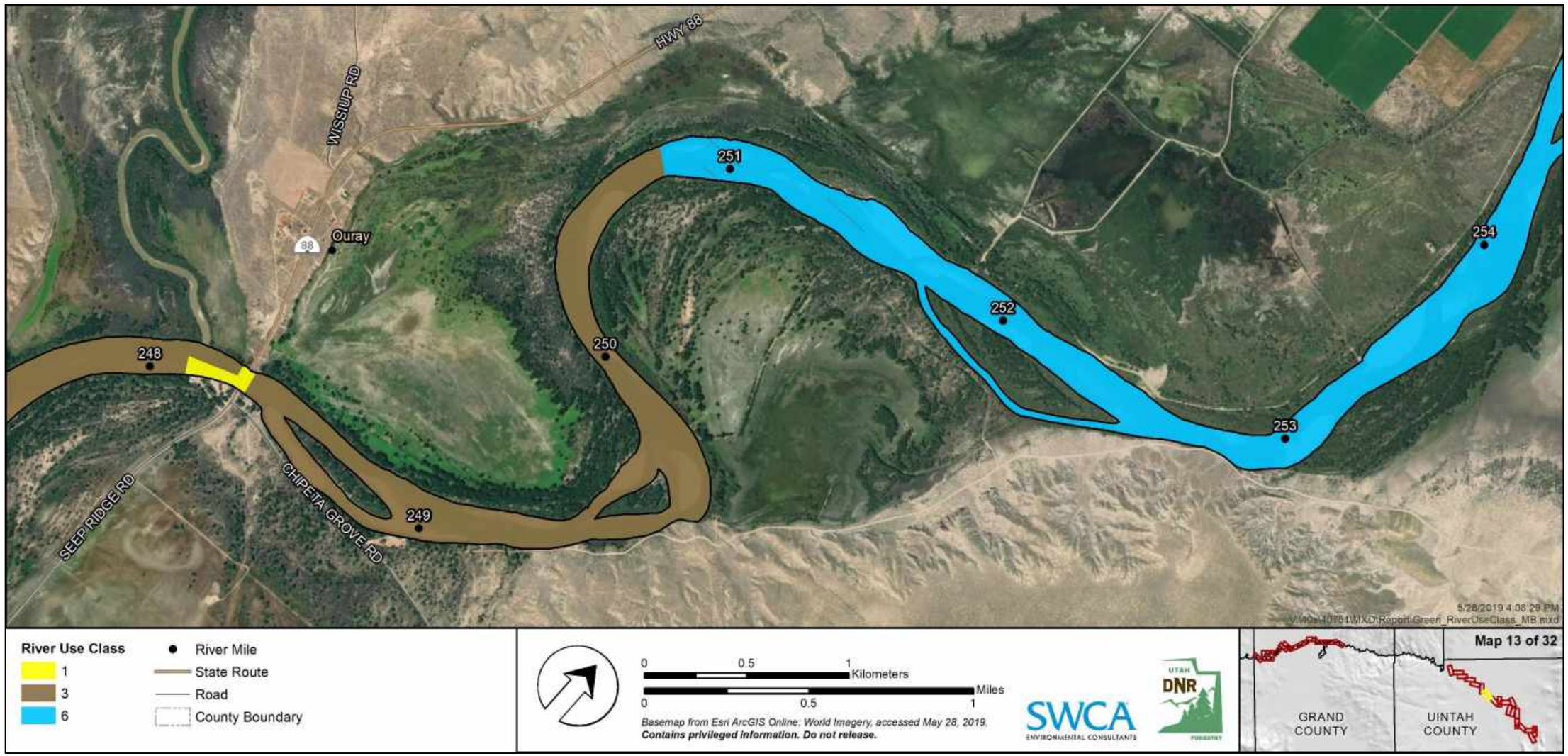


Figure 1.19. River use classes for the Green River, Map 12 of 32.



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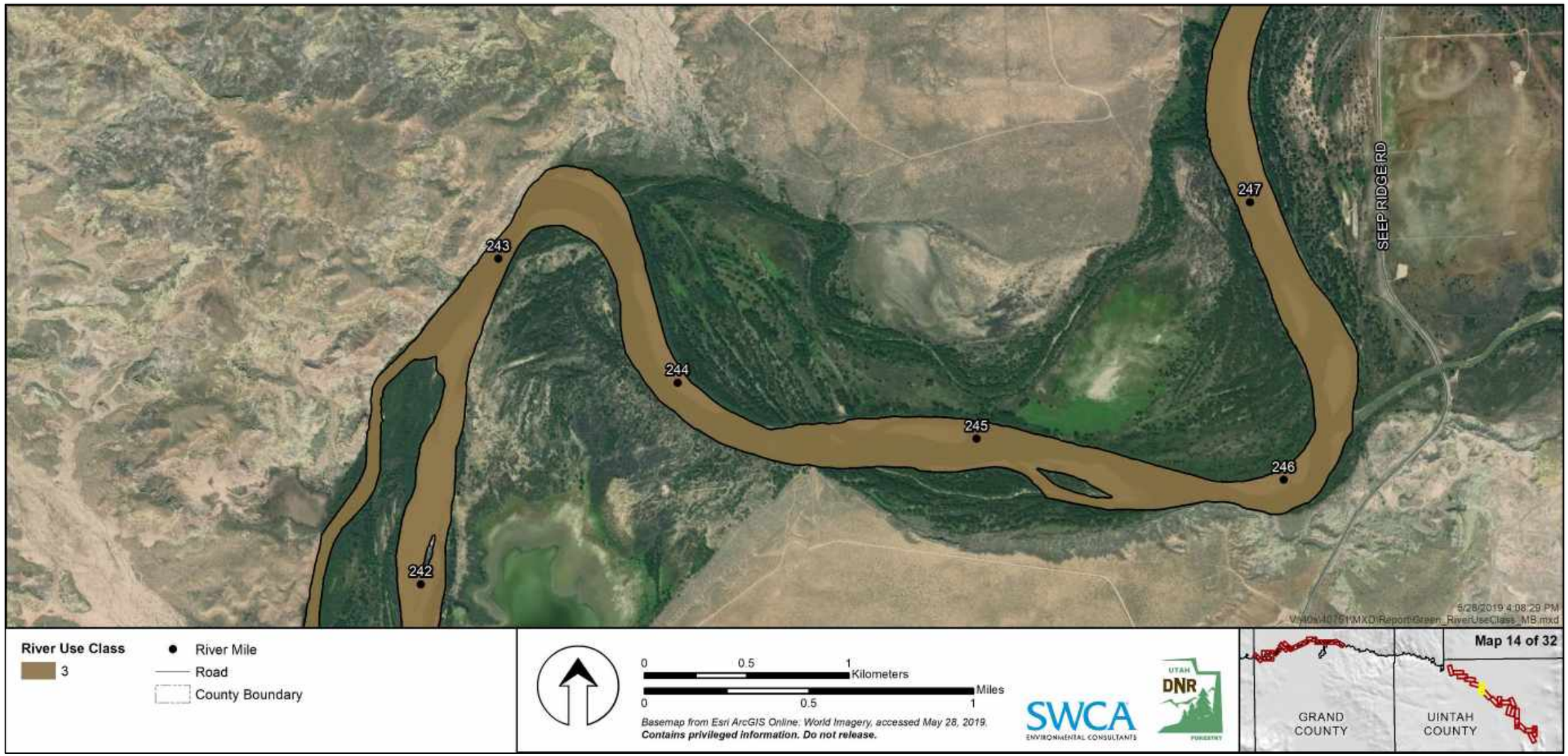

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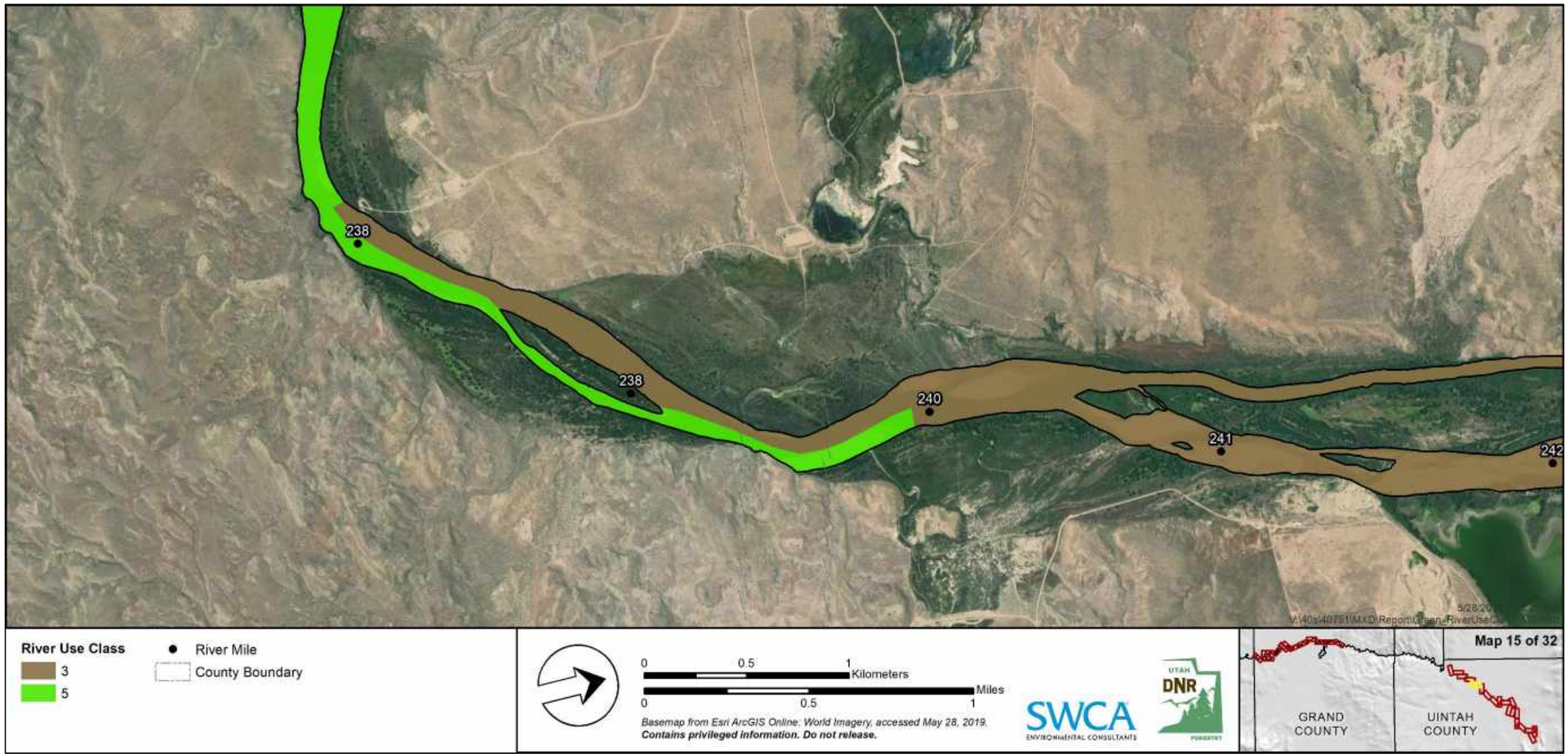
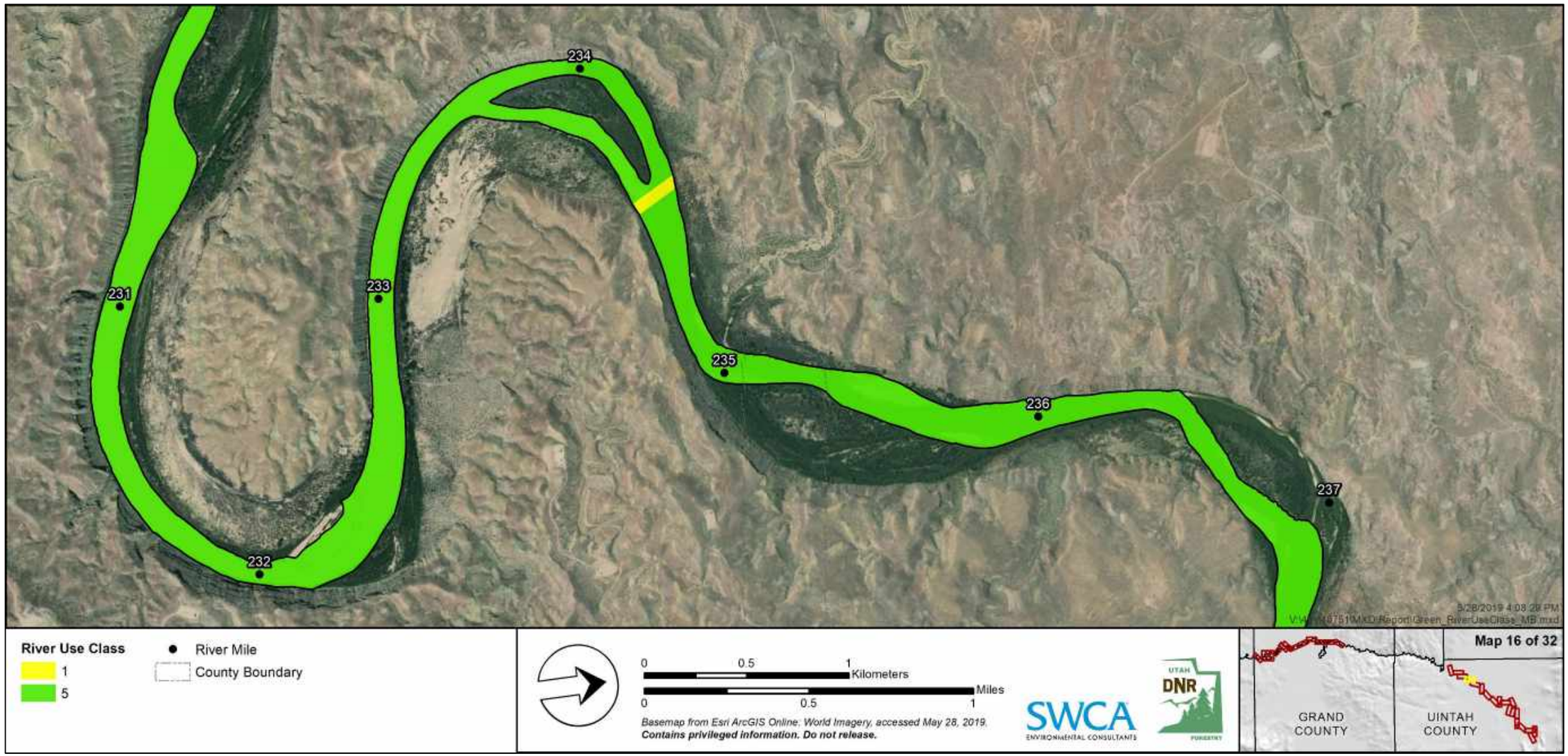


Figure 1.22. River use classes for the Green River, Map 15 of 32.



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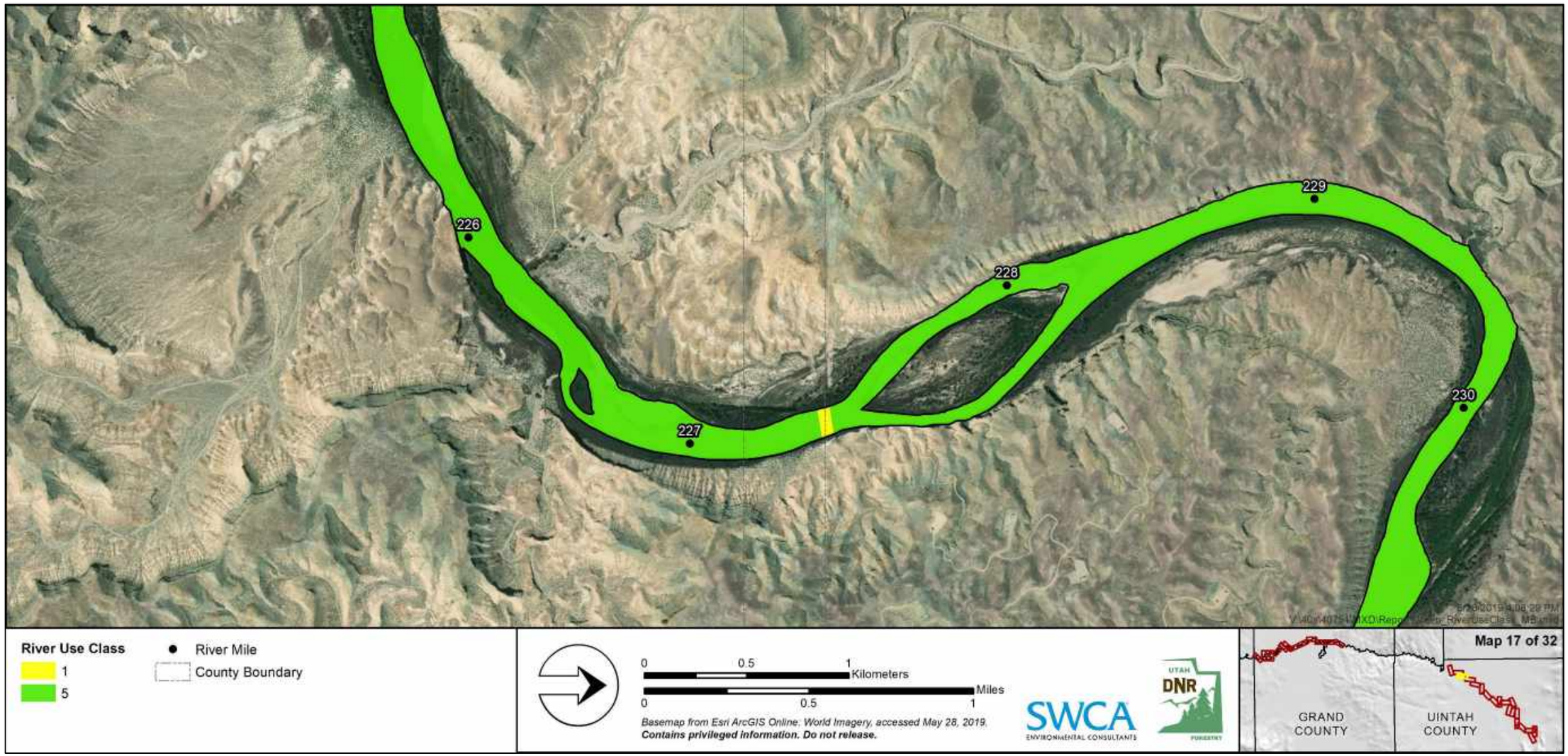


Figure 1.24. River use classes for the Green River, Map 17 of 32.

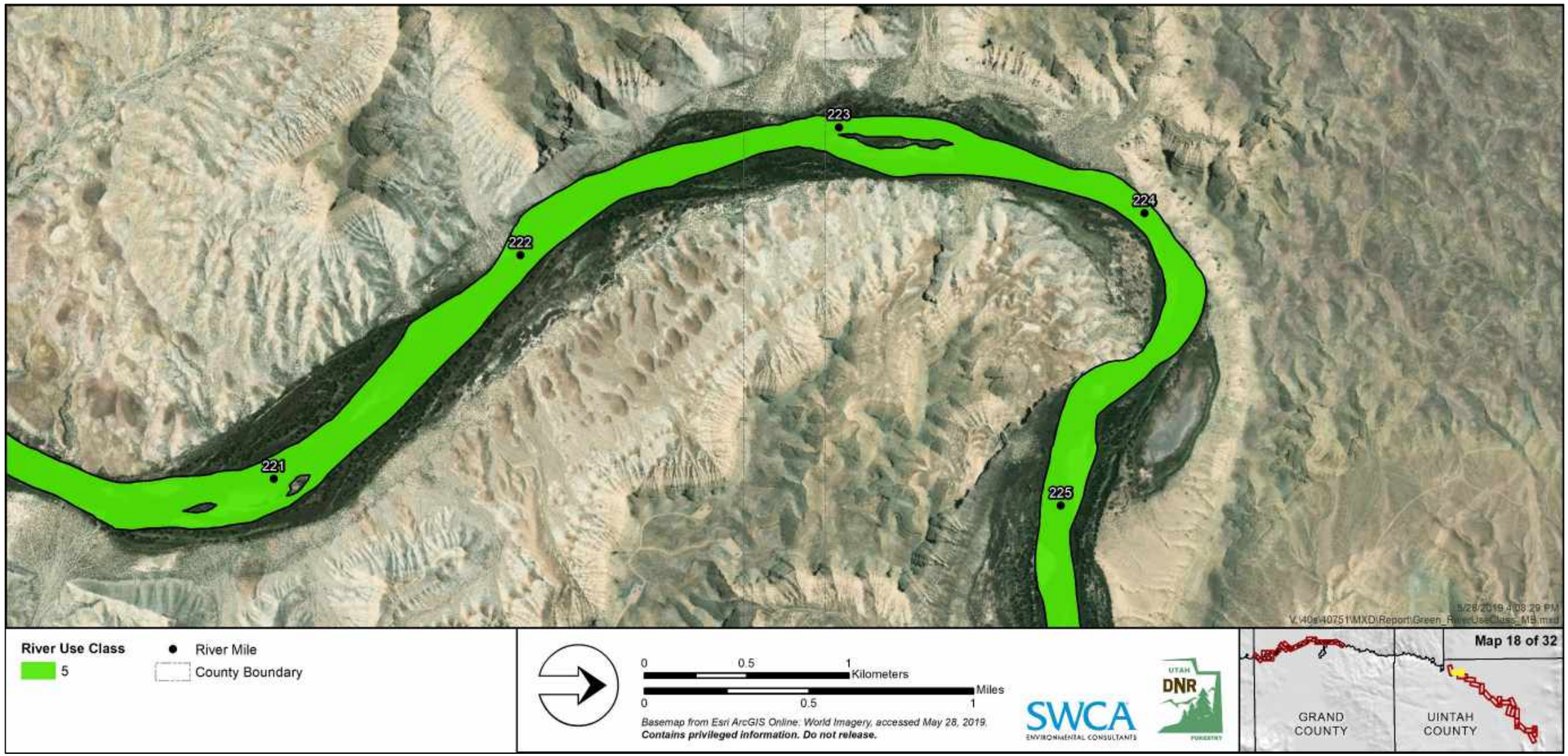
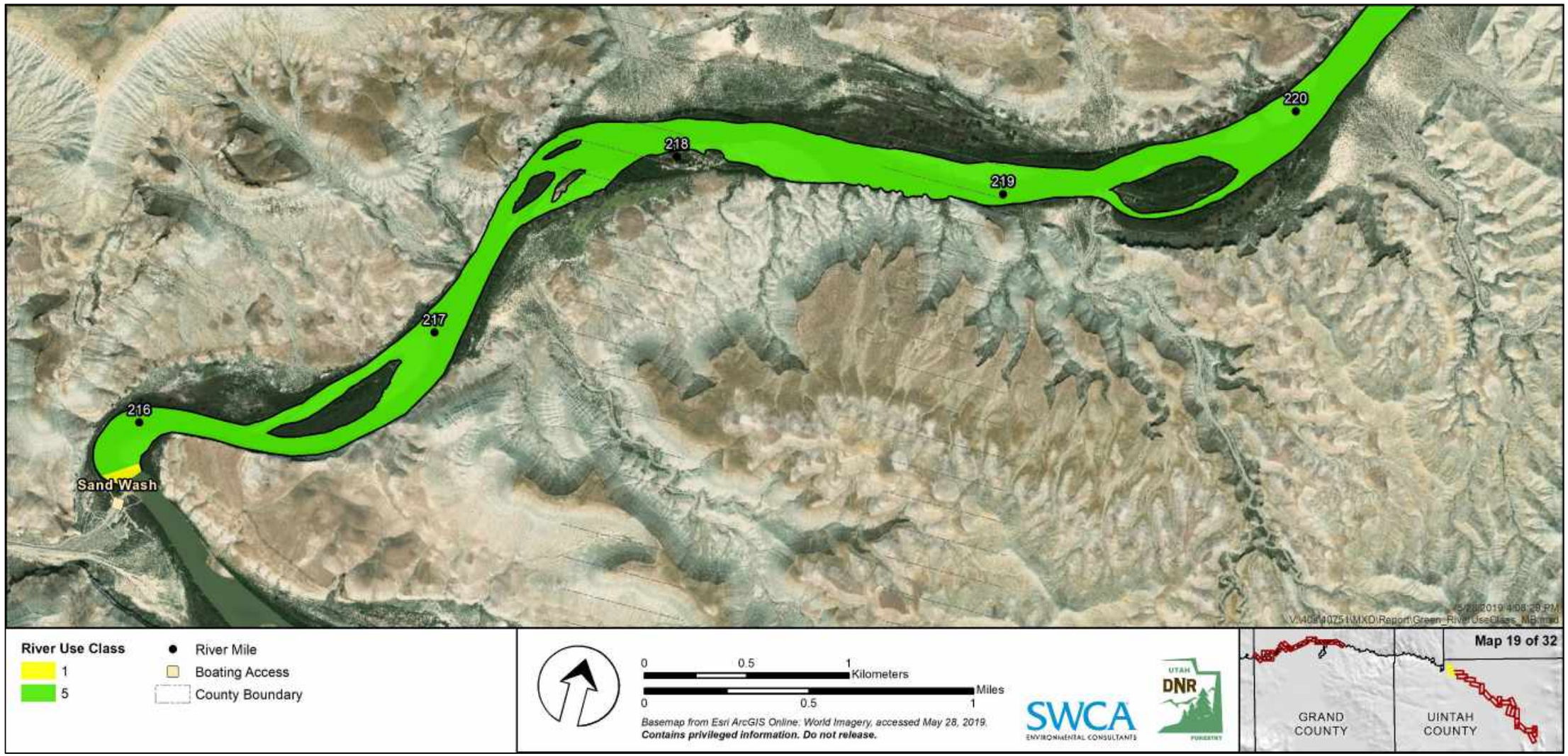


Figure 1.25. River use classes for the Green River, Map 18 of 32.



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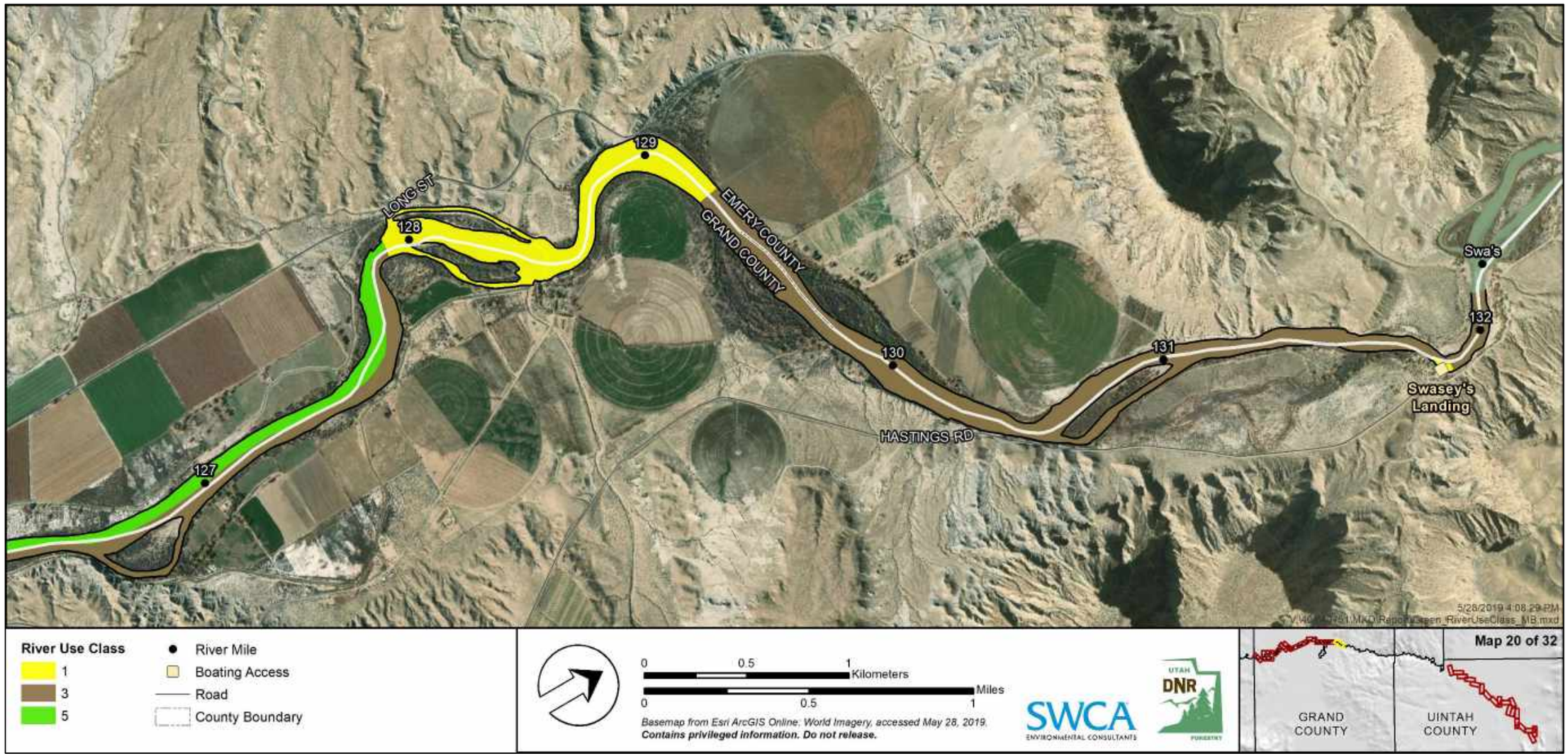

Figure 1.27. River use classes for the Green River, Map 20 of 32.

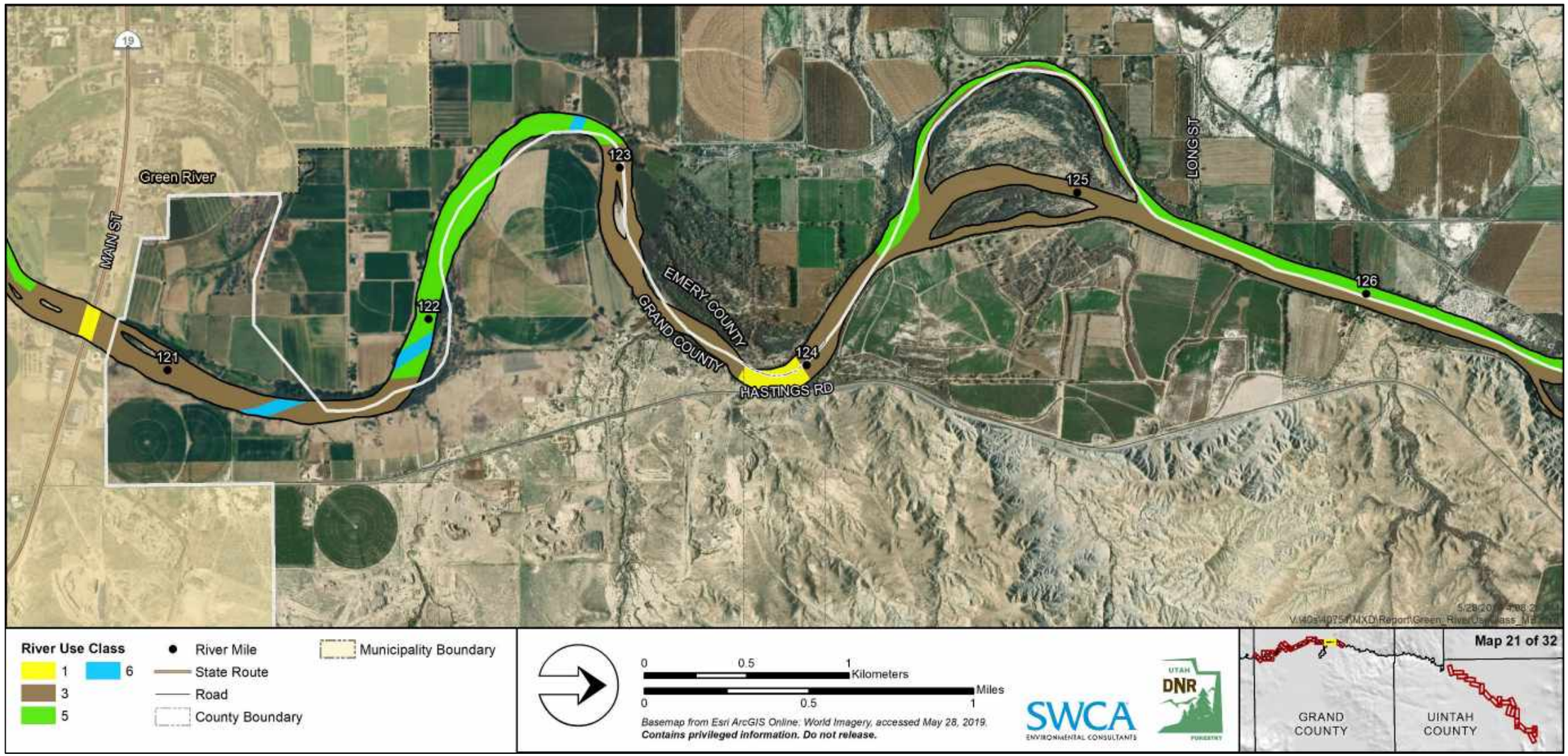

Figure 1.28. River use classes for the Green River, Map 21 of 32.

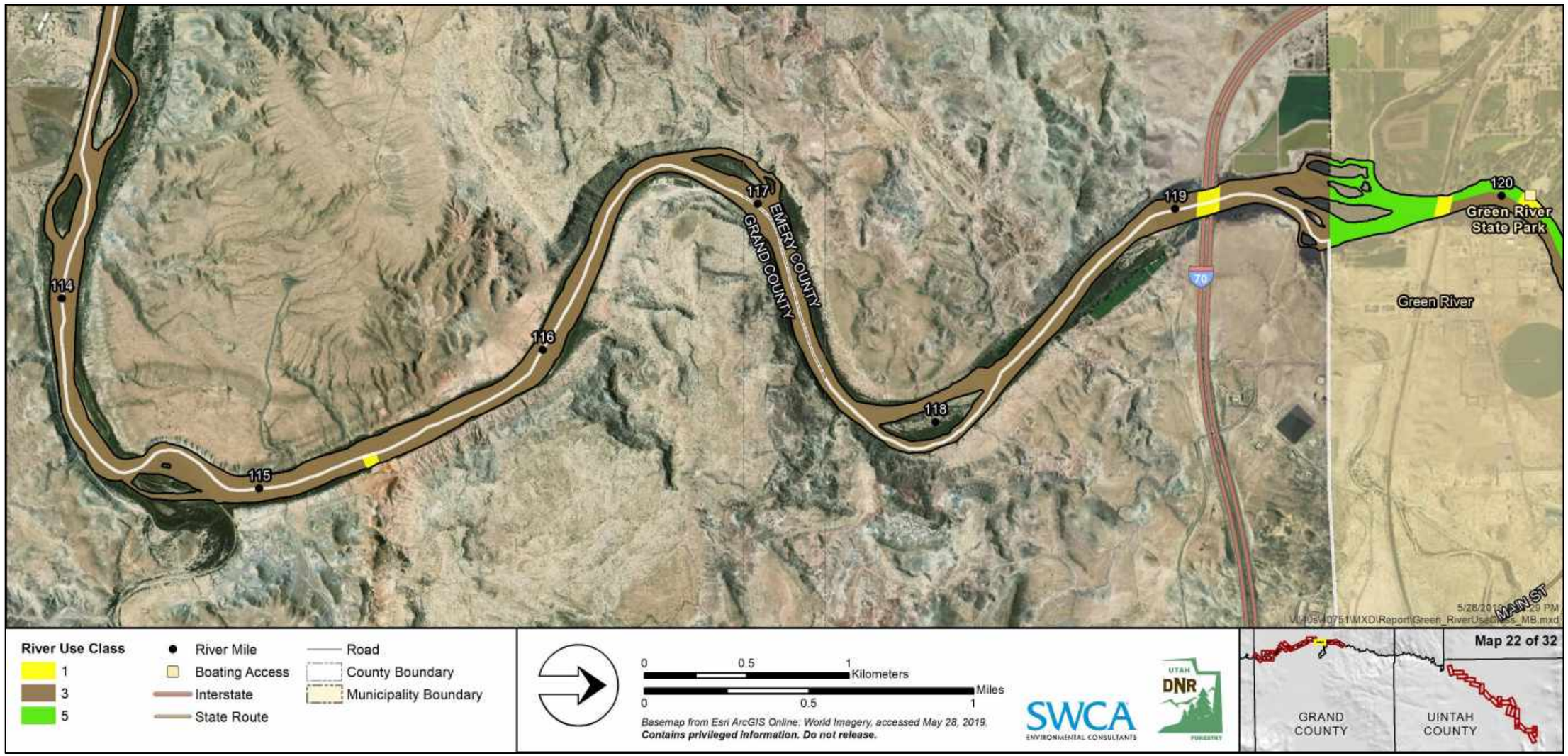

Figure 1.29. River use classes for the Green River, Map 22 of 32.

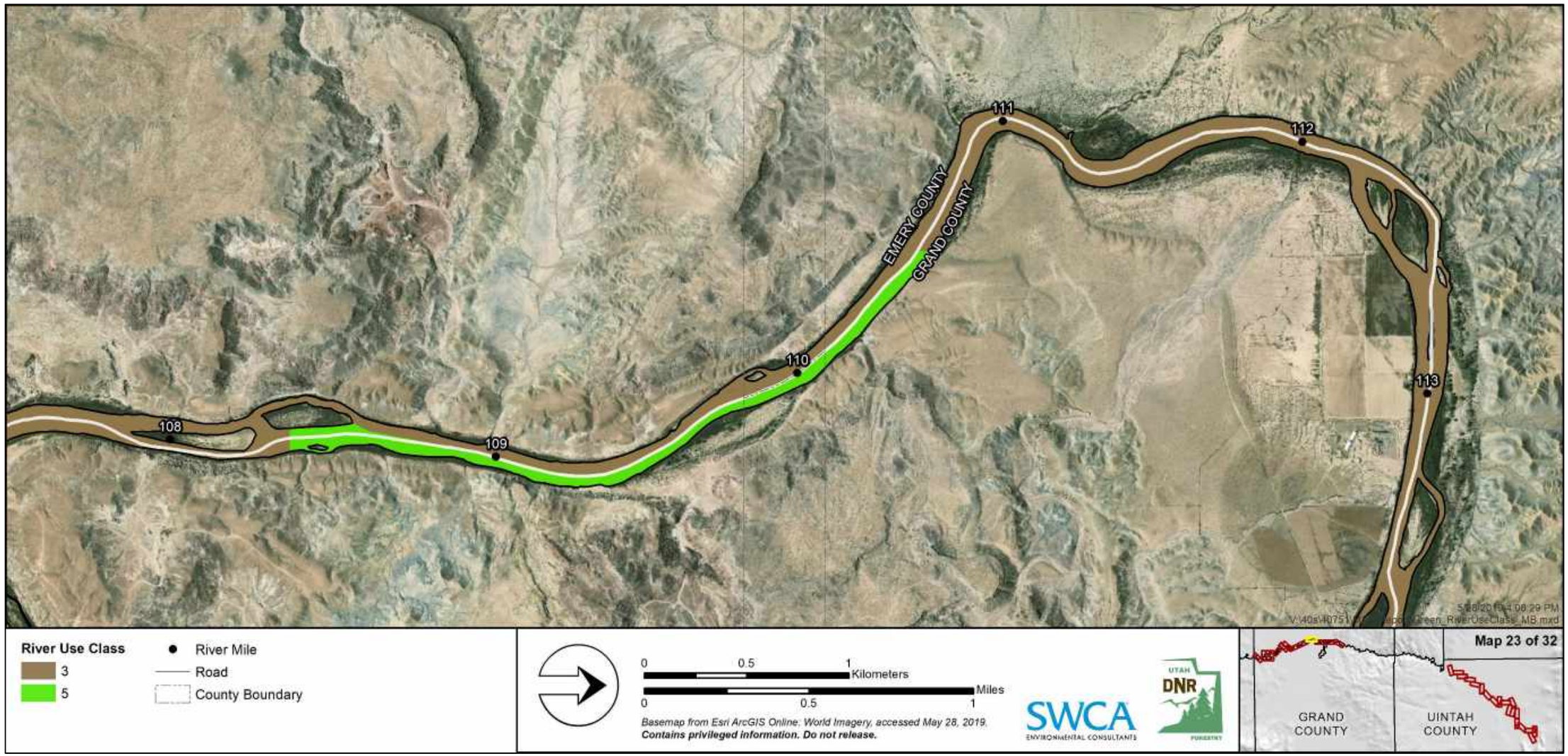

Figure 1.30. River use classes for the Green River, Map 23 of 32.

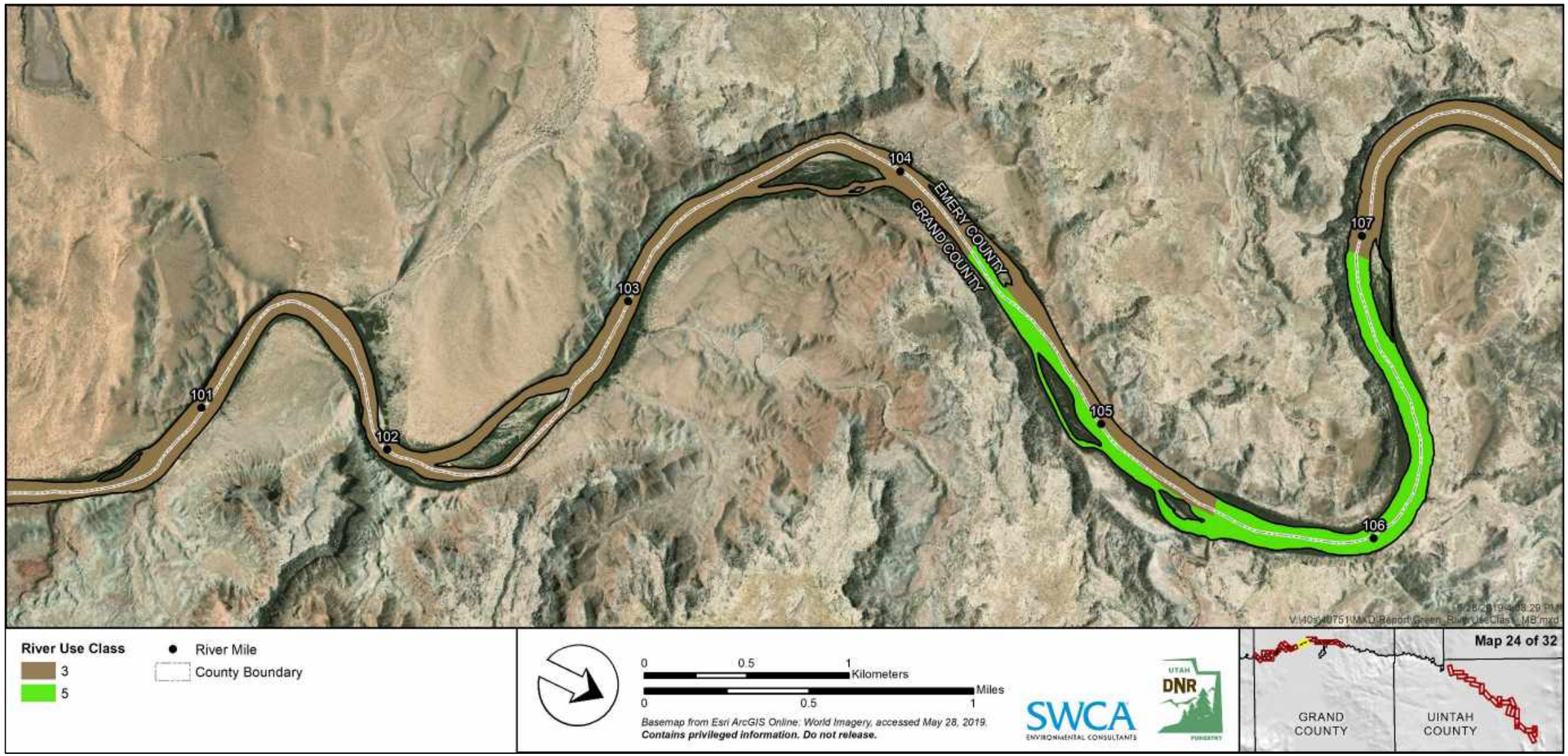

Figure 1.31. River use classes for the Green River, Map 24 of 32.

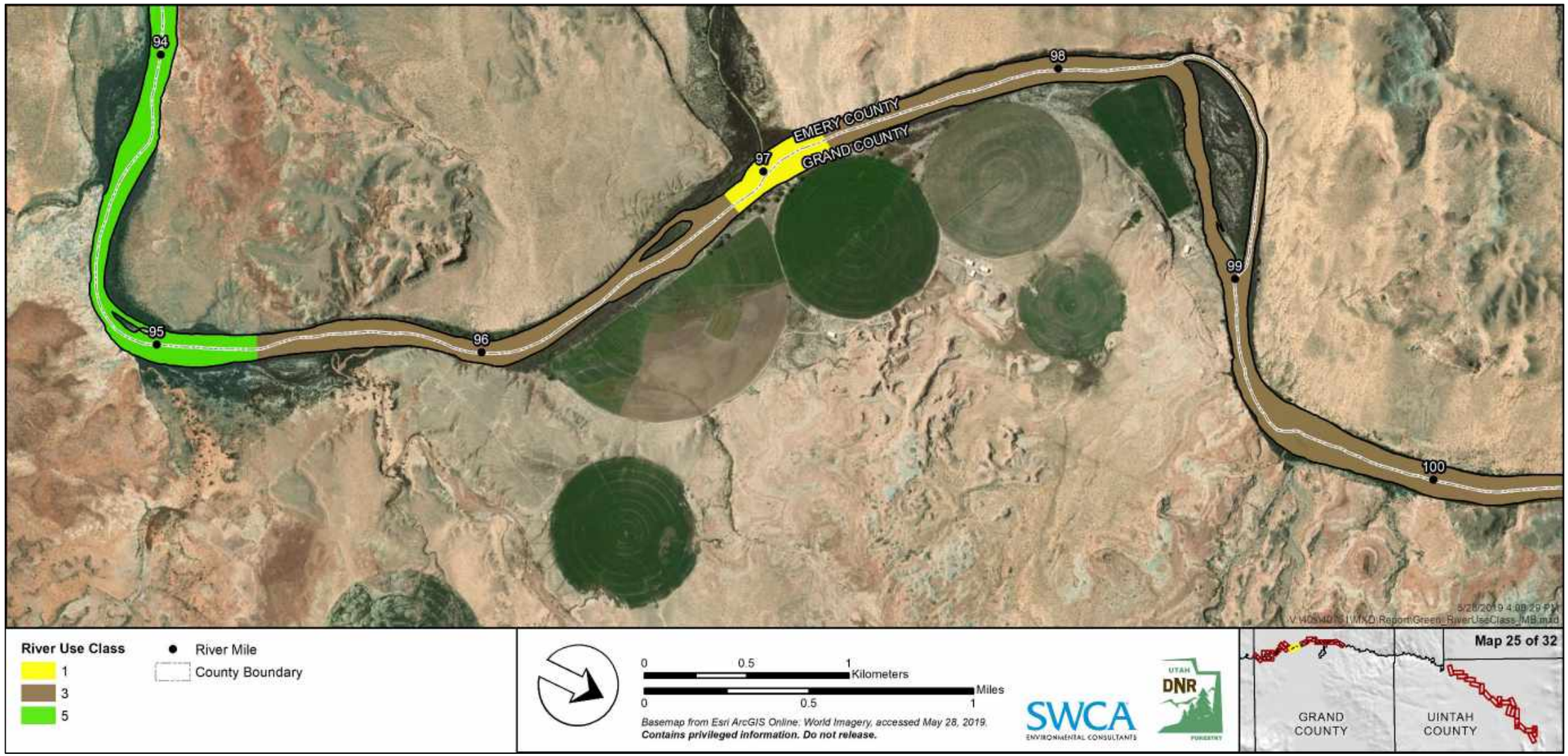

Figure 1.32. River use classes for the Green River, Map 25 of 32.

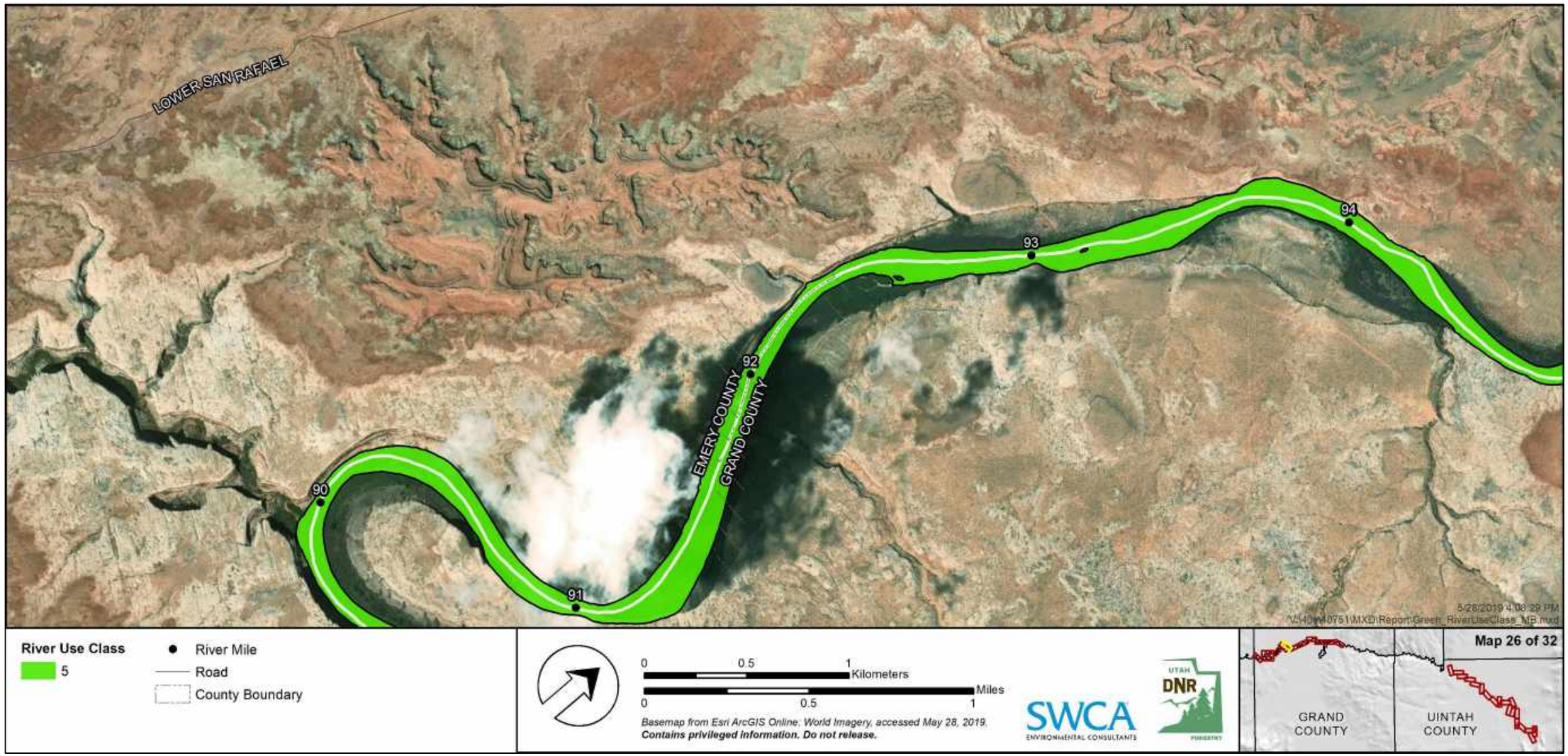

Figure 1.33. River use classes for the Green River, Map 26 of 32.

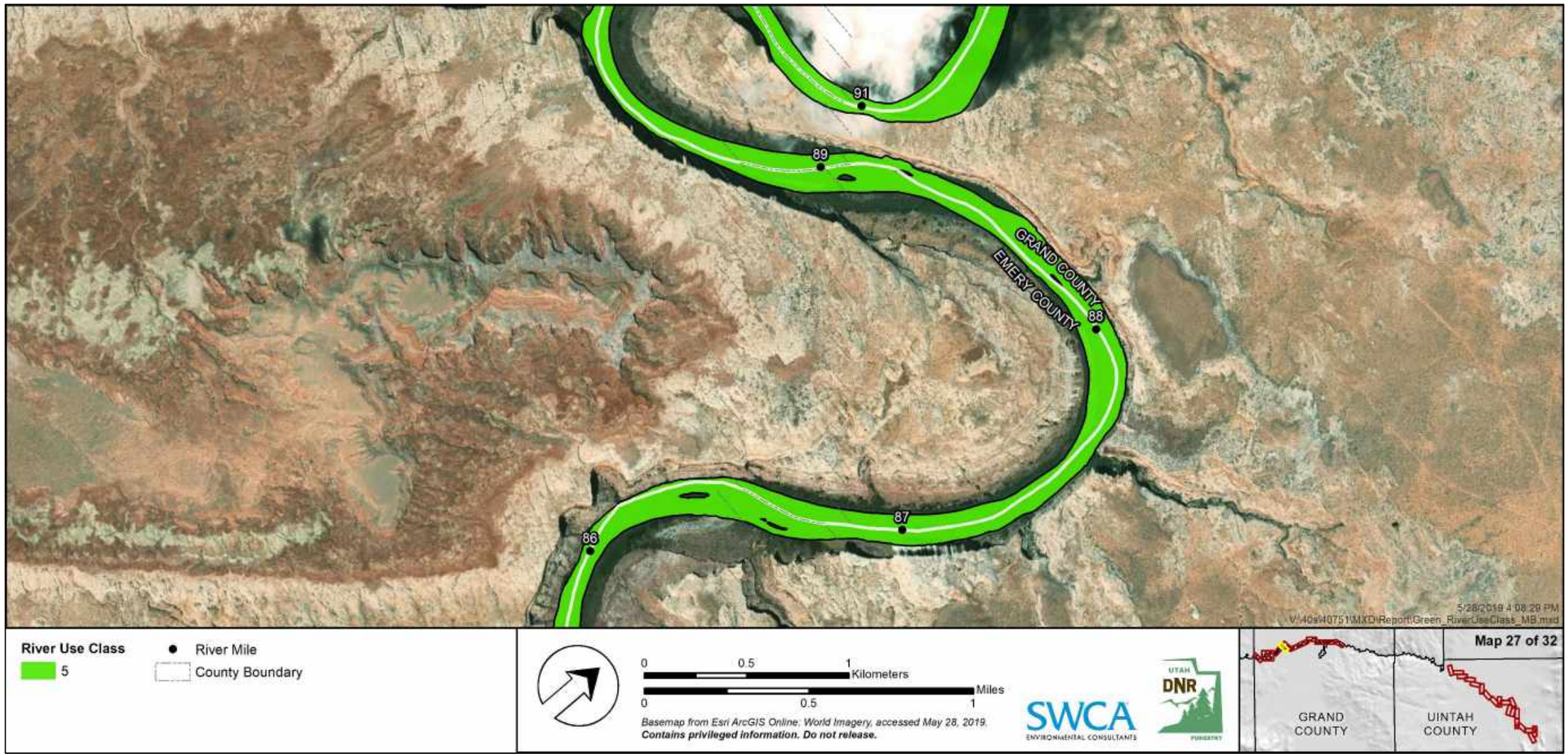

Figure 1.34. River use classes for the Green River, Map 27 of 32.

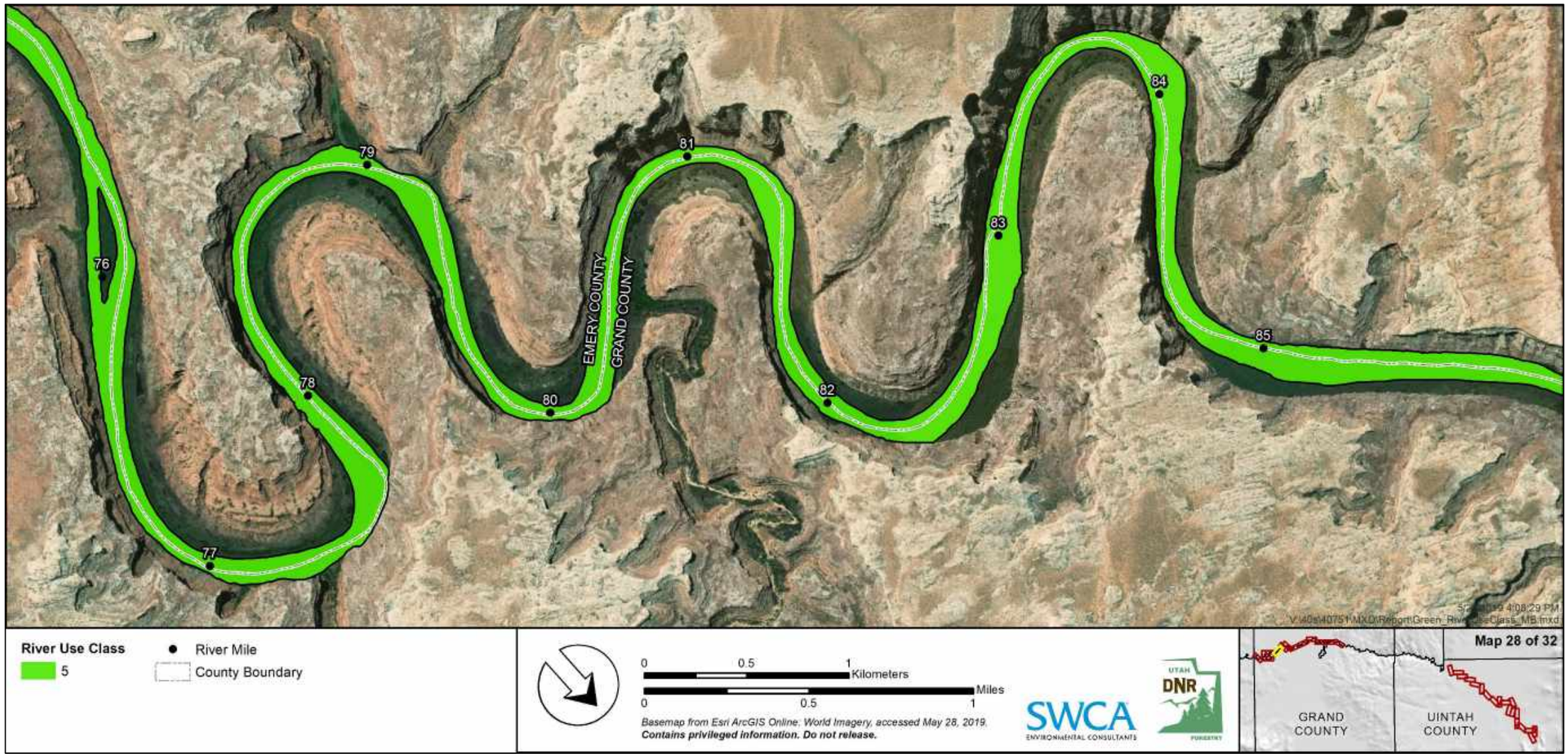

Figure 1.35. River use classes for the Green River, Map 28 of 32.

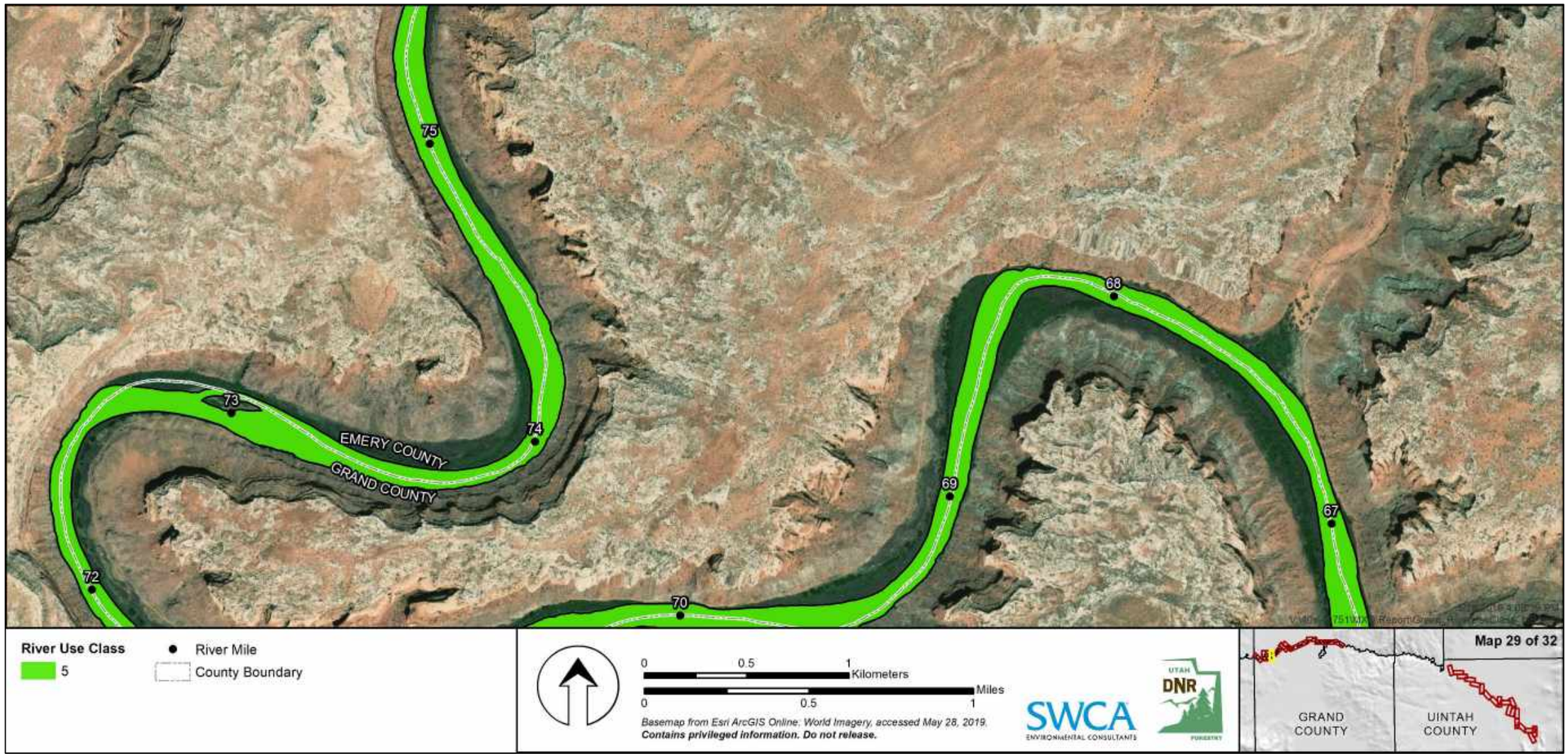

Figure 1.36. River use classes for the Green River, Map 29 of 32.

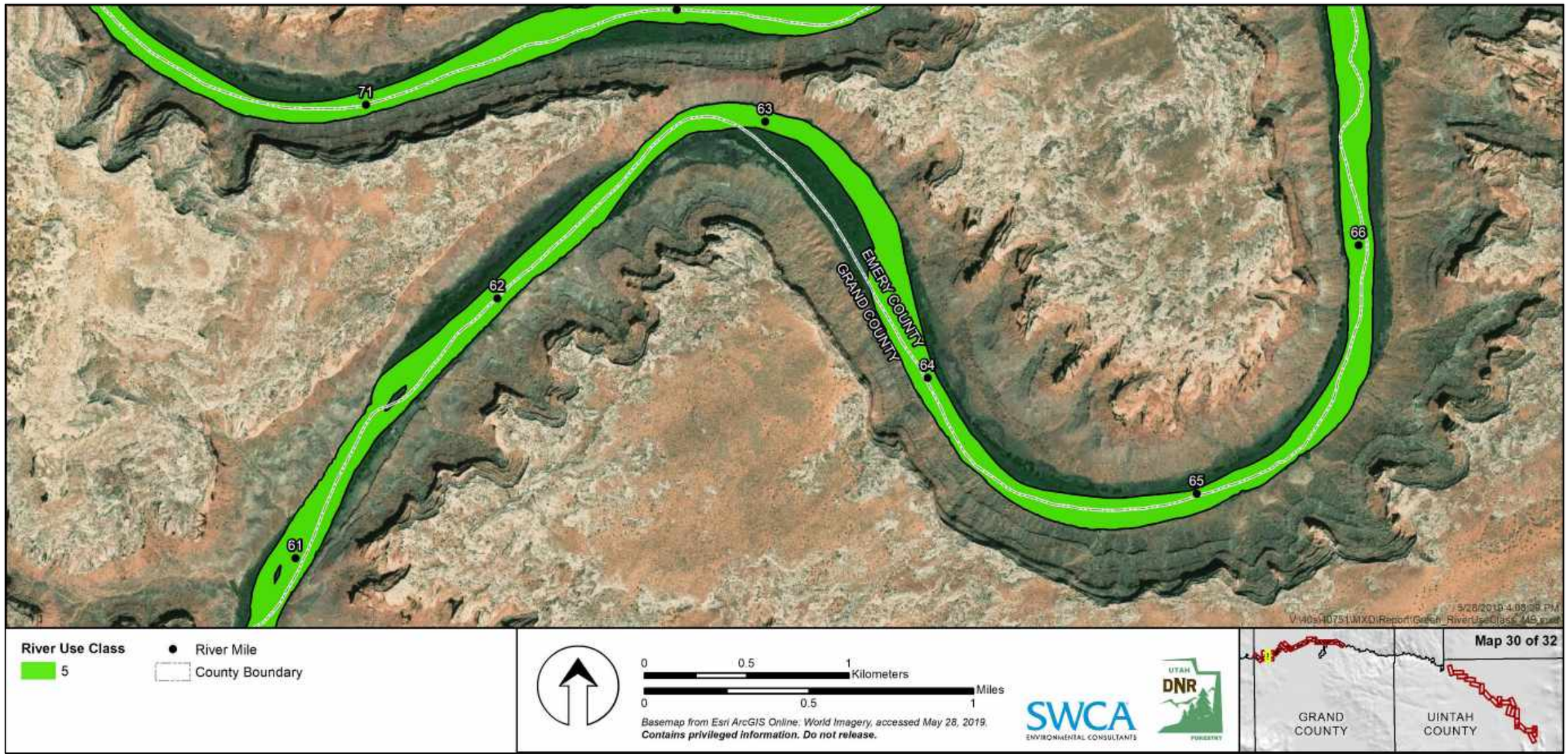

Figure 1.37. River use classes for the Green River, Map 30 of 32.

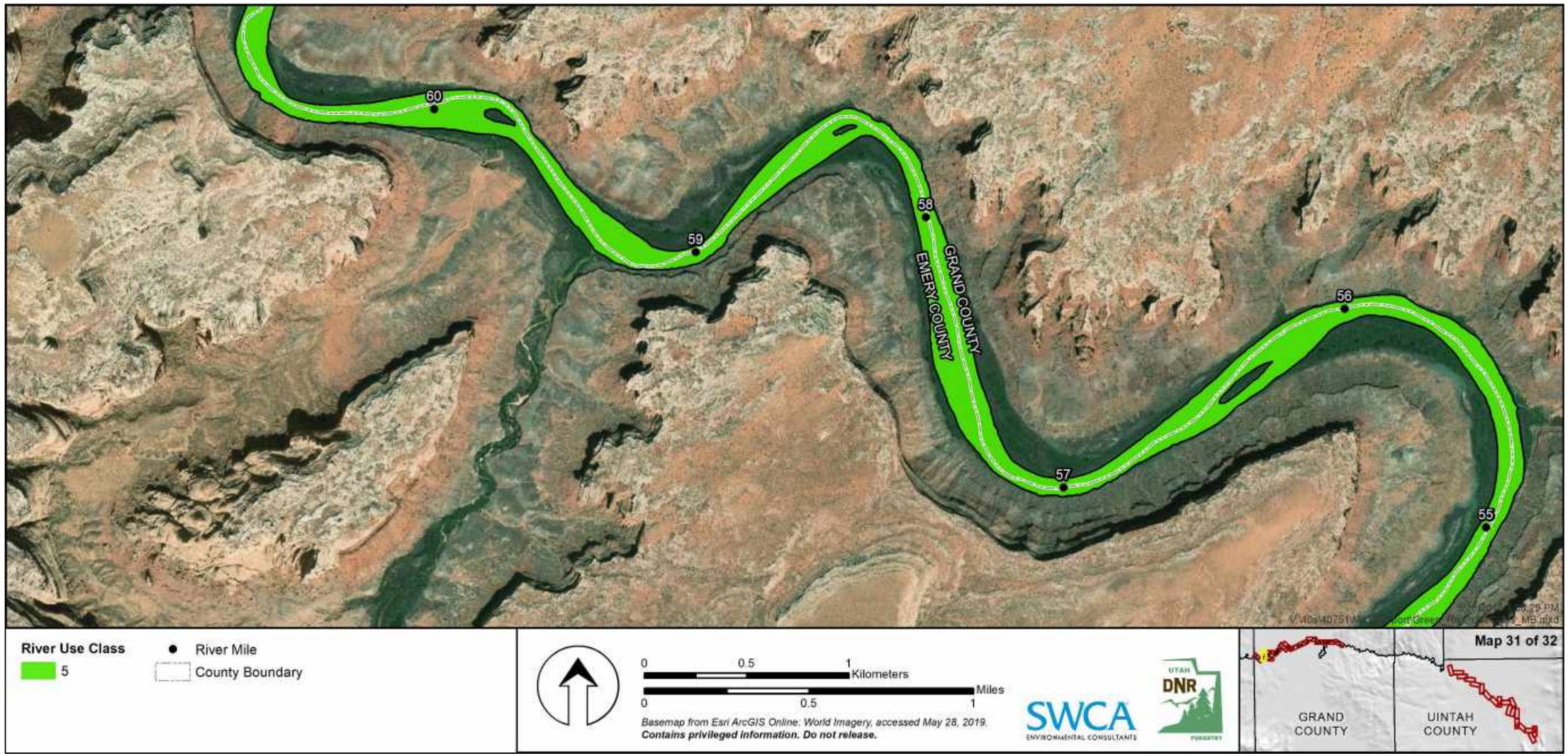

Figure 1.38. River use classes for the Green River, Map 31 of 32.

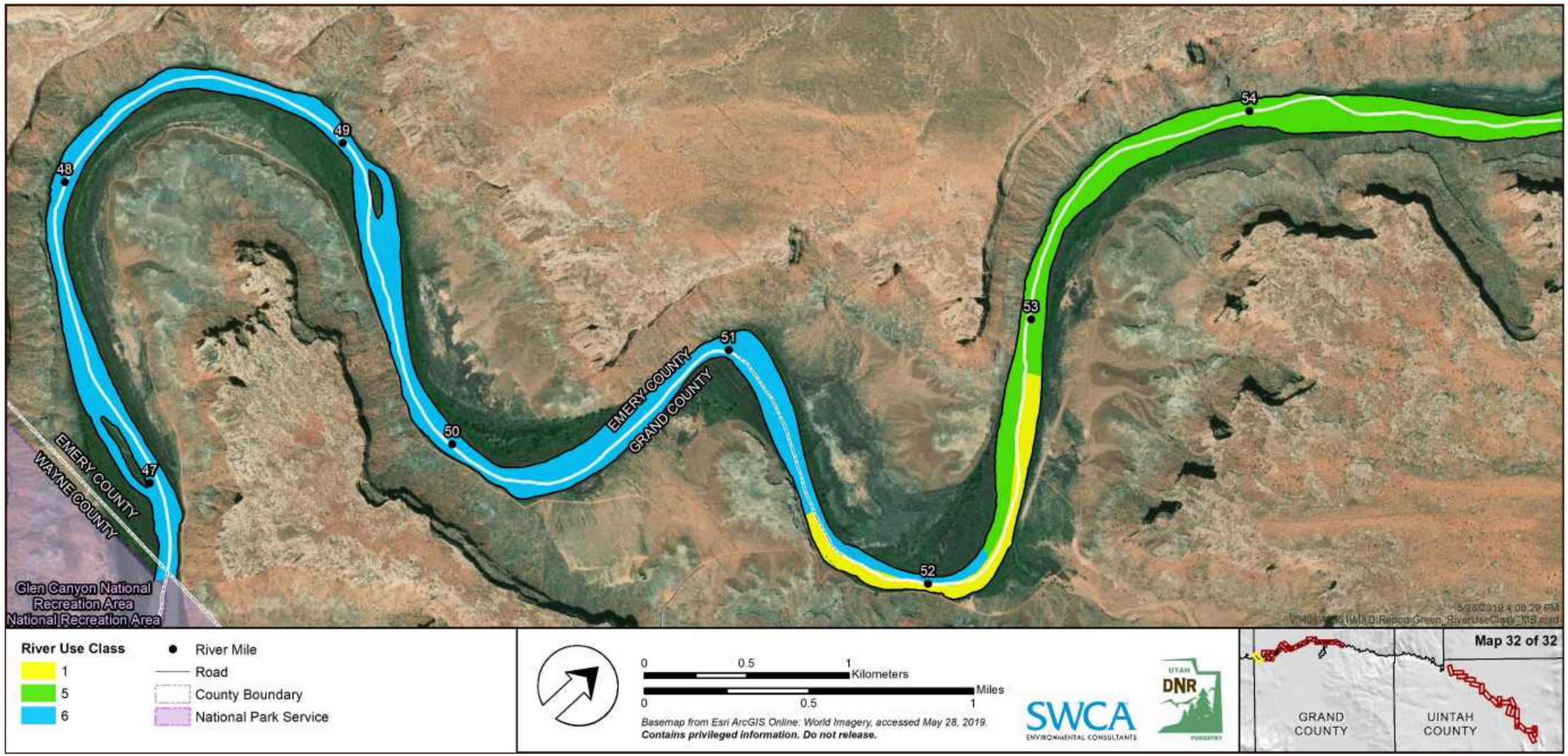

Figure 1.39. River use classes for the Green River, Map 32 of 32.

2.1 Introduction

The Green River is the largest tributary to the Colorado River and is approximately 730 miles long (American Rivers 2017; Webb 1994). The Green River begins on the eastern slopes of Wyoming's Wind River Range, flows into Utah through Flaming Gorge Reservoir, makes an approximately 40-mile loop through northwestern Colorado, and turns back into Utah through Whirlpool Canyon eventually merging with the Colorado River in Canyonlands National Park. During its approximately 450-mile journey in Utah, the Green River drops from an elevation of approximately 6,000 feet above sea level to approximately 3,000 feet above sea level at The Confluence (Webb 1994). Tributaries of the Green River include the Yampa, Duchesne, White, and San Rafael Rivers.

The Green River traverses several vegetation zones in Utah, ranging from high mountains in the north to slickrock deserts in the south. It drains the northeast corner of Utah or approximately one-quarter of the entire area of the state. Much of its route is through spectacular canyons such as Split Mountain, Desolation, Gray, Labyrinth, and Stillwater (Webb 1994). The Green River provides water for thousands of acres of irrigated land, hydropower to communities, habitat for fish and wildlife, and multiple recreation opportunities.

The Fremont people flourished in tributary canyons and in sheltered areas of the Green River basin from ca. A.D. 600 to A.D. 1200. The Fremont were semi-nomadic, lived in pit houses, and made distinctive pottery and figurines. They are best known for their rock art on canyon walls (Figure 2.1) and sheltered overhangs in the river basin (Webb 1994). The lower stretches of the Green River formed the northern boundary of the Anasazi culture. In later years, Shoshone peoples occupied the Green River basin to the north of the Uinta Mountains and Ute peoples to the south. The Shoshone people called the river "Seeds-kee-dee-Agie, or Prairie Hen River" (Webb 1994). The Uintah and Ouray Indian Reservation, home to the Ute Indian Tribe, is located on either side of the river in the Uinta Basin segment of the planning area.

Figure 2.1. Fremont petroglyphs in Flat Canyon (a tributary to Desolation Canyon) along the Green River.

Photograph by Wayne Wurtsbaugh. Used with permission.

In 1776, the Dominguez-Escalante Expedition crossed the Green River on their way to Utah Valley, leaving a written account and naming the river Rio de San Buenaventura. Other Spaniards and later, Mexicans, were familiar with the Green River; they called it Rio Verde or Green River (the Old Spanish Trail from New Mexico to California crossed the Green River near the City of Green River) (Webb 1994). Although trappers were in the upper basin of the Green River as early as 1819, it was first explored in Utah in 1825 by William Ashley who floated from north of the Uinta Mountains to the mouth of the White River with a party of trappers. In the next decade, the bottoms at the mouth of the White River became a favorite wintering ground and place of rendezvous for trappers (Webb 1994). The Green River was first surveyed and mapped by John Wesley Powell's scientific party in 1869. Powell (Figure 2.2) prepared the first thorough maps of the river basin and named many of the canyons, rapids, and geographic features. In an excerpt from *The Exploration of the Colorado River and Its Canyons*, John Wesley Powell recounts exploring a section of the Green River in 1869:

> There is an exquisite charm in our ride to-day down this beautiful canyon. It gradually grows deeper with every mile of travel; the walls are symmetrically curved and grandly arched, of a beautiful color, and reflected in the quiet waters in many places…At night we camp on the south side of the great Bowknot, and as we eat supper, which is spread on the beach, we name this Labyrinth Canyon. (Powell 1961)

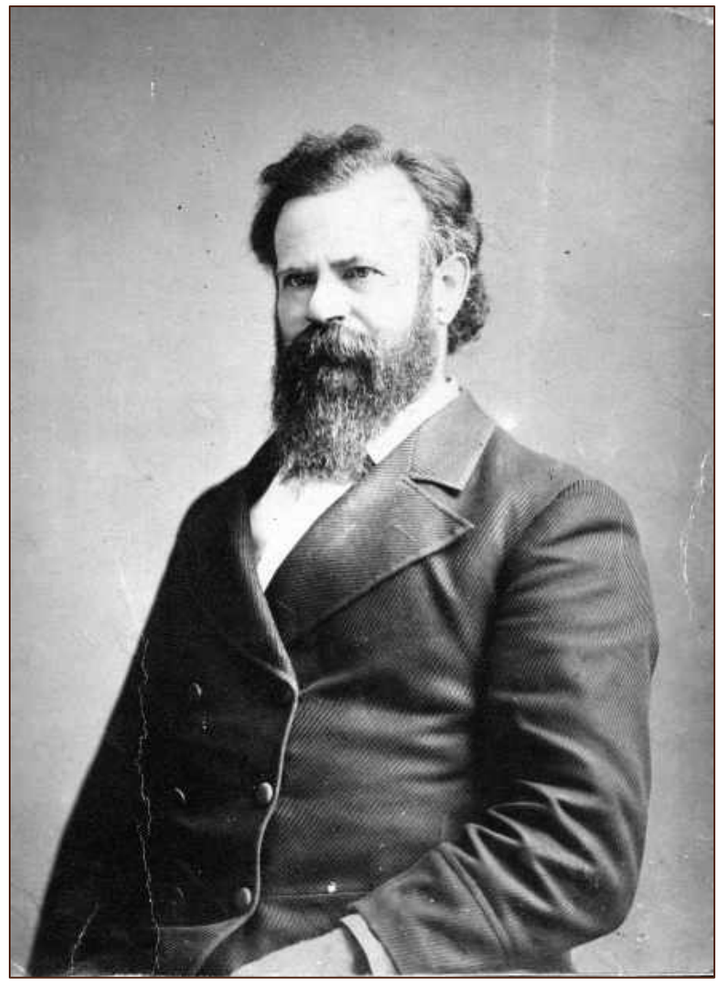

Figure 2.2. John Wesley Powell at age 40.

Photograph public domain.

In 1878, the first permanent settlement in Utah's Green River drainage was founded at Vernal. The town of Blake was founded a few years later near the old Spanish crossing of the Green River, and the city of Green River was founded in the late nineteenth century across the river from Blake (Webb 1994). The two towns have since grown together and are known as the city of Green River. The Green River in the first half of the twentieth century is shown in Figures 2.3 and 2.4.

Figure 2.3. Ferry and railroad bridge on the Green River near the city of Green River, Utah, early twentieth century.

Photograph from the Multimedia Archives, Special Collections, J. Willard Marriott Library, University of Utah. Used with permission.

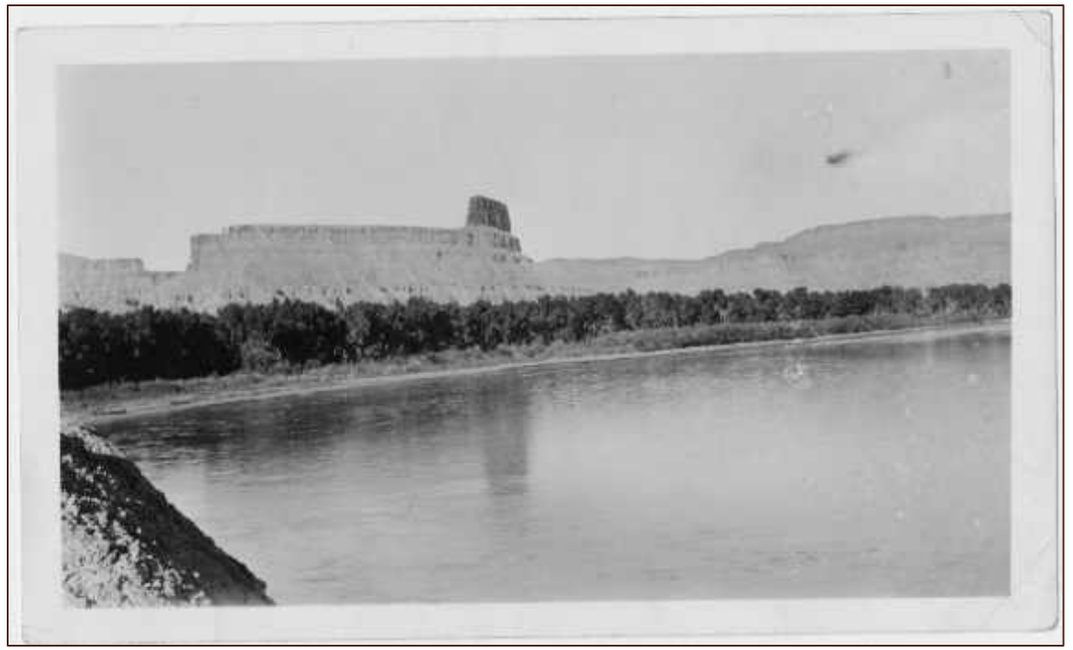

Figure 2.4. The Green River in the first half of the twentieth century near Gunnison Butte, Green River, Utah.

Photograph from the Utah State Historical Society. Used with permission.

As early as 1904, the possibility of building dams on the Green River for water reclamation and power production was discussed. A dam site survey of the Green River was undertaken by the U.S. Geological Survey (USGS) and Utah Power and Light Company from 1914 to 1922. Shortly after World War II, the USBR announced plans to build a large dam on the Green River in Dinosaur National Monument, just inside the Colorado border. Another was planned for Split Mountain Canyon, a few miles downstream (Figure 2.5). This plan met fierce opposition from conservationists and was ultimately defeated (Webb 1994). The 1956 Colorado River Storage Project Act resulted in the development of the Flaming Gorge Dam on the Green River, which was completed in 1963. Several other dams have since been developed on the Green River and its tributaries.

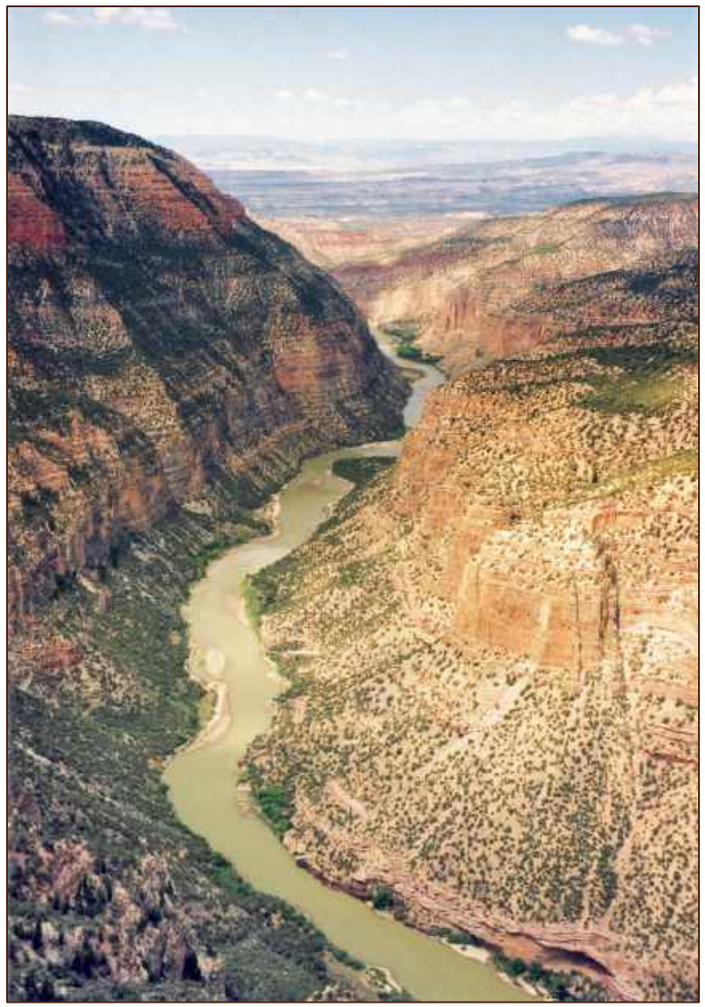

Figure 2.5. The Green River in Whirlpool Canyon in Dinosaur National Monument, which would have been flooded by Split Mountain Dam.

Photograph from Dr. John Crossley, www.americansouthwest.net. Used with permission.

In the late 1920s, Bus Hatch, along with his brothers and cousins, set out from Vernal to explore the Green River in a homemade wooden boat. River running quickly turned into a passion for Bus (Figure 2.6), and he soon established a river running business called Hatch River Expeditions. By the early 1950s, Hatch was running hundreds of passengers at a time through Dinosaur National Monument in his boats, laying the foundation for a recreational boating industry on the Green River (Don Hatch River Expeditions n.d. [2018]; Hatch River Expeditions n.d. [2018]; Webb 2008).

Figure 2.6. Bus Hatch of Hatch River Expeditions floating the Green River.

Photograph from the Utah State Historical Society. Used with permission.

The Plan

The GRCMP focuses specifically on FFSL's mandate to manage state sovereign lands associated with the Green River, but it implicitly includes recognition of the national and international value of the larger Green River corridor and watershed.

This chapter provides a description of current conditions on Green River sovereign lands and is divided into four resource sections: Ecosystem Resources; Water Resources; Geology, Paleontology, Oil and Gas, and other Mineral Resources; and Community Resources. The current conditions reported here are based on best available data. FFSL recognizes that a management document cannot be a complete inventory of all information, and that there are still gaps in our understanding of the Green River. Where applicable, the GRCMP calls out additional reading under each specific section in "Further Reading" boxes. For example, stakeholders who wish to know more about important habitats can reference the *Utah Wildlife Action Plan* (Utah Wildlife Action Plan Joint Team 2015), whereas readers interested in the effects of land use on water quality can review the *Riparian Buffer Design Guidelines For Water Quality and Wildlife Habitat Functions on Agricultural Landscapes in the Intermountain West* (Johnson and Buffler 2008).

Information in this chapter offers a framework for developing management goals and objectives and, in that sense, is more relevant than other available information. As new data appear and management strategies change, the GRCMP can be updated accordingly. Planning documents like this typically provide comprehensive maps illustrating the resources and data presented. Because of the length of the planning area, the number of resources, and the number of data layers, including a map book in the planning document itself for each individual resource is too cumbersome. Instead, these data are included in two online formats on the FFSL website: 1) an Esri story map and 2) GIS spatial data viewer. Both formats are discussed in detail in Chapter 1.

Finally, as an organizational construct, the Green River is divided into three segments. The segments are described in detail in Chapter 1 and are shown on the GIS spatial data viewer on the FFSL website. However, FFSL management decisions are more closely associated with river use classes rather than river segments. Ultimately, river segments provide a format to discuss similarities and differences in river condition, use, and local government programs such as weed management and restoration efforts. Table 2.1 provides the distribution of river use classes by segment, expressed as percentages of the total area of each segment.

Table 2.1. River Use Class Percentages by River Segment

Segment	Class 1	Class 2	Class 3	Class 5	Class 6
Uinta Basin	1%	0%	34%	45%	20%
Green River Valley	15%	0%	62%	23%	1%
Labyrinth Canyon	2%	0%	28%	64%	7%

Note: Class 4 is not applied to the planning area.

Further Reading

A Green River Reader (Blackstock 2005)

Echo Park: Struggle for Preservation (Cosco 1995)

Riverman: The Story of Bus Hatch (Webb 2008)

The Exploration of the Colorado River and Its Canyons (Powell 1961)

The Green River (Webb 1994)

GIS Data Layers

Land Management, Landownership, Political Boundaries, River Miles, River Segments, River Use Classes, Sovereign Lands of the Green River

2.2 Ecosystem Resources

Wildlife Habitat

Introduction

For the purposes of the plan, the term *habitat* refers to wildlife habitat. Wildlife habitat constitutes a complex system of physical and chemical features that are necessary for a species' persistence. This complex system includes geography, elevation, water, plant and animal communities, and other environmental components that provide food and cover for individual species. The Green River and its adjacent lands and tributaries form a corridor that provides wildlife species with food and cover and facilitates their movement throughout the landscape. A healthy river corridor provides migration routes for wildlife to move through contiguous habitats and between fragmented habitats.

This section discusses wildlife habitats, habitat location and condition, vegetation, and restoration in the planning area. Vegetation is a critical element of wildlife habitat because healthy plant communities support the ecological integrity of wildlife habitats. Restoration is the primary management activity for enhancing, improving, and rehabilitating impaired habitats.

Habitats

The *Utah Wildlife Action Plan* was created to manage native wildlife species in Utah and their habitats to help prevent them from being listed under the ESA (Utah Wildlife Action Plan Joint Team 2015). The Green River planning area contains four DWR key habitats for species of greatest conservation need (SGCN) according to the *Utah Wildlife Action Plan* (Utah Wildlife Action Plan Joint Team 2015). These key habitats are aquatic-forested, aquatic-scrub/shrub, emergent, and riverine. Identification of these key habitats allows river stakeholders to prioritize conservation and restoration focus areas. However, to more broadly understand the landscape context and what DWR considers to be threats to habitats, the GRCMP uses Southwest Regional Gap Analysis Project (SWReGAP) data to define the variety of cover types through which the Green River flows. It should be noted that SWReGAP data are intended to be used at a scale of 1:100,000 and may be less accurate for linear landscape features like the Green River. Using SWReGAP data, vegetation in the planning area was classified with the major land cover types predicted to occur in the planning area. Land cover types are defined as recurring groups of biological communities found in similar physical environments and influenced by similar ecological processes, such as fire or flooding (USGS 2005). Similar land cover types have been grouped together into more generic habitats, resulting in a total of nine wildlife habitats (Table 2.2).

Table 2.2. Percentages of Habitat Types Adjacent to the Planning Area by Segment

Habitat Type	Uinta Basin	Green River Valley	Labyrinth Canyon
Aquatic (DWR key habitat)*	48%	67%	60%
Wetland (DWR key habitat)†	13%	8%	0%
Riparian (DWR key habitat) ‡	22%	9%	23%
Agriculture	2%	11%	< 1%
Barren lands	4%	< 1%	10%
Developed (open space to low-intensity and medium- to high-intensity)	< 1%	3%	< 1%
Grassland	1%	0%	0%
Invasive forbland	0%	0%	< 1%
Shrubland	9%	2%	6%

* Aquatic habitat is the three segments of the Green River planning area and adjacent open water habitat and is comparable to DWR's riverine key habitat.

† Wetland habitat is comparable to DWR's emergent key habitat.

‡ Riparian habitat is comparable to DWR's aquatic-forested and aquatic-scrub/shrub key habitats.

Aquatic wildlife habitat is associated with the Green River itself. The remaining habitat cover types in the planning area were derived from SWReGAP data and National Wetlands Inventory data (USFWS 2018a), and percentages were calculated based on the cumulative length of each habitat type along the boundary of the Green River planning area, i.e., bed and banks of the river.

Physical features and characteristic species of the nine habitats in the planning area are described and illustrated below in Figures 2.7 through 2.15. Characteristic species are listed alphabetically by common name and were developed with assistance from the GRCMP planning team. Scientific names for each characteristic species are provided in Table 2.3.

AQUATIC

Physical Features

Comprises the riverine habitat in the Uinta Basin, Green River Valley, and Labyrinth Canyon segments of the planning area.

Comparable to DWR's riverine key habitat.

Plant Species

Submerged aquatic vegetation includes pondweed species. Floating vegetation includes vernal water-starwort and duckweeds.

Mammal Species

North American beaver and muskrat.

Bird Species

American coot, American white pelican, bald eagle, bank swallow, barn swallow, belted kingfisher, California gull, Canada goose, canvasback, canyon wren, cattle egret, cinnamon teal, cliff swallow, common goldeneye, common merganser, double-crested cormorant, Franklin's gull, gadwall, great blue heron, green-winged teal, lesser scaup, long-billed dowitcher, mallard, marbled godwit, northern shoveler, pied-billed grebe, redhead, ring-billed gull, ring-necked duck, rock wren, ruddy duck, sandhill crane, spotted sandpiper, tree swallow, tundra swan, western grebe, and white-faced ibis.

Fish Species

Nonnative fish species include brook stickleback, channel catfish, common carp, fathead minnow, largemouth bass, red shiner, sand shiner, smallmouth bass, and walleye.

Native fish species include bluehead sucker, bonytail, Colorado pikeminnow, flannelmouth sucker, humpback chub, razorback sucker, roundtail chub, and speckled dace.

Reptile and Amphibian Species

Black-necked garter snake, Great Basin spadefoot, Great Plains toad, northern leopard frog, red-spotted toad, tiger salamander, western terrestrial garter snake, and Woodhouse's toad.

Figure 2.7. Physical features and characteristic species of aquatic habitat in the planning area.

WETLAND

Physical Features

Covers approximately 8% of the length of the planning area. Includes emergent marsh, wet meadow, and shrubby wetlands.

Comparable to DWR's emergent key habitat.

Plant Species

Common emergent and floating vegetation includes bulrush species, broadleaf cattail, arctic rush, pondweed species, knotweed species, duckweed species, common reed, and reed canarygrass.

Shrubby wetland areas are typically dominated or co-dominated by willow species, mainly narrowleaf willow, and tamarisk. If an herbaceous layer is present, it is usually dominated by graminoids (grass species, sedge species, and rush species).

Mammal Species

Common raccoon, deer mouse, muskrat, western jumping mouse, and western pipistrelle.

Bird Species

Bank swallow, barn swallow, California gull, Canada goose, cattle egret, cliff swallow, common yellowthroat, Franklin's gull, great blue heron, greater yellowlegs, killdeer, long-billed dowitcher, marbled godwit, marsh wren, northern harrier, northern rough-winged swallow, northern shoveler, red-winged blackbird, sandhill crane, savannah sparrow, song sparrow, spotted sandpiper, Virginia rail, white-faced ibis, yellow warbler, and yellow-headed blackbird (shown here).

Fish Species

Fathead minnow and green sunfish.

Reptile and Amphibian Species

Black-necked garter snake, Great Basin spadefoot, great plains toad, northern leopard frog, red-spotted toad, smooth greensnake, tiger salamander, western terrestrial garter snake, and Woodhouse's toad.

Figure 2.8. Physical features and characteristic species of wetland habitat in the planning area.

RIPARIAN

Physical Features

Covers approximately 22% of the length of the planning area. Commonly occurs as a mosaic of multiple vegetation types that are dominated by trees and have a diverse shrub component.

Comparable to DWR's aquatic-forested and aquatic-scrub/shrub key habitats.

Disturbance-driven system that requires annual to episodic flooding.

Plant Species

Dominant native trees include boxelder, Gambel oak, and cottonwoods (e.g., Fremont cottonwood). Introduced tree species such as Russian olive and tamarisk are also common.

Shrubs include narrowleaf willow, skunkbush sumac, and Woods' rose. Herbaceous layers are often dominated by annual and perennial grass species, and mesic forbs, sedge species, and rush species may also be present.

Mammal Species

Big free-tailed bat, brown (Norway) rat, brush mouse, California myotis, coyote, deer mouse, desert cottontail, fringed myotis, gray fox, least chipmunk, little brown bat, long-tailed weasel, mule deer, Ord's kangaroo rat, pallid bat, raccoon, spotted bat, Townsend's big-eared bat, western harvest mouse, and western pipistrelle.

Bird Species

American goldfinch, American robin, ash-throated flycatcher, bald eagle, black-billed magpie, black-chinned hummingbird, black-crowned night-heron, black-headed grosbeak, blue grosbeak, broad-tailed hummingbird, Bullock's oriole, cedar waxwing, common raven, Cooper's hawk, dark-eyed junco, double-crested cormorant, Eurasian collared-dove, great blue heron, great horned owl, lazuli bunting, lesser goldfinch, mourning dove, northern flicker, olive-sided flycatcher, peregrine falcon, red-tailed hawk, sharp-shinned hawk, snowy egret, song sparrow, tree swallow, warbling vireo, western screech-owl, western tanager, willow flycatcher, yellow warbler, yellow-breasted chat (shown here), and yellow-rumped warbler.

Reptile and Amphibian Species

Canyon tree frog, cornsnake, Great Basin spadefoot, Great Plains toad, midget faded rattlesnake, red-spotted toad, smooth greensnake, tiger salamander, tree lizard, western terrestrial garter snake, western whiptail, and Woodhouse's toad.

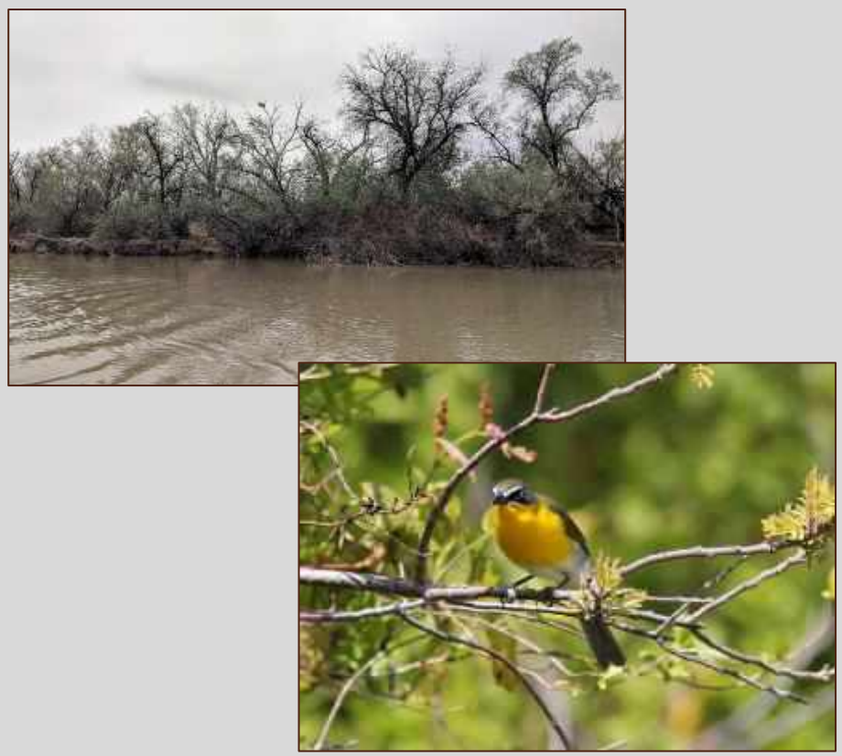

Figure 2.9. Physical features and characteristic species of riparian habitat in the planning area.

AGRICULTURE

Physical Features

Covers approximately 2% of the length of the planning area.

Plant Species

Areas of grasses, legumes, or grass-legume mixtures planted for the production of seed or hay crops, or planted for livestock grazing.

Mammal Species

American badger, Botta's pocket gopher, coyote, deer mouse, mule deer, pronghorn, striped skunk, and Western harvest mouse.

Bird Species

American crow, American kestrel, American robin, barn swallow, black-billed magpie, Brewer's blackbird, California gull, California quail, Canada goose, common raven, Eurasian collared-dove, Franklin's gull, horned lark, killdeer, mourning dove, northern harrier (shown here), red-tailed hawk, ring-billed gull, ring-necked pheasant, rough-legged hawk, sandhill crane, Swainson's hawk, turkey vulture, western kingbird, western meadowlark, white-faced ibis, and wild turkey.

Reptile and Amphibian Species

Midget faded rattlesnake, western rattlesnake, and western terrestrial garter snake.

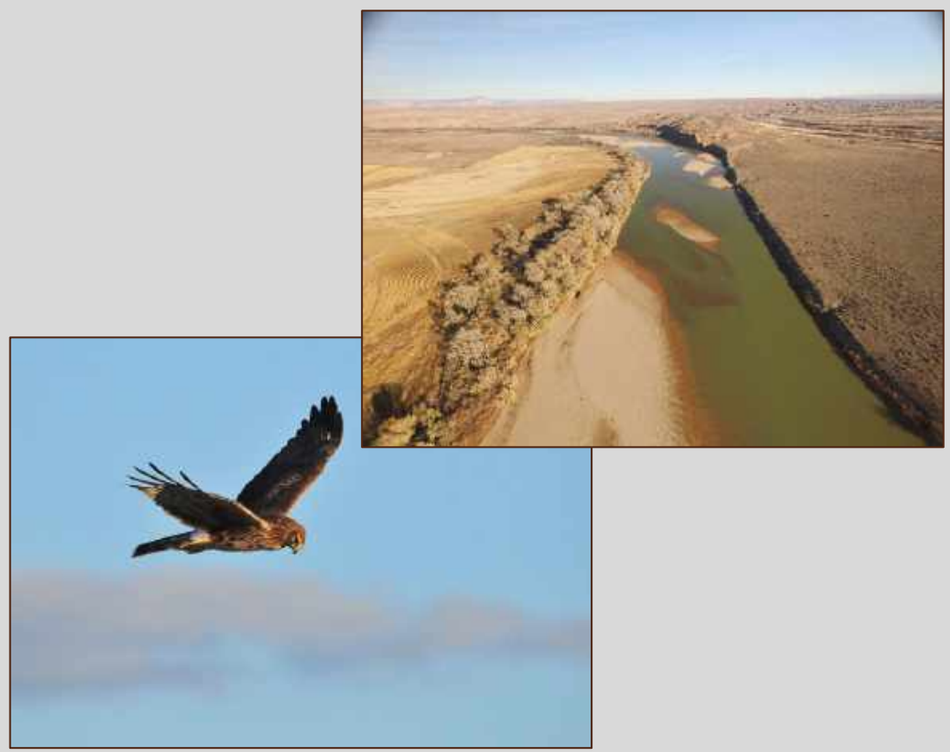

Figure 2.10. Physical features and characteristic species of agriculture habitat in the planning area.

BARREN LANDS

Physical Features

Covers approximately 6% of the length of the planning area.

Areas of open tablelands and steep cliff faces of predominantly sedimentary rocks, and active and stabilized dunes, typically with sparse vegetation.

Plant Species

Tree and shrub species include juniper species, sagebrush species, rubber rabbitbrush, fourwing saltbush, blackbrush, antelope bitterbrush, greenleaf manzanita, horsebrush species, and jointfir species. Dwarf shrub species include mat saltbush, Gardner's saltbush, and birdfoot sagebrush. Herbaceous layers are often dominated by annual and perennial grass species such as Indian ricegrass, alkali sacaton, and invasive cheatgrass.

Mammal Species

American badger, Big free-tailed bat, coyote, deer mouse, desert bighorn sheep, desert woodrat, fringed myotis, least chipmunk, little brown bat, mule deer, pallid bat, pronghorn, rock squirrel, spotted bat, and western pipistrelle.

Bird Species

Bank swallow, black-billed magpie, canyon wren, cliff swallow, common nighthawk, common poorwill, common raven, ferruginous hawk, golden eagle, great horned owl, horned lark (shown here), northern harrier, peregrine falcon, rock wren (shown here), rough-legged hawk, Say's phoebe, turkey vulture, vesper sparrow, violet-green swallow, white-crowned sparrow, white-throated swift, and Woodhouse's scrub-jay.

Reptile and Amphibian Species

Cornsnake, Desert night snake, greater short-horned lizard, long-nosed leopard lizard, midget faded rattlesnake, and western rattlesnake.

Figure 2.11. Physical features and characteristic species of barren lands habitat in the planning area.

DEVELOPED

Physical Features

Covers less than 1% of the length of the planning area.

Includes SWReGAP land cover classifications for Open Space to Low-Intensity Development and Medium- to High-Intensity Development.

Developed, open space to low-intensity includes areas with a mixture of constructed materials and vegetation, with impervious surfaces accounting for < 20% to 49% of total cover. This habitat includes open spaces, golf courses, preserves, parks, natural areas, parkways, gardens, and single-family housing units.

Developed, medium- to high-intensity includes areas with a mixture of constructed materials and vegetation, with impervious surfaces accounting for 50% to 100% of total cover. This habitat includes single-family housing units; apartment complexes; and commercial, industrial, and disturbed areas.

Plant Species

Dominated by turf grass species and landscape or ornamental trees and shrubs. Common weed species include cheatgrass, common mallow, field bindweed, lambsquarter, and weedy mustard species.

Mammal Species

Black rat, brown (Norway) rat, California myotis, common raccoon, coyote, deer mouse, house mouse, least chipmunk, little brown bat, mule deer, northern pocket gopher, rock squirrel, and striped skunk.

Bird Species

American crow, American goldfinch, American robin, black-billed magpie, black-capped chickadee (shown here), black-chinned hummingbird, black-headed grosbeak, broad-tailed hummingbird, brown-headed cowbird, Bullock's oriole, California gull, California quail, Canada goose, Cooper's hawk, downy woodpecker, Eurasian collared-dove, European starling, house finch, house sparrow, killdeer, lesser goldfinch, mallard, mourning dove, northern flicker, red-tailed hawk, rock pigeon, rufous hummingbird, song sparrow, and Woodhouse's scrub-jay.

Reptile Species

Western terrestrial garter snake.

Figure 2.12. Physical features and characteristic species of developed habitat in the planning area.

GRASSLAND

Physical Features

Covers approximately 1% of the length of the planning area.

Includes SWReGAP land cover classifications for Invasive Annual Grassland and Inter-Mountain Basins Semi-Desert Grassland.

Plant Species

Annual and perennial grass species include cheatgrass, Indian ricegrass, needle and thread, blue grama, threeawn species, James' galleta, and muhly species. Scattered shrub species may also be present.

Mammal Species

American badger, Botta's pocket gopher, coyote, deer mouse, desert woodrat, mule deer, Ord's kangaroo rat, pronghorn, western harvest mouse, and western spotted skunk.

Bird Species

American kestrel, Brewer's blackbird, California quail, chipping sparrow, common nighthawk, gray catbird, horned lark, killdeer, lark sparrow, lazuli bunting, mourning dove, northern harrier, orange-crowned warbler, prairie falcon, red-tailed hawk, rough-legged hawk, savannah sparrow, Say's phoebe, Swainson's hawk, vesper sparrow, western kingbird (shown here), and western meadowlark.

Reptile and Amphibian Species

Greater short-horned lizard, midget faded rattlesnake, western rattlesnake, and western terrestrial garter snake.

Figure 2.13. Physical features and characteristic species of grassland habitat in the planning area.

INVASIVE FORBLAND

Physical Features

Covers less than 1% of the length of the planning area.

Includes SWReGAP land cover classifications for Invasive Annual and Biennial Forbland.

Plant Species

Areas dominated by introduced annual and/or biennial forb species such as burningbush, halogeton, and Russian thistle species.

Mammal Species

American badger, Botta's pocket gopher, coyote, deer mouse, desert woodrat, Ord's kangaroo rat, pronghorn, western harvest mouse, and Western spotted skunk.

Bird Species

California quail, chipping sparrow, gray catbird, horned lark, killdeer (shown here), lark sparrow, lazuli bunting, mourning dove, northern harrier, red-tailed hawk, savannah sparrow, Say's phoebe, vesper sparrow, western kingbird, western meadowlark.

Reptile and Amphibian Species

Midget faded rattlesnake, greater short-horned lizard, western rattlesnake, and western terrestrial garter snake.

Figure 2.14. Physical features and characteristic species of invasive forbland habitat in the planning area.

SHRUBLAND

Physical Features

Covers approximately 8% of the length of the planning area.

Plant Species

Areas dominated or co-dominated by Utah juniper and two-needle pinyon, basin big sagebrush, Wyoming big sagebrush, black sagebrush, rabbitbrush species [rubber rabbitbrush and yellow rabbitbrush], blackbrush, saltbush species [fourwing saltbush, shadscale saltbush, mat saltbush, Gardner's saltbush], greasewood, and jointfir species [Mormon tea and Torrey's jointfir]. Other shrub species may include spiny hopsage, winterfat, green manzanita, and sand sagebrush. The herbaceous layer is composed of annual and perennial grasses.

Mammal Species

American badger (shown here), black-tailed jackrabbit, brush mouse, coyote, deer mouse, desert cottontail, gray fox, least chipmunk, mule deer, Ord's kangaroo rat, pallid bat, pronghorn, spotted bat, and white-tailed antelope squirrel.

Bird Species

Black-billed magpie, black-chinned hummingbird, Brewer's sparrow, Brewer's blackbird, California quail, chipping sparrow, common nighthawk, common raven, horned lark, lazuli bunting, mountain bluebird, mourning dove, northern harrier, red-tailed hawk, savannah sparrow, spotted towhee, Townsend's solitaire, vesper sparrow, western kingbird, western scrub-jay, white-crowned sparrow, Woodhouse's scrub-jay, and yellow-breasted chat.

Reptile and Amphibian Species

Desert night snake, desert striped whipsnake, greater short-horned lizard, long-nosed leopard lizard, midget faded rattlesnake, sagebrush lizard, and western whiptail.

Figure 2.15. Physical features and characteristic species of shrubland habitat in the planning area.

Table 2.3. Common and Scientific Names of Characteristic Species in the Planning Area

Common Name	Scientific Name
PLANTS	
Alkali sacaton	*Sporobolus airoides*
Antelope bitterbrush	*Purshia tridentata*
Arctic rush	*Juncus arcticus* var. *balticus*
Basin big sagebrush	*Artemisia tridentata* ssp. *tridentata*
Birdfoot sagebrush	*Artemisia pedatifida*
Black sagebrush	*Artemisia nova*
Blackbrush	*Coleogyne ramosissima*
Blue grama	*Bouteloua gracilis*
Boxelder	*Acer negundo*
Broadleaf cattail	*Typha latifolia*
Bulrushes	*Schoenoplectus acutus, S. americanus S. pungens*
Burningbush	*Bassia scoparia*
Cheatgrass	*Bromus tectorum*
Common mallow	*Malva neglecta*
Common reed	*Phragmites australis*
Duckweeds	*Lemna* spp.
Field bindweed	*Convolvulus arvensis*
Fourwing saltbush	*Atriplex canescens*
Fremont cottonwood)	*Populus fremontii*
Gambel oak	*Quercus gambelii*
Gardner's saltbush	*Atriplex gardneri*
Greasewood	*Sarcobatus vermiculatus*
Greenleaf manzanita	*Arctostaphylos patula*
Halogeton	*Halogeton glomeratus*
Horsebrush species	*Tetradymia* spp.
Indian ricegrass	*Achnatherum hymenoides*
James' galleta	*Pleuraphis jamesii*
Jointfir species	*Ephedra* spp.
Juniper species	*Juniperus* spp.
Knotweeds	*Polygonum* spp.
Lambsquarter	*Chenopodium album*
Mat saltbush	*Atriplex corrugata*
Mormon tea	*Ephedra viridis*
Muhly species	*Muhlenbergia* spp.
Narrowleaf willow	*Salix exigua*
Needle and thread	*Hesperostipa comata*
Pondweed species	*Potamogeton* spp.
Pondweed species	*Stuckenia* spp.
Pondweeds	*Potamogeton* spp.
Reed canarygrass	*Phalaris arundinacea*
Rubber rabbitbrush	*Ericameria nauseosa*
Rushes	*Juncus* spp.
Russian olive	*Elaeagnus angustifolia*
Russian thistle species	*Salsola* spp.
Sagebrush species	*Artemisia* spp.
Sand sagebrush	*Artemisia filifolia*
Sedges	*Carex* spp.

Common Name	Scientific Name
Shadscale saltbush	*Atriplex confertifolia*
Skunkbush sumac	*Rhus trilobata*
Spiny hopsage	*Grayia spinosa*
Tamarisk	*Tamarix ramosissima*
Threeawn species	*Aristida* spp.
Torrey's jointfir	*Ephedra torreyana*
Two-needle pinyon	*Pinus edulis*
Utah juniper	*Juniperus osteosperma*
Vernal water-starwort	*Callitriche palustris*
Weedy mustard species	*Lepidium* spp.
Willow species	*Salix* spp.
Winterfat	*Krascheninnikovia lanata*
Woods' rose	*Rosa woodsii*
Wyoming big sagebrush	*Artemisia tridentata* ssp. *wyomingensis*
Yellow rabbitbrush	*Chrysothamnus viscidiflorus*
MAMMALS	
American badger	*Taxidea taxus*
Big free-tailed bat	*Nyctinomops macrotis*
Black rat	*Rattus rattus*
Black-tailed jackrabbit	*Lepus californicus*
Botta's pocket gopher	*Thomomys bottae*
Brown (Norway rat)	*Rattus norvegicus*
Brush mouse	*Peromyscus boylii*
California myotis	*Myotis californicus*
Common raccoon	*Procyon lotor*

Common Name	Scientific Name
Coyote	*Canis latrans*
Deer mouse	*Peromyscus maniculatus*
Desert bighorn sheep	*Ovis canadensis nelsoni*
Desert cottontail	*Sylvilagus audubonii*
Desert woodrat	*Neotoma lepida*
Fringed myotis	*Myotis thysanodes*
Gray fox	*Urocyon cinereoargenteus*
House mouse	*Mus musculus*
Least chipmunk	*Neotamias minimus*
Little brown bat	*Myotis lucifugus*
Long-tailed weasel	*Mustela frenata*
Mule deer	*Odocoileus hemionus*
Muskrat	*Ondatra zibethicus*
North American beaver	*Castor canadensis*
Northern pocket gopher	*Thomomys talpoides*
Ord's kangaroo rat	*Dipodomys ordii*
Pallid bat	*Antrozous pallidus*
Pronghorn	*Antilocapra americana*
Raccoon	*Procyon lotor*
Rock squirrel	*Spermophilus variegatus*
Spotted bat	*Euderma maculatum*
Striped skunk	*Mephitis mephitis*
Townsend's big-eared bat	*Corynorhinus townsendii*
Western harvest mouse	*Reithrodontomys megalotis*
Western jumping mouse	*Zapus princeps*

Common Name	Scientific Name
Western pipistrelle	*Pipistrellus hesperus*
Western spotted skunk	*Spilogale gracilis*
White-tailed antelope squirrel	*Ammospermophilus leucurus*
BIRDS	
American coot	*Fulica americana*
American crow	*Corvus brachyrhynchos*
American goldfinch	*Spinus tristis*
American kestrel	*Falco sparverius*
American robin	*Turdus migratorius*
American white pelican	*Pelecanus erythrorhynchos*
Ash-throated flycatcher	*Myiarchus cinerascens*
Bald eagle	*Haliaeetus leucocephalus*
Bank swallow	*Riparia riparia*
Barn swallow	*Hirundo rustica*
Belted kingfisher	*Megaceryle alcyon*
Black-billed magpie	*Pica hudsonia*
Black-capped chickadee	*Poecile atricapillus*
Black-chinned hummingbird	*Archilochus alexandri*
Black-crowned night-heron	*Nycticorax nycticorax*
Black-headed grosbeak	*Pheucticus melanocephalus*
Blue grosbeak	*Guiraca caerulea*
Brewer’s sparrow	*Spizella breweri*
Brewer's blackbird	*Euphagus cyanocephalus*
Broad-tailed hummingbird	*Selasphorus platycercus*
Brown-headed cowbird	*Molothrus ater*

Common Name	Scientific Name
Bullock's oriole	*Icterus bullockii*
California gull	*Larus californicus*
California quail	*Callipepla californica*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Canyon wren	*Catherpes mexicanus*
Cattle egret	*Bubulcus ibis*
Cedar waxwing	*Bombycilla cedrorum*
Chipping sparrow	*Spizella passerina*
Cinnamon teal	*Anas cyanoptera*
Cliff swallow	*Petrochelidon pyrrhonota*
Common goldeneye	*Bucephala clangula*
Common merganser	*Mergus merganser*
Common nighthawk	*Chordeiles minor*
Common poorwill	*Phalaenoptilus nuttallii*
Common raven	*Corvus corax*
Common yellowthroat	*Geothlypis trichas*
Cooper's hawk	*Accipiter cooperii*
Dark-eyed junco	*Junco hyemalis*
Double-crested cormorant	*Phalacrocorax auritus*
Downy woodpecker	*Picoides pubescens*
Eurasian collared-dove	*Streptopelia decaocto*
European starling	*Sturnus vulgaris*
Ferruginous hawk	*Buteo regalis*
Franklin’s gull	*Leucophaeus pipixcan*

Common Name	Scientific Name
Gadwall	*Anas strepera*
Golden eagle	*Haliaeetus leucocephalus*
Gray catbird	*Dumetella carolinensis*
Great blue heron	*Ardea herodias*
Great horned owl	*Bubo virginianus*
Greater yellowlegs	*Tringa melanoleuca*
Green-winged teal	*Anas crecca*
Horned lark	*Eremophila alpestris*
House finch	*Haemorhous mexicanus*
House sparrow	*Passer domesticus*
Killdeer	*Charadrius vociferus*
Lark sparrow	*Chondestes grammacus*
Lazuli bunting	*Passerina amoena*
Lesser goldfinch	*Spinus psaltria*
Lesser scaup	*Aythya affinis*
Long-billed dowitcher	*Limnodromus scolopaceus*
Mallard	*Anas platyrhynchos*
Marbled godwit	*Limosa fedoa*
Marsh wren	*Cistothorus palustris*
Mountain bluebird	*Sialia currucoides*
Mourning dove	*Zenaida macroura*
Northern flicker	*Colaptes auratus*
Northern harrier	*Circus cyaneus*
Northern rough-winged swallow	*Stelgidopteryx serripennis*
Northern shoveler	*Anas clypeata*

Common Name	Scientific Name
Olive-sided flycatcher	*Contopus cooperi*
Orange-crowned warbler	*Oreothlypis celata*
Peregrine falcon	*Falco peregrinus*
Pied-billed grebe	*Podilymbus podiceps*
Prairie falcon	*Falco mexicanus*
Redhead	*Aythya Americana*
Red-tailed hawk	*Buteo jamaicensis*
Red-winged blackbird	*Agelaius phoeniceus*
Ring-billed gull	*Larus delawarensis*
Ring-necked duck	*Aythya collaris*
Ring-necked pheasant	*Phasianus colchicus*
Rock pigeon	*Columba livia*
Rock wren	*Salpinctes obsoletus*
Rough-legged hawk	*Buteo lagopus*
Ruddy duck	*Oxyura jamaicensis*
Rufous hummingbird	*Selasphorus rufus*
Sandhill crane	*Grus canadensis*
Savannah sparrow	*Passerculus sandwichensis*
Say’s phoebe	*Sayornis saya*
Sharp-shinned hawk	*Accipiter striatus*
Snowy egret	*Egretta thula*
Song sparrow	*Melospiza melodia*
Spotted sandpiper	*Actitis macularius*
Spotted towhee	*Pipilo maculatus*
Swainson's hawk	*Buteo swainsoni*

Common Name	Scientific Name
Townsend's solitaire	*Myadestes townsendi*
Tree swallow	*Tachycineta bicolor*
Tundra swan	*Cygnus columbianus*
Turkey vulture	*Cathartes aura*
Vesper sparrow	*Pooecetes gramineus*
Violet-green swallow	*Tachycineta thalassina*
Virginia rail	*Rallus limicola*
Warbling vireo	*Vireo gilvus*
Western grebe	*Aechmophorus occidentalis*
Western kingbird	*Tyrannus verticalis*
Western meadowlark	*Sturnella neglecta*
Western screech-owl	*Megascops kennicottii*
Western scrub-jay	*Aphelocoma californica*
Western tanager	*Piranga ludoviciana*
White-crowned sparrow	*Zonotrichia leucophrys*
White-faced ibis	*Plegadis chihi*
White-throated swift	*Aeronautes saxatalis*
Wild turkey	*Meleagris gallopavo*
Willow flycatcher	*Empidonax traillii*
Woodhouse's scrub-jay	*Aphelocoma woodhouseii*
Yellow warbler	*Setophaga petechia*
Yellow-breasted chat	*Icteria virens*
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
Yellow-rumped warbler	*Setophaga coronata*

Common Name	Scientific Name
FISHES	
Bluehead sucker	*Catostomus discobolus*
Bonytail	*Gila elegans*
Brook stickleback	*Culaea inconstans*
Channel catfish	*Ictalurus punctatus*
Colorado pikeminnow	*Ptychocheilus lucius*
Common carp	*Cyprinus carpio*
Fathead minnow	*Pimephales promelas*
Flannelmouth sucker	*Catostomus latipinnis*
Green sunfish	*Lepomis cyanellus.*
Humpback chub	*Gila cypha*
Largemouth bass	*Micropterus salmoides*
Razorback sucker	*Xyrauchen texanus*
Red shiner	*Cyprinella lutrensis*
Roundtail chub	*Gila robusta*
Sand shiner	*Notropis stramineus*
Smallmouth bass	*Microterus dolomieu*
Speckled dace	*Rhinichthys osculus*
Walleye	*Sander vitreus*
REPTILES AND AMPHIBIANS	
Black-necked garter snake	*Thamnophis cyrtopsis*
Canyon tree frog	*Hyla arenicolor*
Cornsnake	*Elaphe guttata*
Desert night snake	*Hypsiglena torquata deserticola*

Common Name	Scientific Name
Desert striped whipsnake	*Masticophis taeniatus taeniatus*
Great Basin spadefoot	*Spea intermontana*
Great plains toad	*Anaxyrus cognatus*
Greater short-horned lizard	*Phrynosoma hernandesi*
Long-nosed leopard lizard	*Gambelia wislizenii*
Midget faded rattlesnake	*Crotalus oreganus concolor*
Northern leopard frog	*Lithobates pipiens*
Red-spotted toad	*Anaxyrus punctatus*
Sagebrush lizard	*Sceloporus graciosus*
Smooth greensnake	*Opheodrys vernalis*
Tiger salamander	*Ambystoma tigrinum*
Tree lizard	*Urosaurus ornatus*
Western rattlesnake	*Crotalus viridis*
Western terrestrial garter snake	*Thamnophis elegands*
Western whiptail	*Cnemidophorus tigris*
Woodhouse's toad	*Anaxyrus woodhousii*

HABITAT LOCATION AND CONDITION

Figure 2.16 lists the habitat types in the planning area by river segment. This figure also provides information on proposed critical habitats for bird species and on important bird areas (IBAs). IBAs are areas identified for conservation and management that are vital to birds and other biodiversity. IBAs may provide important migratory stop-over, foraging, nesting, and/or wintering habitat. The IBA program, administered by BirdLife International and its United States partner, the National Audubon Society, is an international effort to identify, monitor, and protect areas that provide essential habitat for bird populations (Wells et al. 2005).

Using a cross section of the river, Figure 2.17 shows specific aquatic and riverbank habitats along the planning area. The condition and quality of habitat in the planning area can be negatively affected through habitat degradation, fragmentation, and loss. Such effects can stem from development (e.g., dams), the introduction and spread of invasive species, the presence of noise and light, and pollution (e.g., sedimentation, sewage, fertilizer runoff, and chemicals from oil and gas development). Habitat in the planning area has been altered from its pre-settlement condition from the draining and filling of wetlands, construction of dams, diversions for irrigation, and the degradation of water quality from municipal, industrial, and agricultural sources. Section 2.3 of the GRCMP discusses in more detail the impacts of dams on Green River sediment and flow regimes. In general, human disturbances have in many places fragmented contiguous grasslands, shrublands, and woodlands, and have altered the riparian corridor species composition along the river. In addition, invasive species have been introduced to river habitats. More recently, a concerted effort has been taken to protect and restore wildlife habitat associated with the Green River, including tamarisk (*Tamarix ramosissima*) treatment projects, improving irrigation water management and efficiency, and stream and riparian corridor restoration projects to benefit native fishes and other aquatic and riparian-dependent species.

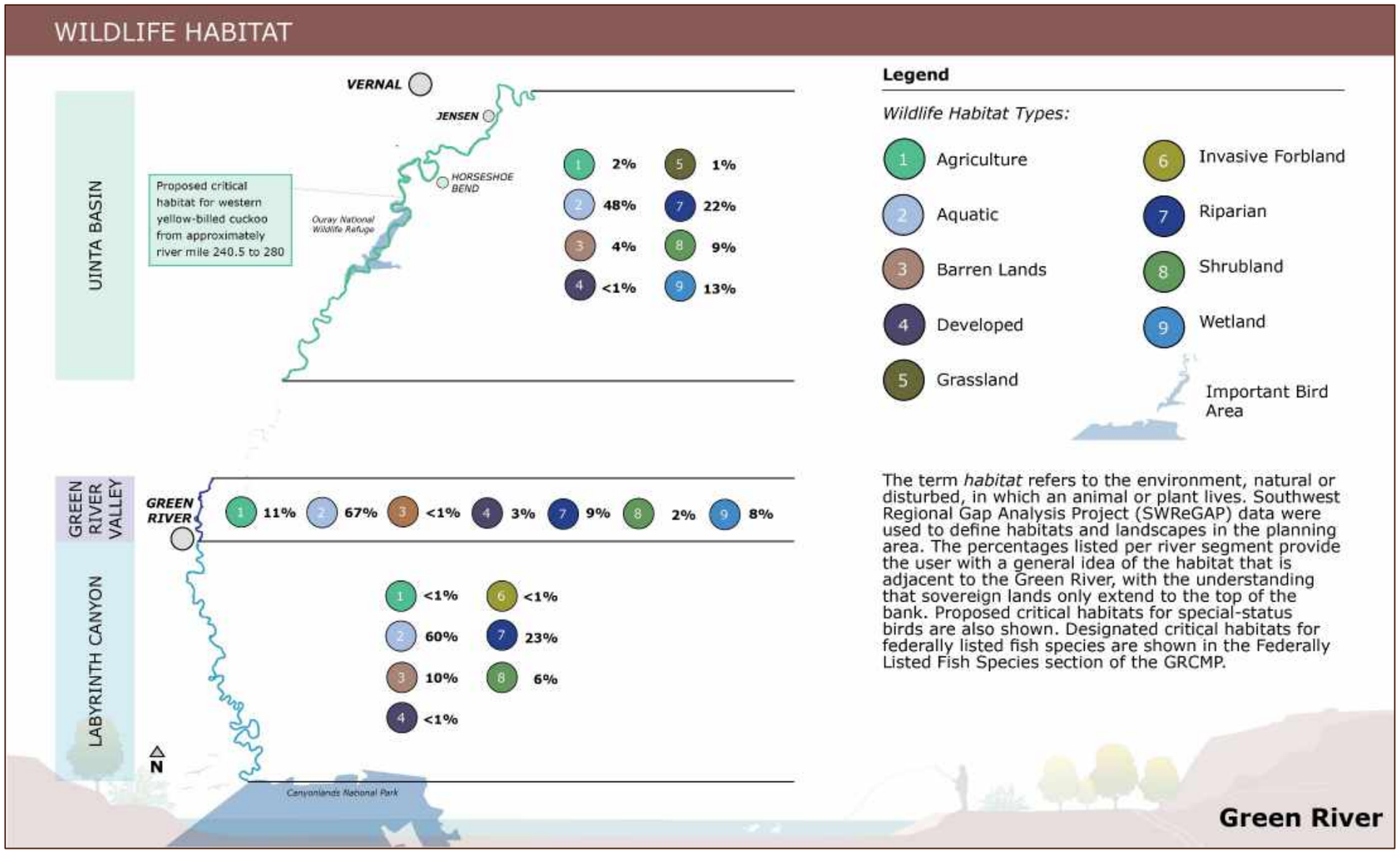

Figure 2.16. Habitat types, proposed critical habitats for bird species, and important bird areas in the planning area by river segment.

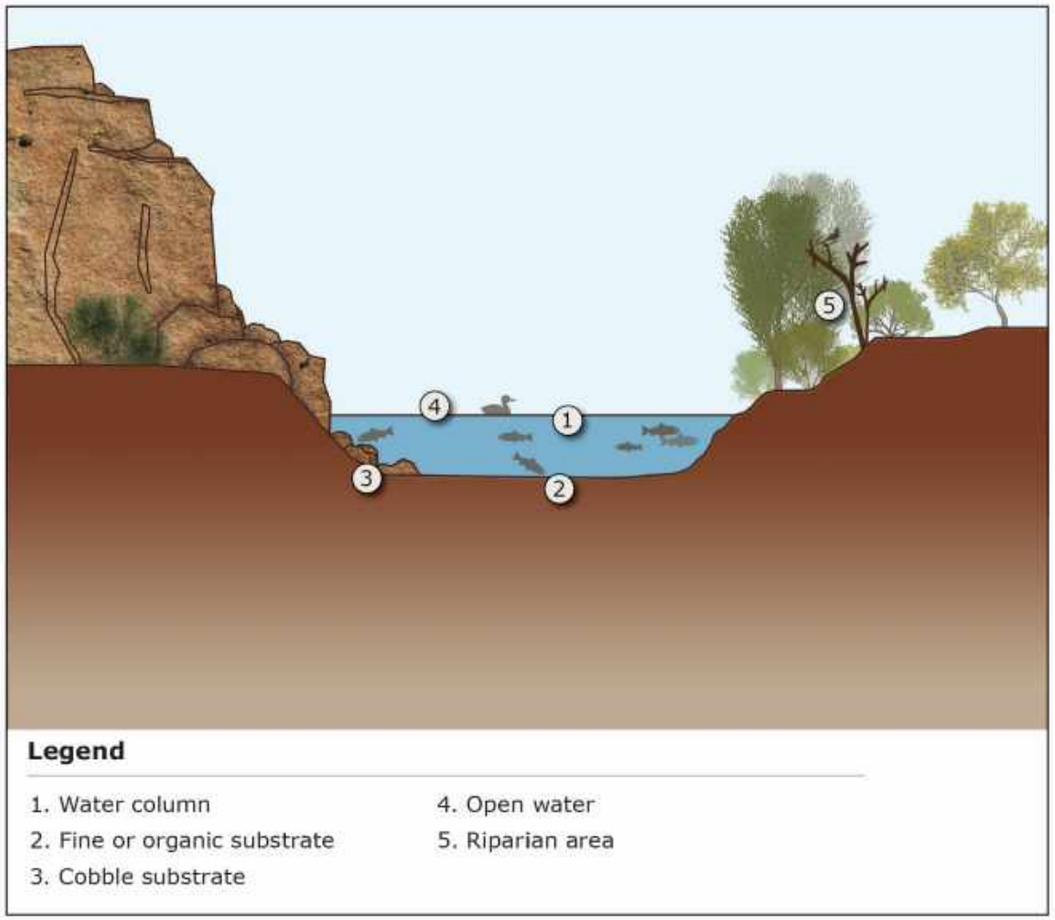

Figure 2.17. Cross section showing aquatic and riverbank habitats in the planning area.

Vegetation

A major structural component of habitat is vegetation. Vegetation is often classified by vertical structure or layers such as grasses and forbs (herbaceous), shrubs, and trees. Vegetation in the planning area can also be categorized in terms of native or desirable, special-status species, and invasive and noxious weed species. These categories are not mutually exclusive but are helpful when making management decisions regarding restoration, regulations, and weed management. The distribution and abundance of plant species can be influenced by disturbance; the proximity of disturbance to the river; and seed dispersal by wildlife, wind, water, and recreation activities.

NATIVE PLANT SPECIES

A native plant species is one that has evolved and occurs naturally in a particular region, ecosystem, or habitat (U.S. Forest Service 2018). Native plant communities provide a range of ecological functions such as increased native wildlife habitat and species diversity, erosion control, flood moderation, water filtration, and development and enrichment of soil. Table 2.4 lists native plant species in the planning area (along with their wetland indicator status) that are recommended for restoration and revegetation projects. The wetland indicator status of a plant reflects the likelihood of its presence in a wetland and influences where a particular plant species is planted during restoration and revegetation projects. For example, a plant with an upland wetland indicator status almost never occurs in wetlands and would therefore be planted in an upland area rather than a wetland area. This plant list should serve as a guide for planning restoration or revegetation projects, but is not meant to be an exhaustive list and does not reflect current seed or plant stock availability.

Table 2.4. Native Plant Species in the Planning Area Recommended for Restoration and Revegetation Projects

Common Name	Scientific Name	Wetland Indicator Status*
AQUATIC AND WETLAND PLANTS		
Bulrush species	*Schoenoplectus* spp.	OBL
Duckweed species	*Lemna* spp.	OBL
Fineleaf pondweed	*Stuckenia filiformis*	OBL
Longleaf pondweed	*Potamogeton nodosus*	OBL
Sago pondweed	*Stuckenia pectinata*	OBL
Spiral ditchgrass	*Ruppia cirrhosa*	OBL
RIPARIAN TREES		
Box elder	*Acer negundo*	FACW
Fremont cottonwood	*Populus fremontii*	FACW
Narrowleaf cottonwood	*Populus angustifolia*	FACW
Peachleaf willow	*Salix amygdaloides*	FACW
Whiplash willow	*Salix lucida*	FACW
SHRUBS		
Big sagebrush	*Artemisia tridentata*	FACU
Broom snakeweed	*Gutierrezia sarothrae*	NI
Chokecherry	*Prunus virginiana*	FAC
Fourwing saltbush	*Atriplex canescens*	UPL
Golden currant	*Ribes aureum*	FAC
Greasewood	*Sarcobatus vermiculatus*	FAC
Narrowleaf willow	*Salix exigua*	FACW
Rubber rabbitbrush	*Ericameria nauseosa*	UPL
Silver buffaloberry	*Shepherdia argentea*	FACU
Skunkbush sumac	*Rhus trilobata*	FACU
Spearleaf rabbitbrush	*Chrysothamnus linifolius*	FAC
Stretchberry	*Forestiera pubescens*	FACU
Woods' rose	*Rosa woodsii*	FACU
FORBS		
Alkali buttercup	*Ranunculus cymbalaria*	OBL
Blanket flower species	*Gaillardia* spp.	FACU
Hoary tansyaster	*Machaeranthera canescens*	UPL
Lewis flax	*Linum lewisii*	NI
Milkvetch species	*Astragalus* spp.	Varies by species
Milkweed species	*Asclepias* spp.	Varies by species
Rocky Mountain beeplant	*Cleome serrulata*	NI
Scarlet globemallow	*Sphaeralcea coccinea*	UPL
Small-leaf globemallow	*Sphaeralcea parviflora*	NI
Western white clematis	*Clematis ligusticifolia*	FAC
White sagebrush	*Artemisia ludoviciana*	FACU
Yellow beeplant	*Cleome lutea*	FACU
GRASSES		
Alkali sacaton	*Sporobolus airoides*	FAC
Arctic rush	*Juncus arcticus*	FACW
Common spikerush	*Eleocharis palustris*	OBL
Indian ricegrass	*Achnatherum hymenoides*	UPL
Inland saltgrass	*Distichlis spicata*	FAC

Common Name	Scientific Name	Wetland Indicator Status*
Nuttall's alkaligrass	*Puccinellia nuttalliana*	FACW
Sand dropseed	*Sporobolus cryptandrus*	FACU
Sandberg bluegrass	*Poa secunda*	FACU
Western wheatgrass	*Pascopyrum smithii*	FAC

* UPL = upland (almost never occurs in wetlands), FACU = facultative upland (usually occurs in non-wetlands, but may occur in wetlands), FACW = facultative wetland (usually occurs in wetlands), FAC = facultative (occurs in wetlands and non-wetlands), OBL = obligate (almost always occurs in wetlands), NI = non-indicator (Lichvar et al. 2016).

SPECIAL-STATUS PLANT SPECIES

Special-status species are species for which state or federal agencies afford an additional level of protection by law, regulation, or policy. The presence of potential habitat in the planning area for federally listed plant species was determined by comparing individual species habitat requirements to the SWReGAP land cover types predicted to occur in the planning area and to local elevation. Table 2.5 provides a list of federally listed plant species, their location per county in the planning area, and their potential to occur in the planning area by segment.

Table 2.5. Special-Status Plant Species and their Potential to Occur in the Planning Area by River Segment

Common and Scientific Name	Status*	Habitat	County	Potential to Occur in the Planning Area by Segment†		
				Uinta Basin	Green River Valley	Labyrinth Canyon
Barneby reed-mustard *Schoenocrambe barnebyi*	E-ESA	On soils derived from the Chinle Formation; in mixed shadscale (*Atriplex confertifolia*), buckwheat (*Eriogonum* spp.), and jointfir (*Ephedra* spp.) communities.	Emery, Wayne	None		
Clay reed-mustard *Schoenocrambe argillacea*	T-ESA	Along canyon rims and steep slopes; grows on soils derived from the Uinta and Green River Formations in mixed desert shrub communities.	Uintah	High; this species has been documented near this river segment.	None	
Heliotrope milkvetch *Astragalus montii*	T-ESA	Plateau margins or openings in spruce-fir forests on Flagstaff limestone.	Emery	None		
Jones cycladenia *Cycladenia humilis* var. *jonesii*	T-ESA	On soils derived from Chinle, Cutler, and Summerville Formations; grows in cool desert shrub, juniper (*Juniperus* spp.), buckwheat, and jointfir communities.	Emery, Grand, Wayne	None	Low; habitat for this species is not typically found immediately adjacent to the Green River in these river segments.	
Last chance townsendia *Townsendia aprica*	T-ESA	On clay or clay silt soils derived from Blue Gate Member of Mancos shale; grows in pinyon-juniper and salt desert shrub communities.	Emery, Wayne	None	None	
Navajo sedge *Carex specuicola*	T-ESA	Restricted to seeps-springs, hanging gardens, or pockets in Navajo sandstone.	Emery, Grand, Wayne	None	Low; this species has the potential to occur in seeps, springs, and hanging garden where Navajo sandstone is found.	
Pariette Cactus *Sclerocactus brevispinus*	T-ESA	On soils derived from the Uinta Formation, Wagonhound Member, and in alkaline clay; in saltbush flats, typically in flat cobbles and gravels.	Uintah	None		
San Rafael cactus *Pediocactus despainii*	E-ESA	Desert pavements, limestone gravels and flakes; in grama grass (*Bouteloua* spp.) and open pinyon-juniper communities.	Emery, Wayne	None		
Shrubby reed-mustard *Schoenocrambe suffrutescens*	E-ESA	On soils derived from the Green River Formation and calcareous shale; in mixed desert shrub, pinyon-juniper-sagebrush (*Artemisia* spp.), and mountain brush communities.	Uintah	None		
Uinta Basin hookless cactus *Sclerocactus wetlandicus*	T-ESA	On soils derived from the Duchesne River, Green River, and Mancos Formations; in salt desert shrub and pinyon (*Pinus edulis*) communities; on river benches, rolling hills, and valley slopes.	Uintah	High; this species has been documented near this river segment.	None	
Ute ladies'-tresses *Spiranthes diluvialis*	T-ESA	In moist to wet meadows; along streams; in abandoned stream meanders; near lake shores, seeps, and springs; and in loamy or sandy soils that are typically mixed with gravel.	Uintah, Wayne	Moderate; patches of suitable habitat may be present along the banks of the Green River in this river segment.	None	
Winkler cactus *Pediocactus winkleri*	T-ESA	In salt desert shrub and pinyon-juniper communities; on alkaline hills, desert pavements, small gravel barrens, or clay.	Emery, Wayne	None		
Wright fishhook cactus *Sclerocactus wrightiae*	E-ESA	On soils derived from Mancos shale, and Curtis, Dakota, Entrada, and Summerville Formations; in salt desert shrub, shrub-grass, and pinyon juniper communities.	Emery, Wayne	None		

Sources: USFWS (2018b, 2018c, 2018d, 2018e); DWR (2018a); Utah Rare Plants (2018). * E-ESA = ESA endangered ESA, T-ESA = ESA threatened. † "None" = there are no records of this species in this river segment and/or there is no suitable habitat for this species in this river segment.

INTRODUCED, INVASIVE, AND NOXIOUS WEED SPECIES

A weed is any plant that is not desired in a particular location and may be introduced, invasive, and/or noxious. Weedy plant species terminology and definitions are provided in Figure 2.18.

As defined by Title 4, Chapter 17 of the Utah Noxious Weed Act, a *noxious weed* is, "any plant the commissioner determines to be especially injurious to public health, crops, livestock, land, or other property" and a county-declared noxious weed is, "any plant that is: a) not on the state noxious weed list; b) especially troublesome in a particular county; and c) declared by the county legislative body to be a noxious weed within the county" (Utah Code 4-17-102). Invasive plant species, including most noxious weeds, are early successional species that possess numerous adaptations for rapid colonization and spread in disturbed habitats. These adaptations include high reproductive rates; rapid germination and growth; and annual life histories in which the plant grows, flowers, sets seed, and dies in a single season. Noxious plant species may also have superior abilities to use soil and water resources, possess allelopathic mechanisms to suppress competing species, and have been removed from their native predators and pathogens in their new environment (Coombs et al. 2004; Mack et al. 2000; Sperry et al. 2006). These factors can result in a shift in the plant community toward dominance of nonnative, invasive plant species (Mack et al. 2000). In general, nonnative and invasive plants do not provide the same habitat function as native plants. In addition, nonnative or invasive species can displace native vegetation, resulting in a reduction of plant diversity and a decrease in overall habitat structure and function.

Introduced Plant Species

A plant species living outside of its native range because of deliberate or accidental transport by human activities.

Shown here is halogeton.

Invasive Plant Species

An introduced plant species that adversely affects native species, habitats, or ecosystems.

Shown here is cheatgrass.

Noxious Weed Species

An introduced, invasive plant species that has been designated as injurious to native species, habitats, ecosystems, crops, or the health of humans or livestock.

Shown here is tamarisk.

Figure 2.18. Weedy plant species terminology and definitions.

Four noxious weed species of particular concern in the planning area are tamarisk, Russian olive (*Elaeagnus angustifolia*), Russian knapweed (*Acroptilon repens*), and perennial pepperweed (*Lepidium latifolium*). Brief descriptions of these four species are provided in Figure 2.19. Concerns about these specific species include the high potential for spreading, impeded access to the river, degradation to wildlife habitat, impairment of the viewshed, and fire safety concerns related to stands of dead and defoliated tamarisk.

Weed management in the planning area is often done by individual county weed departments in cooperation with FFSL. In addition, Utah has 20 Cooperative Weed Management Areas (CWMAs), which are partnerships of federal, state, and local government agencies, tribes, and private landowners that set common goals and pool resources to effectively manage noxious weeds across Utah. The BLM in Utah provides financial assistance to most counties in the state for weed control. CWMAs operating in the planning area are the North Ute Indian Tribe, Middle Colorado River Watershed, and Uinta Basin CWMA in Uintah County; the Skyline CWMA in Emery County; the Middle Colorado River Watershed CWMA in Grand County; and the South Central Utah CWMA in Wayne County.

Perennial Pepperweed (*Lepidium latifolium*)

Perennial pepperweed originated in southeastern Europe and Asia. This long-lived herbaceous perennial can establish in a wide range of environments, including riparian areas, wetlands, floodplains, pastures, and roadsides. It reproduces by prolific seed production and perennial rootstock. Perennial pepperweed can rapidly form large, dense stands, quickly outcompeting native vegetation, and is difficult to remove once established. This species is a Class 3 declared noxious weed in Utah. Class 3 weeds are found extensively throughout Utah, and statewide efforts are aimed at containment of smaller infestations (UDAF 2018).

Russian Olive (*Elaeagnus angustifolia*)

Russian olive originated in Europe and has been used as an ornamental tree in the United States. The fruits can be a valuable food source, and the tree often provides habitat for birds and wildlife. It grows well in meadows, pasturelands, and along waterways. Reproduction is from seed and rootstock, and thick stands can develop if left unchecked (Lowry et al. 2017). Russian olive often outcompetes native vegetation, altering the plant community structure and reducing wildlife habitat for some species (Zouhar 2005). It avoids drought stress by tapping into groundwater. Some suggest that Russian olive can alter nutrient cycling and stream hydrology (Tu 2003). Russian olive is a common tree throughout all Utah counties. This species is a Class 4 declared noxious weed in Utah. Class 4 prohibited noxious weeds are annual, biennial, or perennial designated plants that pose a threat to the state through the propagation and retail sale in the greenhouse and plant nursery industry (UDAF 2018).

Russian Knapweed (*Acroptilon repens* [synonym: *Rhaponticum repens*, *Centaurea repens*])

Russian knapweed is a deep-rooted perennial that forms large, dense monotypic stands from widely spreading horizontal roots. Russian knapweed originated in Eurasia and was initially introduced to North America in the early 1900s as a contaminant of seed (Zouhar 2001). Russian knapweed degrades forage quality and reduces plant diversity on rangelands and occurs in all Utah counties. Russian knapweed releases allelopathic compounds into the soil that suppress the growth of competing vegetation (Lowry et al. 2017). Russian knapweed can cause "chewing disease" or equine nigropallidal encephalomalacia in horses that consume it (Lowry et al. 2017). This species is a Class 3 declared noxious weed in Utah.

Tamarisk (*Tamarix ramosissima*)

Tamarisk, also known as saltcedar, is an aggressive, woody noxious plant that has become established on more than 1 million acres of the western United States. Tamarisk crowds out native stands of riparian and wetland vegetation. It increases the salinity of surface soil, rendering the soil inhospitable to native plant species, and avoids drought stress by tapping into groundwater. Tamarisk provides generally lower wildlife habitat value, but can provide vital shade in hot, arid climates. These plants can widen floodplains by clogging stream channels and increase sediment deposition because of the abundance of tamarisk stems in dense stands (Colorado State University 2000). This species is a Class 3 declared noxious weed in Utah.

Figure 2.19. Weed species of particular concern in the planning area.

Introduced, invasive, and/or noxious weed plant species that are common in and adjacent to the planning area that should be considered as part of integrated weed management are listed in Table 2.6.

Table 2.6. Introduced, Invasive, and/or Noxious Weed Plant Species Present in or Adjacent to the Planning Area

Common Name	Scientific Name
Bull thistle	*Cirsium vulgare*
Burdock	*Arctium minus*
Burningbush	*Bassia scoparia*
Canada thistle	*Cirsium arvense*
Cheatgrass	*Bromus tectorum*
Cocklebur	*Xanthium strumarium*
Common ragweed	*Ambrosia artemisiifolia*
Common reed	*Phragmites australis*
Common teasel	*Dipsacus fullonum*
Field bindweed	*Convolvulus arvensis*
Halogeton	*Halogeton glomeratus*
Hoary cress (whitetop)	*Cardaria draba*
Houndstongue	*Cynoglossum officinale*
Mullein	*Verbascum thapsus*
Pepperweed species	*Lepidium* spp.
Perennial pepperweed	*Lepidium latifolium*
Poison hemlock	*Conium maculatum*
Purple loosestrife	*Lythrum salicaria*
Reed canarygrass	*Phalaris arundinacea*
Russian knapweed	*Acroptilon repens*
Russian olive	*Elaeagnus angustifolia*
Russian thistle	*Salsola tragus*
Spotted knapweed	*Centaurea stoebe*
Tamarisk	*Tamarix ramosissima*
Yellow sweetclover	*Melilotus officinalis*

Restoration

Human encroachment on a river corridor can have a negative impact on the natural functionality of the waterway and its surrounding habitat. Negative effects from human encroachment near portions of the planning area specifically include habitat fragmentation, erosion, changes to the river channel and water flows, a reduction in species diversity, and the proliferation of invasive species. The restoration of species diversity and habitats can combat the negative impacts of these effects and provide important ecosystem services to the surrounding areas and the waterway itself. Restoring native plant diversity and improving fish and wildlife habitats throughout the planning area can reduce erosion and flooding hazards, increase pollination for adjacent environments, reduce water pollution, help establish natural hydro-morphological processes, benefit wildlife, improve visual aesthetics, and create recreational opportunities for the general public.

An example of weed management along the Colorado River system (which includes the Green River) is tamarisk control. In 2001, the tamarisk leaf beetle (*Diorhabda* spp.) was released as a biological control to help manage tamarisk (RiversEdge West 2016). The beetle damages tamarisk through repeated leaf defoliation. Since the release of the tamarisk leaf beetle on the Colorado Plateau, tamarisk leaf beetle populations have widely expanded and can be found in all three segments of the planning area, as well as portions of California, Arizona, Nevada, New Mexico, Texas, Oklahoma, Oregon, Idaho, and Wyoming (Tamarisk Coalition 2017). Restoration projects involving tamarisk treatment have been conducted at the northern end of the Green River Valley segment and in two areas of the Labyrinth Canyon segment.

AREAS OF FOCUS

Restoration focus areas along the three segments of the Green River are native vegetation enhancement and bank and channel restoration (Figure 2.20).

Figure 2.21 illustrates the conceptual difference between a degraded riverbank with limited habitat value and limited stability and a restored riverbank with native vegetation communities that improve habitat and river function.

Native Vegetation Enhancement

Noxious plant species such as tamarisk (*Tamarix ramosissima*) form large monocultures that displace native plants and reduce habitat quality for wildlife. Since the release of the tamarisk leaf beetle (*Diorhabda* spp.), much of the tamarisk along the Green River corridor has started to die. With tamarisk stands declining, noxious species such as Russian olive (*Elaeagnus angustifolia*) and Russian knapweed (*Acroptilon repens*), along with other invasive species like tree of heaven (*Ailanthus altissima*), Siberian elm (*Ulmus pumila*), and Ravenna grass (*Saccharum ravennae*) have become established. Not only do invasive species cause habitat degradation, they also decrease the aesthetic value of the river as a recreational resource. Revegetation with desirable, native plant species provides structured plant communities for quality wildlife habitat and bank stability. Controlling invasive species and revegetating with native plants comprise a major goal of restoration efforts along the Green River.

Bank and Channel Restoration

Some areas of the Green River experience significant bank erosion from flowing water, wave action, or adjacent land uses. In some locations, vertical cut banks are present that cannot support vegetation, making them more likely to erode. The lowering of the channel bottom can also cause major undercutting in places and significantly decrease bank stability. Other areas of the Green River exhibit channel narrowing, the filling of secondary channels and side channels, and vegetation encroachment. Channel narrowing is likely the effect of a reduction in frequency of high flow events compromising sediment mobility in the main channel of the river and is more pronounced in the lower gradient reaches of the Green River. As channels narrow, they become disconnected from their floodplain. Narrowing channels and vegetation encroachment simplify and degrade habitats available to native fish. Physically restoring banks and channels and improving connections to floodplains and riparian areas is crucial to restoring a variety of habitats along the river.

Figure 2.20. Restoration focus areas in the planning area.

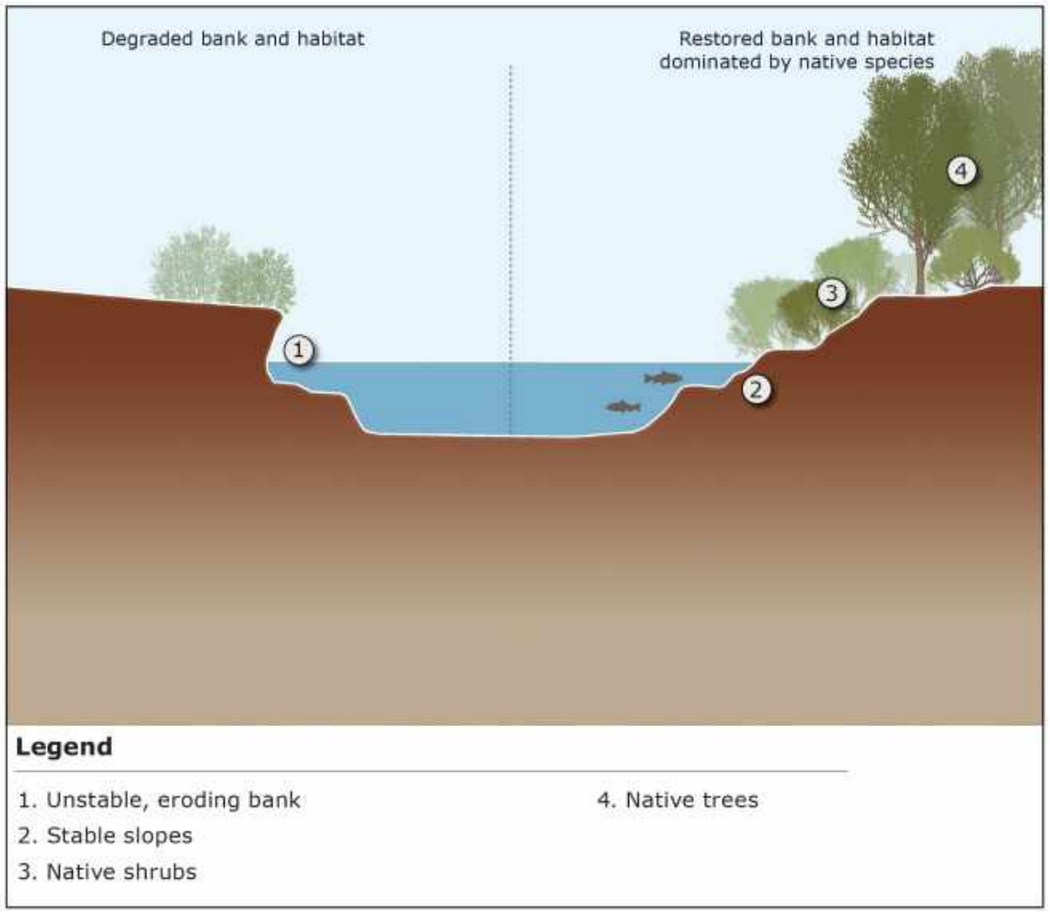

Figure 2.21. River restoration cross section showing degraded banks versus restored riverbank with diverse habitats.

Further Reading

An Evaluation of Ecosystem Restoration and Management Options for the Ouray National Wildlife Refuge, Utah (Heitmeyer and Fredrickson 2005)

Best Management Practices for Revegetation After Tamarisk Removal: In the Upper Colorado River Basin (Sher et al. 2010)

Conservation Buffers: Design Guidelines for Buffers, Corridors, and Greenways (Bentrup 2008)

Field Guide for Managing Russian Olive in the Southwest (U.S. Forest Service 2014a)

Field Guide for Managing Saltcedar in the Southwest (U.S. Forest Service 2014b)

Natural Resources Conservation Service Stream Restoration website (Natural Resources Conservation Service 2018)

Riparian Buffer Design Guidelines for Water Quality and Wildlife Habitat Functions on Agricultural Landscapes in the Intermountain West (Johnson and Buffler 2008).

Stream Corridor Restoration: Principles, Processes, and Practices (Federal Interagency Stream Restoration Working Group 2001)

The Practical Streambank Bioengineering Guide (Natural Resources Conservation Service 1998)

Why Are My Trees Brown? Tamarisk and the Tamarisk Beetle (Tamarisk Coalition 2016)

GIS Data Layers

Areas of Critical Concern, Habitat Types, National Wetlands Inventory, Noxious Weeds, Restoration Projects, Soil Types, Vegetation Types (LANDFIRE), Vegetation Types (SWReGAP)

Wildlife Species

Introduction

Riparian areas generally support a range of wildlife species. This section provides information on populations of wildlife species known to occur in or adjacent to the planning area. It is intended to complement the Wildlife Habitat section by identifying priority wildlife species on which to base development of habitat restoration, enhancement, and/or preservation goals and provide information regarding certain species of regulatory and management concern. The Green River corridor provides habitat for many native wildlife species and provides important nesting, stop-over areas, wintering areas, and foraging opportunities for migratory birds and raptors. Given anthropogenic disturbance in some areas, populations of nonnative wildlife species are also found. Habitat associations for particular wildlife can be found in the Wildlife Habitat section in Figures 2.7–2.15.

Agencies and stakeholders working in the planning area should understand that certain wildlife species are classified as special-status species, are legally protected, and may require special management under federal or state law. They should also understand that certain wildlife species add to, or detract from, the overall health of the Green River ecosystem (e.g., native species versus invasive species). Planning area agencies and stakeholders may also be interested in wildlife species that have recreational value, such as birds. Not only does the presence of a variety of wildlife species provide recreational opportunities, it is also an indicator of a healthy ecosystem.

Figure 2.22 illustrates the abundant and common native and nonnative fish species along the three river segments, as well as eBird locations (hotspots) from which bird species data for Table 2.10 were obtained.

The sections that follow describe special-status species, fish species, bird species, and species of management concern found within the planning area.

Special-Status Species

Special-status wildlife species include federally listed species that are protected under the ESA (threatened and endangered species), species considered candidates for such listing (candidate species), Utah wildlife species of concern (SPC), and species receiving special management under a conservation agreement to preclude the need for federal listing (CS).

Table 2.7 provides a list of special-status species, their location per county in the planning area, and their potential to occur in or adjacent to the planning area by segment. The table also includes each species' status and general habitat association. This list of special-status wildlife species was compiled from the Utah's state listed species by county list, which uses known species occurrences and observations from the Utah Natural Heritage Program's Biodiversity Tracking and Conservation System (DWR 2017) and the USFWS Information for Planning and Consultation for individual counties in the planning area (USFWS 2018b, 2018c, 2018d, 2018e). Fish species occurrence information was also obtained from Dr. Richard Valdez, fisheries subject matter expert, who has 46 years of experience in aquatic ecosystems of western North America (including the planning area).

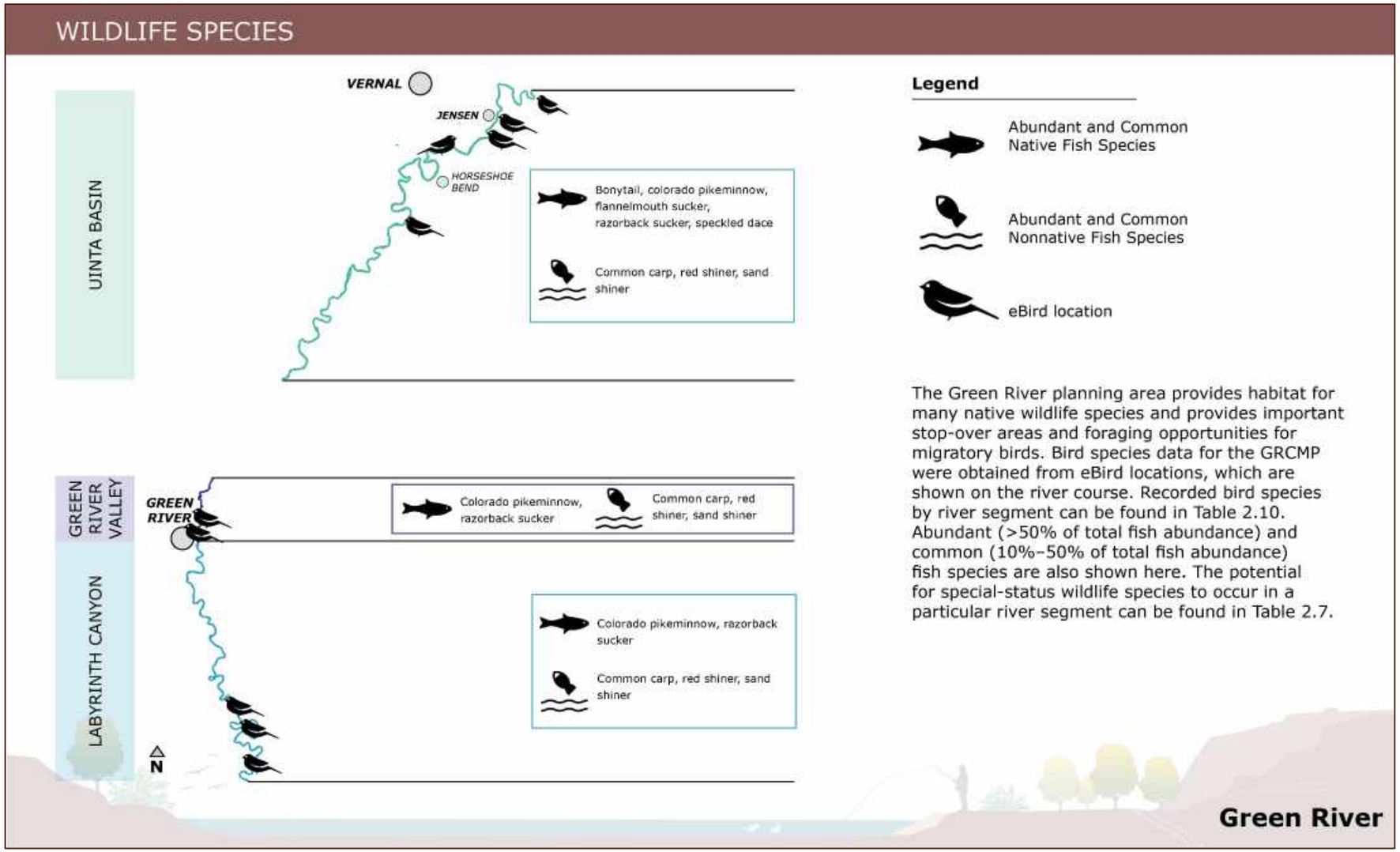

Figure 2.22. Abundant and common native and nonnative fish species and eBird locations (hotspots) in the planning area by river segment.

Table 2.7. Special-Status Wildlife Species and their Potential to Occur in or Adjacent to the Planning Area by Segment

Common Name and Scientific Name	Status*	General Habitat Association	County	Potential to Occur in or adjacent to the Planning Area by Segment		
				Uinta Basin	Green River Valley	Labyrinth Canyon
BIRDS						
American three-toed woodpecker *Picoides dorsalis*	SPC	This species inhabits mixed conifer and aspen forests. It is a cavity nester.	Grand, Uintah	This species is not expected to occur in these river segments.		
American white pelican *Pelecanus erythrorhynchos*	SPC	Foraging sites for this species are often waterbodies less than 8 feet deep where they feed on small fish, generally less than half of their bill length.	Grand, Uintah, Wayne	This species has been documented in this river segment and at nearby Pelican Lake.	This species is not expected to occur in these river segments.	
Bald eagle *Haliaeetus leucocephalus*	SPC	This species tends to nest within 650 feet of water. They eat mainly fish and carrion.	Emery, Grand, Uintah, Wayne	This species has been documented along these river segments.		
Bobolink *Dolichonyx oryzivorus*	SPC	This species nests in marshes, grasslands, and in hayfields.	Uintah	This species may use riparian and wetland areas along this river segment during the summer months.	This species is not expected to occur in these river segments.	
Burrowing owl *Athene cunicularia*	SPC	This species nests in burrows made by prairie dogs, badgers, or ground squirrels in open grassland and desert environments.	Emery, Grand, Uintah, Wayne	This species may occur along these river segments during summer months.		
California condor *Gymnogyps californianus*	E-ESA, EXPN-ESA	Foraging sites for this species are open grasslands, typically far from nesting sites. This species nests on cliffs in forested mountain regions.	Emery, Grand, Uintah, Wayne	This species is not expected to occur in these river segments.		
Ferruginous hawk *Buteo regalis*	SPC	This species generally nests and forages in open country, primarily prairies, plains, and desert. It tends to nest on cliffs, trees, or in power poles.	Emery, Grand, Uintah, Wayne	This species may nest along these river segments and can be observed during the spring and fall migration. Some individuals may winter along these river segments.		
Grasshopper sparrow *Ammodramus savannarum*	SPC	This ground-nesting species forages and nests in grasslands.	Wayne	This species may occur along this river segment during summer months.	This species is not expected to occur in these river segments.	
Greater sage-grouse *Centrocercus urophasianus*	SPC	This species inhabits sagebrush steppe and uses several types of sagebrush habitats during different times of the year.	Emery, Grand, Uintah, Wayne	This species may use riparian habitat along the portions of the river segment that are located adjacent to DWR designated occupied and brooding habitat.	This species is not expected to occur in these river segments.	

Common Name and Scientific Name	Status*	General Habitat Association	County	Potential to Occur in or adjacent to the Planning Area by Segment		
				Uinta Basin	Green River Valley	Labyrinth Canyon
Gunnison sage-grouse *Centrocercus minimus*	T-ESA	This species uses sagebrush and sagebrush-grassland habitats. This species is restricted to western Colorado and eastern Utah where it is a year-round resident.	Grand	This species is not expected to occur in these river segments.		
Lewis's woodpecker *Melanerpes lewis*	SPC	This species generally occurs in open woodland areas. It is a cavity nester.	Grand, Uintah	This species has been documented along this river segment.	This species may use riparian areas along these river segments for nesting and foraging.	
Long-billed curlew *Numenius americanus*	SPC	This species primarily nests in short grass and prairies. Migratory habitat includes shortgrass prairies, wetlands, and some agricultural areas such as alfalfa and barley fields.	Uintah	This species has been documented along this river segment.	This species may occur along this river segment during summer months.	This species is not expected to occur in this river segment.
Mexican spotted owl *Strix occidentalis lucida*	T-ESA	In Utah, this species occupies steep rocky canyons and is non-migratory.	Emery, Grand, Uintah, Wayne	This species may use riparian areas along this river segment for foraging.	This species may use riparian areas along this river segment for foraging.	This species may use riparian areas along this river segment for foraging. Designated critical habitat for this species is located south of this river segment in Canyonlands National Park.
Mountain plover *Charadrius montanus*	SPC	In Utah, this ground-nesting species occupies sparsely vegetated sagebrush-grassland and shrub-steppe habitat during the summer nesting season.	Uintah	This species does not nest along this river segment but may be observed migrating during the spring and fall.	This species is not expected to occur in these river segments.	
Northern goshawk *Accipiter gentilis*	CS	This species nests in mature forests and forages in forested areas and along riparian corridors.	Emery, Grand, Uintah, Wayne	This species may use riparian areas along these river segments for foraging.		
Short-eared owl *Asio flammeus*	SPC	This species nests and forages in open grasslands, shrublands, and other open habitats.	Uintah, Wayne	This species has been documented along this river segment.	This species may use riparian areas along these river segments for foraging.	
Southwestern willow flycatcher *Empidonax traillii extimus*	E-ESA	This species is associated with riparian habitats, particularly in areas of dense willow and tamarisk.	Emery, Grand, Uintah, Wayne	This species is not known to occur in these river segments.		

Common Name and Scientific Name	Status*	General Habitat Association	County	Potential to Occur in or adjacent to the Planning Area by Segment		
				Uinta Basin	Green River Valley	Labyrinth Canyon
Western yellow-billed cuckoo *Coccyzus americanus*	T-ESA	This species is a late migrant, arriving in Utah in late May or early June and breeding in late June through July. This species nests in patches of multi-layered riparian vegetation that are at least 12 acres or greater in extent and are separated from other patches of suitable habitat by at least 980 feet.	Emery, Grand, Uintah, Wayne	This species has been documented along this river segment during summer months. Proposed critical habitat for this species is located along a continuous segment of the Green River near Ouray in Uintah County, Utah.	This species has been documented along this river segment during summer months.	This species has been documented along this river segment during summer months. Proposed critical habitat for this species is located south of this river segment in Canyonlands National Park.
MAMMALS						
Allen's big-eared bat *Idionycteris phyllotis*	SPC	This species occurs in the southern portion of Utah and uses riparian and rocky areas in scrub-shrub and wooded areas. It roosts in caves and rock crevices.	Grand, Wayne	This species is likely to occur at least sporadically along these river segments.		
Big free-tailed bat *Nyctinomops macrotis*	SPC	This species is migratory. It occurs in rocky and woodland habitats and roosts in mines, caves, rock crevices, and buildings.	Grand, Uintah, Wayne	This species is likely to occur at least sporadically along these river segments.		
Black-footed ferret *Mustela nigripes*	E-ESA, EXPN-ESA	This species is closely associated with prairie dogs. They live in prairie dog burrows and their primary food source is prairie dogs.	Uintah	This species has not been documented recently near this river segment.	This species is not expected to occur in these river segments.	
Canada lynx *Lynx canadensis*	T-ESA	This species prefers montane coniferous forests.	Uintah	This species, if present, may pass through these river segments but would not be a resident.		
Fringed myotis *Myotis thysanodes*	SPC	This species is migratory. It occurs in desert and woodland areas. It roosts in caves, mines, and buildings.	Grand, Uintah, Wayne	This species may migrate through these river segments.		
Gunnison's prairie dog *Cynomys gunnisoni*	SPC	This species forms colonies and lives in underground burrows, often hibernating during the winter months. This species is found in the southeastern part of Utah.	Grand	This species is not expected to occur in these river segments.		
Kit fox *Vulpes macrotis*	SPC	This species occurs in desert, open prairie, and plains habitats in the western portion of Utah.	Emery, Grand, Uintah, Wayne	This species has been documented near this river segment.	This species is not expected to occur in these river segments.	
Pygmy rabbit *Brachylagus idahoensis*	SPC	This species prefers areas with tall, dense sagebrush and loose soils in northern and western Utah.	Wayne	This species is not expected to occur in these river segments.		
Spotted bat *Euderma maculatum*	SPC	This species roosts and hibernates in rock crevices and caves and can be found in a variety of habitats including forested mountains and deserts.	Grand, Uintah, Wayne	This species may occur in these river segments.		

Common Name and Scientific Name	Status*	General Habitat Association	County	Potential to Occur in or adjacent to the Planning Area by Segment		
				Uinta Basin	Green River Valley	Labyrinth Canyon
Townsend's big-eared bat *Corynorhinus townsendii*	SPC	This species is often found near forested and riparian areas and uses caves, mines, and buildings for day roosting and winter hibernation.	Emery, Grand, Uintah, Wayne	This species has been documented along these river segments.		
Utah prairie dog *Cynomys parvidens*	T-ESA	This species forms colonies and lives in underground burrows, often hibernating during the winter months. This species is endemic to Utah.	Emery, Wayne	This species is not known to occur in these river segments.		
White-tailed prairie dog *Cynomys leucurus*	SPC	This species forms colonies and lives in underground burrows, often hibernating during the winter months. This species is endemic to Utah.	Emery, Grand, Uintah	This species has been documented adjacent to these river segments.		
FISHES						
Bluehead sucker *Catostomus discobolus*	CS	This species is a bottom dweller that feeds primarily on algae that it scrapes from the surface of rocks. It occurs in the upper Colorado River system, the Snake River system, and the Lake Bonneville basin.	Emery, Grand, Uintah, Wayne	This species has been documented in these river segments.		
Bonytail *Gila elegans*	E-ESA	This species prefers backwaters, pools, and eddies near swift current in the Colorado River system.	Emery, Grand, Uintah, Wayne	This species has been documented in this river segment.	This species has been documented in this river segment. The northern end of this river segment (approximately 0.25 mile) is designated critical habitat for this species.	This species has been documented in this river segment.
Colorado pikeminnow *Ptychocheilus lucius*	E-ESA	Young of this species prefer slow-moving backwaters of the Colorado River system, whereas adults inhabit a range of habitats from flooded lowlands to turbid rapids.	Emery, Grand, Uintah, Wayne	This species has been documented in these river segments. Designated critical habitat for this species is located in these river segments.		
Colorado River cutthroat trout *Oncorhynchus clarkia pleuriticus*	CS	This species historically occurred throughout the colder waters of the Colorado River basin, mainly in Colorado, Utah, and Wyoming. This species inhabits pools and small riffles in relatively steep, coldwater streams and rivers.	Emery, Uintah, Wayne	This species may occur in some of the smaller tributaries of the Green River but is not expected to occur in these river segments.		
Flannelmouth sucker *Catostomus latipinnis*	CS	In Utah, this species occurs in deep pools of slow-flowing, low-gradient reaches of the mainstem of the Colorado River and its larger tributaries.	Emery, Grand, Uintah, Wayne	This species has been documented in these river segments.		

Common Name and Scientific Name	Status*	General Habitat Association	County	Potential to Occur in or adjacent to the Planning Area by Segment		
				Uinta Basin	Green River Valley	Labyrinth Canyon
Humpback chub *Gila cypha*	E-ESA	This species spawns in shallow, backwater areas containing cobble substrate. Adults use rapids and whitewater areas of the Colorado, Green, and White Rivers.	Emery, Grand, Uintah, Wayne	This species has been documented in this river segment.	This species has been documented in this river segment, primarily in the upper mile of the segment in Gray Canyon. The northern end of this river segment (approximately 0.25 mile) is designated critical habitat for this species.	This species uses this river segment as a movement corridor.
Razorback sucker *Xyrauchen texanus*	E-ESA	This species uses impoundments and slow-moving backwater habitats in the Colorado River system.	Emery, Grand, Uintah, Wayne	This species has been documented in these river segments. Designated critical habitat for this species is located in this segment.		
Roundtail chub *Gila robusta*	CS	This species uses murky pools near fast currents in the mainstem of the Colorado River and its larger tributaries.	Emery, Grand, Uintah, Wayne	This species has been documented in these river segments.		
AMPHIBIANS						
Great Plains toad *Anaxyrus cognatus*	SPC	This species prefers grassland, desert, and agricultural habitats. This species burrows underground and becomes inactive during the cold winter months.	Emery, Grand,	This species has been documented in areas adjacent to this river segment.	This species may occur in this river segment.	This species has been documented adjacent to this river segment.
Western (boreal) toad *Anaxyrus* (syn. *Bufo*) *boreas*	SPC	This species is generally a high-elevation species that occurs in wetlands surrounded by a variety of habitats.	Emery, Wayne	This species is not known to occur in these river segments.		
REPTILES						
Cornsnake *Elaphe guttata*	SPC	This species occurs in forested or rocky habitats or near streams in eastern Utah.	Grand, Uintah	This species is not known to occur in this river segment.	This species has been documented near this river segment.	This species is not known to occur in this river segment.
Smooth greensnake *Opheodrys vernalis*	SPC	This species prefers meadows and moist grassy areas and is known to occur in the Uinta, La Sal, Abajo, and Wasatch Mountains in Utah.	Grand, Uintah	This species is not known to occur in these river segments.		
INVERTEBRATES						
Eureka mountainsnail *Oreohelix eurekensis*	SPC	This species is endemic to Utah and has been reported from six localities that represent four widely separated populations in northern Utah.	Grand	This species is not known to occur in these river segments.		

* E-ESA = ESA endangered, EXPN-ESA = experimental, non-essential under the ESA, T-ESA = ESA threatened, SPC = Utah wildlife species of concern, CS = species receiving special management under a Conservation Agreement to preclude the need for federal listing.

The *Utah Wildlife Action Plan* identifies 141 SGCN in Utah and provides a summary of the distribution and abundance information on these species and a threat assessment for some species and their habitats. Many SGCN, such as the white-faced ibis (*Plegadis chihi*), olive-sided flycatcher (*Contopus cooperi*), bald eagle (*Haliaeetus leucocephalus*), and golden eagle (*Aquila chrysaetos*), are found along the three river segments and adjacent habitats. The planning area provides habitat for SGCN bat species such as big free-tailed bat (*Nyctinomops macrotis*), fringed myotis (*Myotis thysanodes*), spotted bat (*Euderma maculatum*), and Townsend's big-eared bat (*Corynorhinus townsendii*). Additionally, SGCN fish species such as bluehead sucker (*Catostomus discobolus*), bonytail (*Gila elegans*), Colorado pikeminnow (*Ptychocheilus lucius*), flannelmouth sucker (*Catostomus latipinnis*), humpback chub (*Gila cypha*), razorback sucker (*Xyrauchen texanus*), and roundtail chub (*Gila robusta*) are found in various segments of the planning area.

Fish Species

The Green River provides fish spawning, rearing, and nursery habitat. Figure 2.23 provides a plan view and accompanying cross sections showing examples of this habitat in the planning area.

In total, 30 species of fish inhabit the Green River in the planning area. These comprise 22 nonnative species and eight native species (Table 2.8). Four of the native species are listed as endangered under the ESA (i.e., bonytail, Colorado pikeminnow, humpback chub, and razorback sucker), and three native species are included in a range-wide species conservation plan (i.e., flannelmouth sucker, bluehead sucker, and roundtail chub). These seven species are discussed in more detail in this section.

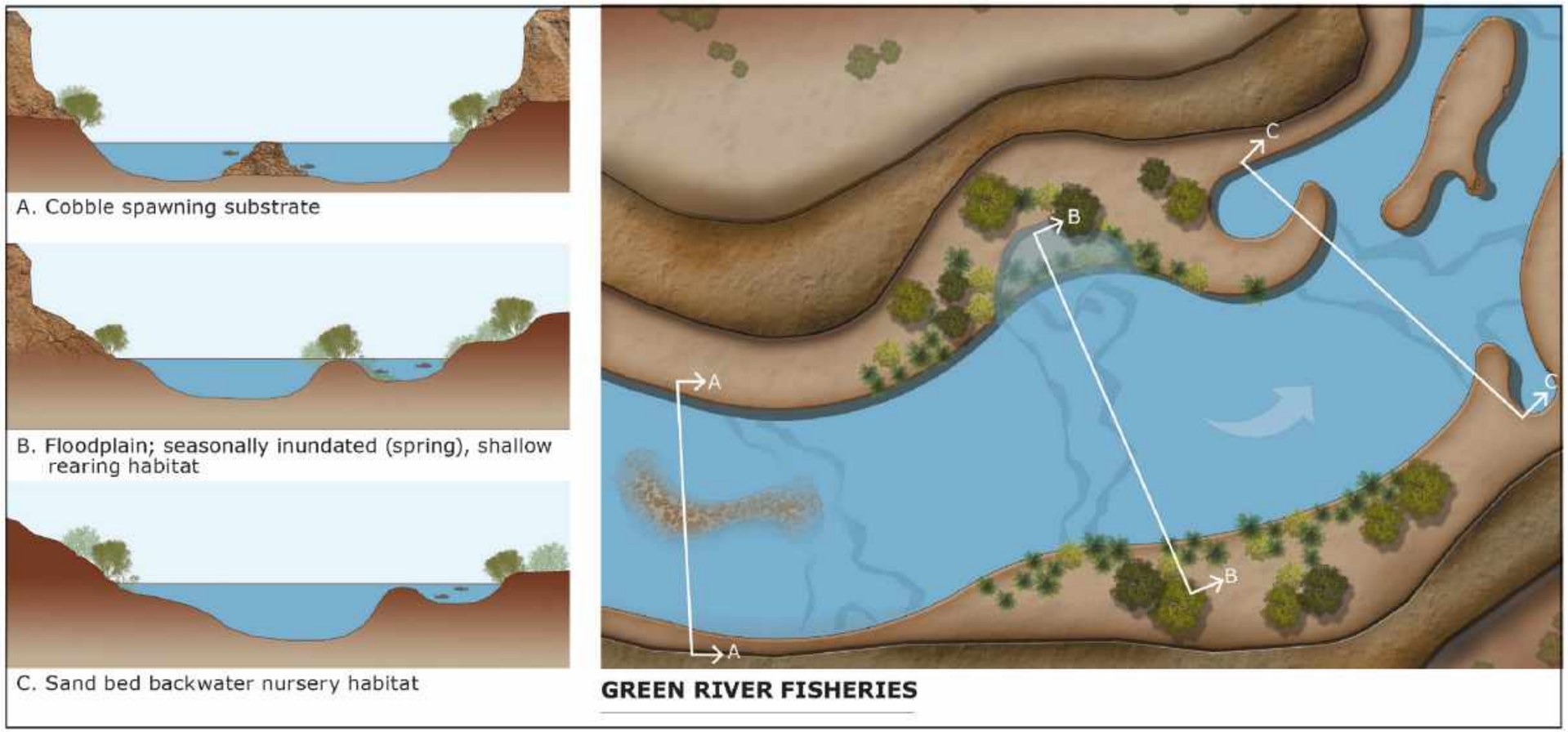

Figure 2.23. Green River plan view and cross sections of fish spawning, rearing, and nursery habitats.

Table 2.8. Approximate Relative Abundance of Fish Species in the Planning Area by Segment

Common Name	Scientific Name	Uinta Basin	Green River Valley	Labyrinth Canyon
NATIVE FISHES				
Bluehead sucker	*Catostomus discobolus*	R	R	R
Bonytail	*Gila elegans*	C	R	R
Colorado pikeminnow	*Ptychocheilus lucius*	C	C	C
Flannelmouth sucker	*Catostomus latipinnis*	C	R	R
Humpback chub	*Gila cypha*	R	R	–
Roundtail chub	*Gila robusta*	R	R	R
Razorback sucker	*Xyrauchen texanus*	C	C	C
Speckled dace	*Rhinichthys osculus*	C	R	R
NONNATIVE FISHES				
Black bullhead	*Ameiurus melas*	R	R	R
Black crappie	*Pomoxis nigromaculatus*	R	R	–
Bluegill	*Lepomis macrochirus*	R	–	–
Brassy minnow	*Hybognathus hankinsoni*	R	–	–
Brook stickleback	*Culaea inconstans*	R	–	–
Channel catfish	*Ictalurus punctatus*	R	R	R
Common carp	*Cyprinus carpio*	C	C	C
Creek chub	*Semotilus atromaculatus*	R	–	–
Fathead minnow	*Pimephales promelas*	R	R	R
Gizzard shad	*Dorosoma cepedianum*	R	R	R
Grass carp	*Ctenopharyngodon idella*	R	R	R
Green sunfish	*Lepomis cyanellus*	R	R	–
Iowa darter	*Etheostoma exile*	R	–	–
Largemouth bass	*Micropterus salmoides*	R	R	R
Mosquitofish	*Gambusia affinis*	R	R	R
Plains killifish	*Fundulus zebrinus*	R	R	–
Red shiner	*Cyprinella lutrensis*	A	A	A
Redside shiner	*Richardsonius balteatus*	R	R	R
Smallmouth bass	*Micropterus dolomieu*	R	R	R
Sand shiner	*Notropis stramineus*	C	C	C
Walleye	*Sander vitreus*	R	R	R
White sucker	*Catostomus commersonii*	R	R	R

Source: Valdez (2018).

Notes: A = abundant, > 50% of total fish abundance; C = common, 10%–50% of total fish abundance; R = rare, < 10% of total fish abundance; Dash = the species is not found in that segment.

Section 7 of the ESA requires federal agencies to ensure that the effects of actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of endangered species. These determinations are made through ESA Section 7 consultations that include a biological assessment or a biological opinion. Federally endangered and threatened species are also protected from "take" under Section 9 of the ESA. The ESA defines *take* as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct" (USFWS 2013). In addition, the ESA requires the designation of critical habitat for listed species when "prudent and determinable" (USFWS 2013).

Conservation species are included in a range-wide conservation agreement intended to implement conservation and management actions to avert federal listing. The conservation agreement for the three conservation species discussed in this section is signed by six western states: Arizona, Nevada, Utah, New Mexico, Colorado, and Wyoming (DWR 2006).

FEDERALLY LISTED FISH SPECIES

BONYTAIL

The bonytail is a large cyprinid (minnow) fish (Figure 2.24) endemic to the Colorado River basin. Adults live up to 40 years and attain a maximum size of approximately 550 millimeters (mm) total length (TL) and a weight of 1.1 kilograms (kg). The bonytail was listed as endangered under the ESA in 1980 (45 *Federal Register* 27710, April 23, 1980). A recovery plan was approved on September 4, 1990 (USFWS 1990a), and recovery goals were approved on August 1, 2002 (USFWS 2002a). Critical habitat was designated in 1994 (59 *Federal Register* 13374, April 20, 1994).

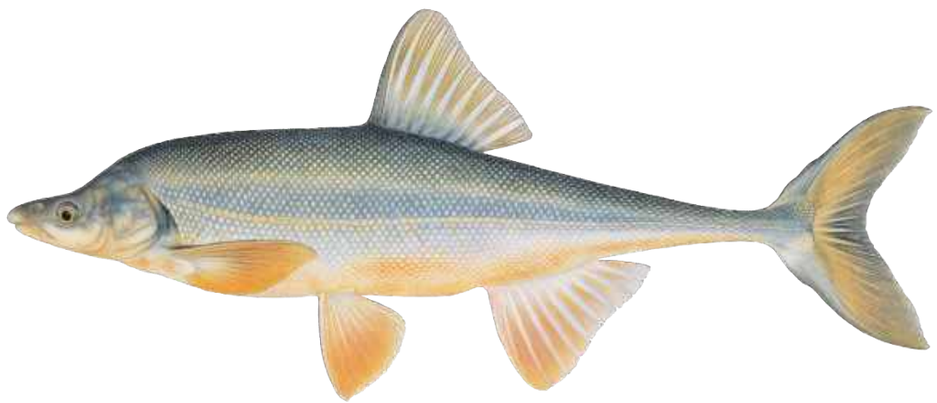

Figure 2.24. Adult bonytail.

The bonytail is the rarest native fish in the Colorado River basin. Few wild bonytail have been collected in the last 35 years, and wild fish are rarely found in the upper basin (USFWS 2002a). Reasons for decline include habitat alteration and destruction, disruption of natural flow and temperature, disruption of sediment regimes by mainstem dams and diversions, and competition and predation from nonnative fishes.

Because of their streamlined body and because many individuals were historically caught in swift stretches of the Colorado River, the bonytail was originally thought to be a canyon-dweller like the humpback chub. The reaches of designated critical habitat are in canyon-bound areas (Figure 2.25). However, recent releases of large numbers of hatchery-reared bonytail indicate that the species may be more reliant on floodplain habitats and not necessarily canyon-bound reaches.

To assist with species recovery, hatchery propagation of bonytail began in 1981 with 11 wild adults that were captured from Lake Mohave. Hatchery-reared bonytail have been stocked in both upper and lower basins of the Colorado River system. More than 500,000 bonytail were released in the upper basin from 2000 to 2016, with 63% stocked in the Green River subbasin and the balance stocked in the Colorado River subbasin. Between 16,000 and 35,000 bonytail have been stocked annually in the upper basin since the 2000.

Stocking in the upper basin has occurred in a variety of habitats, including high-gradient, canyon-bound reaches as well as low-gradient, alluvial sections, often at sites where last-known wild individuals were captured or where floodplain wetlands exist. Use of floodplain wetlands and selected riverine backwaters was in response to successful stocking of bonytail in isolated off-channel ponds of the lower Colorado River. Recently, successful reproduction of bonytail was documented in inundated floodplains (i.e., Stewart Lake and Johnson Bottom) of the middle Green River (Bestgen et al. 2017). Because successful reproduction by bonytail in the wild has only been recently documented, the habitat used and behavior of the adults are still unknown. Nevertheless, the evidence is compelling that the bonytail appear to use a variety of habitats but seem to survive as young fish in inundated floodplains of reaches like the middle Green River.

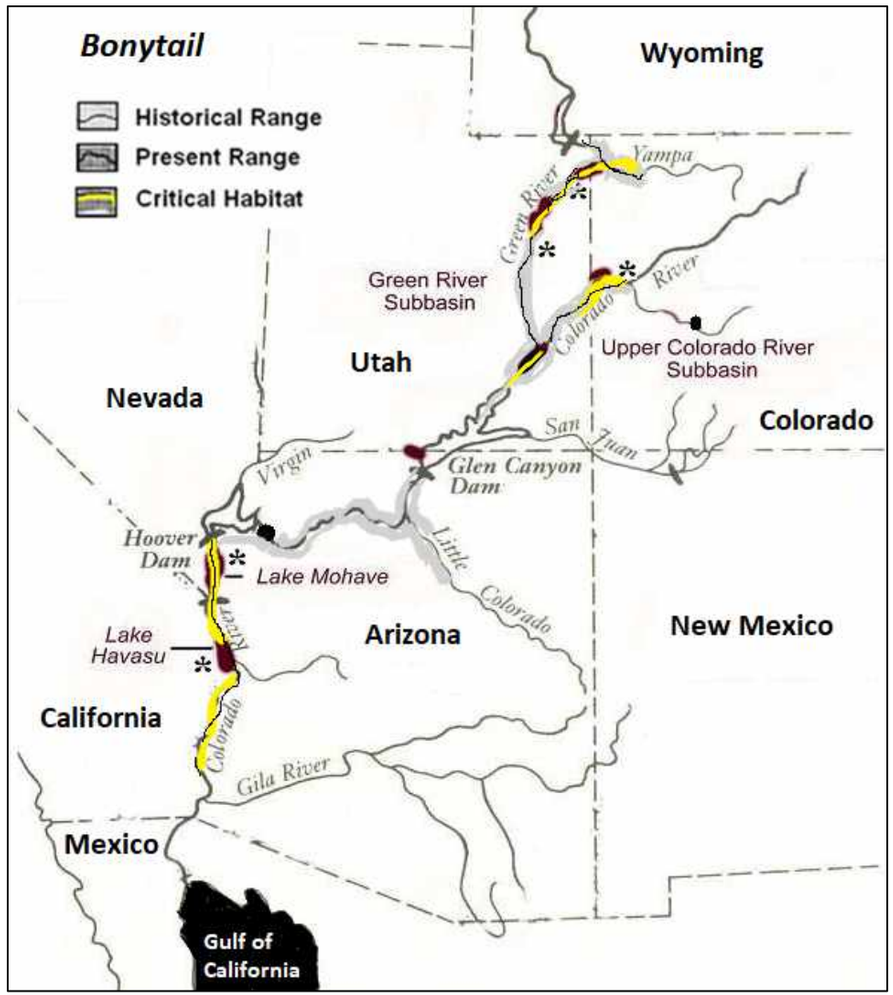

Figure 2.25. Historical and present distribution of the bonytail with designated critical habitat in the Colorado River system.

Source: Valdez et al. (2012). Used with permission.

Colorado Pikeminnow

The Colorado pikeminnow is a large cyprinid (minnow) fish species (Figure 2.26) and is the largest cyprinid in North America. The species attains a maximum size of approximately 1.8 meters (m) TL and a weight of 36 kg. Adults mature at 5 to 7 years of age and can live for 40 years.

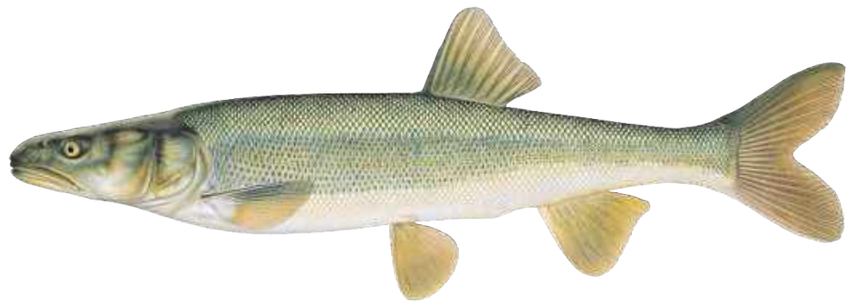

Figure 2.26. Adult Colorado pikeminnow.

Illustration © Joseph R. Tomelleri. Used with permission.

The Colorado pikeminnow is listed as endangered under the ESA (32 *Federal Register* 4001, March 11, 1967; 50 *Federal Register* 30194, July 24, 1985). The latest revised Colorado squawfish (pikeminnow) recovery plan was approved on August 6, 1991 (USFWS 1991) and recovery goals were approved on August 1, 2002 (USFWS 2002b). The final rule for designation of critical habitat became effective in 1994 (59 *Federal Register* 13374, April 20, 1994).

The Colorado pikeminnow was once distributed throughout much of the Colorado River and its tributaries. Today, wild, reproducing populations occur in the Green River and upper Colorado River subbasins of the upper basin (i.e., upstream of Glen Canyon Dam, Arizona), and there are small numbers of wild individuals (with limited reproduction) in the San Juan River subbasin (Miller 2014; Figure 2.27). The species was extirpated from the lower basin in the 1970s but was reintroduced into the Gila and Verde Rivers in 1985 as a nonessential, experimental population (*Federal Register* Vol. 50. No. 142, 30188–30195, July 24, 1985), where it persists in small numbers today.

The Colorado pikeminnow is a long-distance migrator, moving hundreds of kilometers to and from spawning areas. Spawning occurs in late June and July after spring runoff at water temperatures of 18 degrees Celsius (°C) to 23°C. Spawning in the Green River subbasin occurs in primarily two rocky canyon areas, the lower Yampa River (i.e., Cleopatra's Couch) and lower Gray Canyon (i.e., Fish Ford rapid). Eggs are broadcast and fertilized over cobble and gravel substrates. The eggs incubate in 5 to 7 days, and the newly hatched larvae remain in the substrate for a few days before emerging and becoming transported downstream. The larval and post-larval fish become entrained in warm productive backwaters where they remain for the rest of the summer and winter, until the following spring runoff. Juveniles and subadults use a variety of habitats in sandy reaches of river and adults require pools, deep runs, and eddy habitats maintained by high spring flows. These high spring flows maintain channel and habitat diversity, flush sediments from spawning areas, rejuvenate food production, form gravel and cobble deposits used for spawning, and rejuvenate backwater nursery habitats.

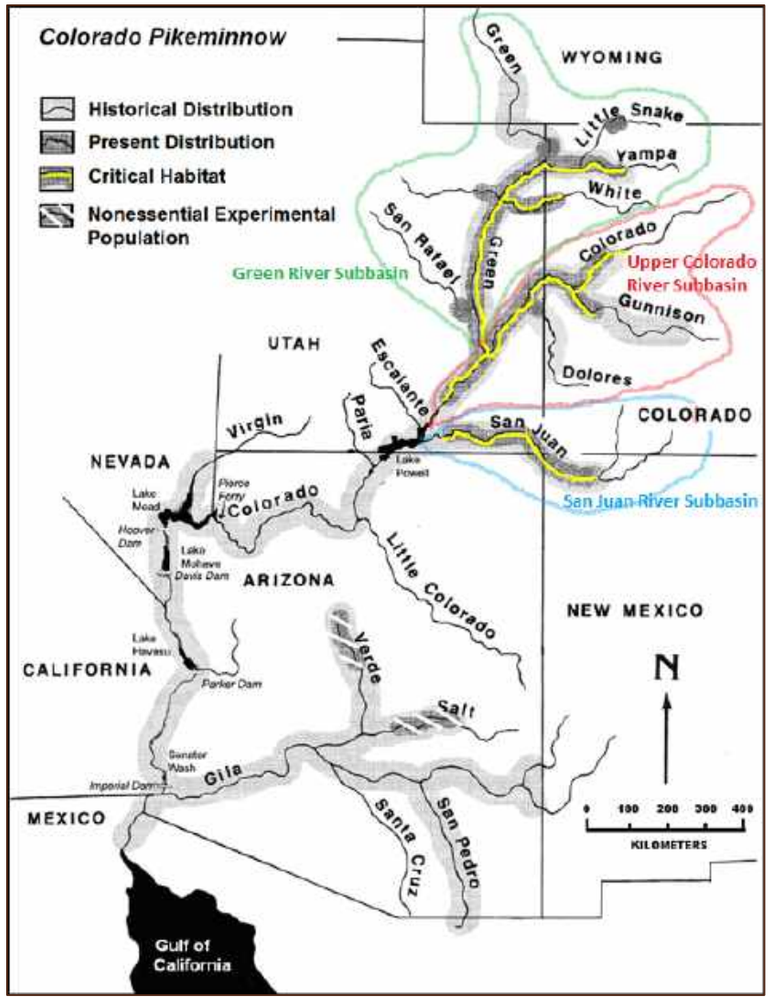

Figure 2.27. Historical and present distribution of the Colorado pikeminnow with designated critical habitat in the Colorado River system.

Source: Miller (2018). Used with permission.

HUMPBACK CHUB

The humpback chub is a warm-water cyprinid (minnow) fish species (Figure 2.28) endemic to the Colorado River system of the southwestern United States. The species attains a maximum size of 480 mm TL and a weight of 1.2 kg.

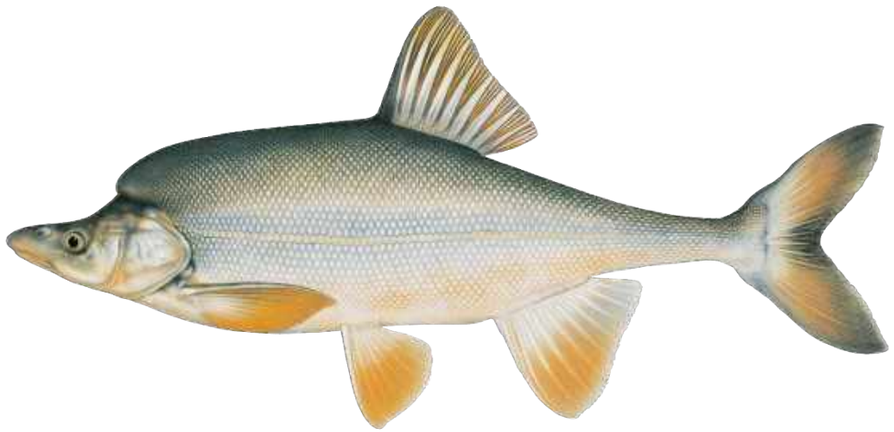

Figure 2.28. Adult humpback chub.

Illustration © Joseph R. Tomelleri. Used with permission.

The humpback chub is listed as endangered under the ESA (32 *Federal Register* 4001, March 11, 1967; 50 *Federal Register* 30194, July 24, 1985). The latest revised humpback chub recovery plan was approved on September 19, 1990 (USFWS 1990b) and recovery goals were approved on August 1, 2002 (USFWS 2002c). The final rule for designation of critical habitat became effective in 1994 (59 *Federal Register* 13374, April 20, 1994).

The humpback chub is native to Arizona, Colorado, Utah, and Wyoming. Its current range is approximately 1,353 km, or 62% of its historical range (Figure 2.29). Range reduction has occurred largely from inundation by large human-made reservoirs, including Lake Mead, Lake Powell, and Flaming Gorge (USFWS 2018f).

The species is currently found as five populations, comprising four in the upper basin (Black Rocks, Westwater Canyon, Desolation and Gray Canyons, and Cataract Canyon), and one in the lower basin in the Grand Canyon. A sixth upper basin population in Dinosaur National Monument is below detection level and is now considered functionally extirpated. The five populations occupy 598 km of river, or approximately 78% of the historically occupied habitat of 764 km. Each population consists of a discrete, geographically separate group of fish, with a few individuals moving among populations at a decadal scale, based on genetic evidence. The lower basin population became isolated from the five upper basin populations with completion of Glen Canyon Dam in 1963.

Humpback chub mature at 3 to 5 years of age and they live up to 40 years. They spawn from April through June, during and shortly after the peak of spring runoff at water temperatures of 16°C to 22°C. Aggregations of adults release and fertilize eggs over rubble, cobble, and gravel substrates along channel margins or on large submerged mid-channel cobble bars. The eggs incubate in interstitial spaces and hatch in approximately 5 days. The larvae remain for several days before drifting short distances to shallow, protected shoreline habitats. Timing and magnitude of runoff can influence habitat conditions and temperature for reproduction and incubation of eggs; although there is evidence that humpback chub can spawn in a wide range of flows and temperatures (USFWS 2018f).

Humpback chub larvae do not appear to drift great distances. Larvae are commonly found along warm sheltered shoreline habitats, and they may be found in backwaters, although these habitat features are rare in canyon reaches and particularly during spring runoff when the larvae are emerging. Young-of-year continue to use shallow, warm, productive, sheltered habitats that they entered as larvae. They may use backwaters if available, although this habitat feature is not common in canyon-bound reaches where population centers occur. A major controlling factor of humpback chub populations is predation on young by a variety of nonnative fish species.

Humpback chub dramatically shift habitat use in their second or third years of life and move from shallow, sheltered shorelines to large mid-channel recirculating eddies. These eddies provide large entrainment zones for food and low-velocity regions for resting. Adult humpback chub are uniquely suited to live in the swift canyon reaches of the Colorado River system. High spring flows create severe hydrologic conditions that preclude most other fish species from these habitats, but prolonged year-round low flows and periods of drought can break down these isolating mechanisms and disrupt food production and allow for invasion by competing or hybridizing fish species.

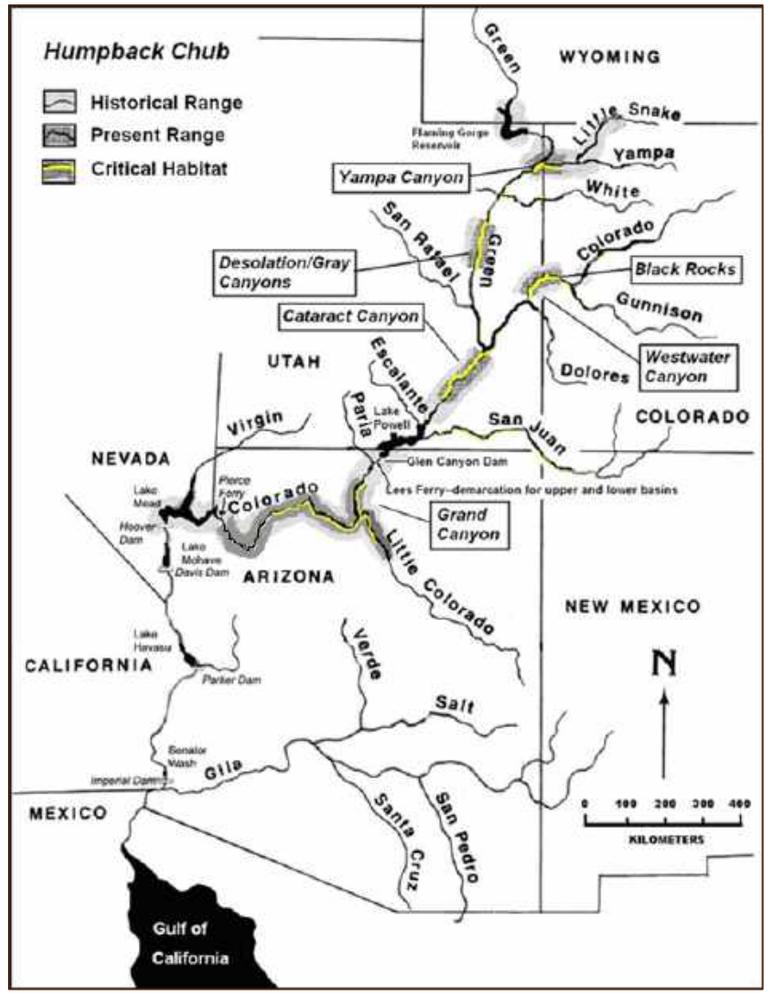

Figure 2.29. Historical and present distribution of the humpback chub with designated critical habitat in the Colorado River system.

Source: USFWS (2018f). Used with permission.

RAZORBACK SUCKER

The razorback sucker is a large catostomid fish (Figure 2.30) endemic to the Colorado River basin. Adults live approximately 40 years and attain a maximum size of approximately 1 m TL and a weight of 5 to 6 kg.

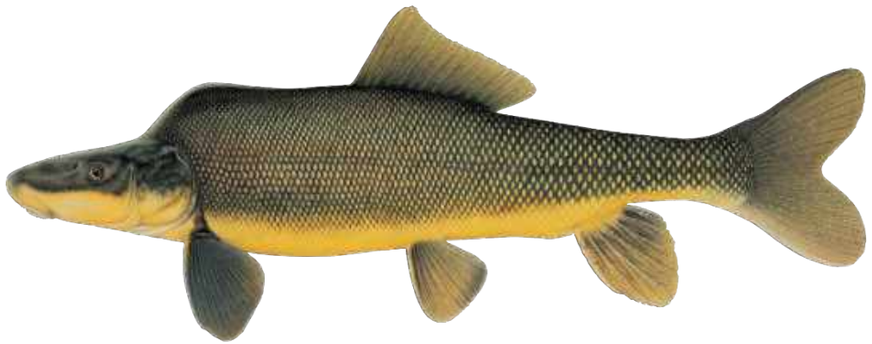

Figure 2.30. Adult razorback sucker.

The razorback sucker was listed as endangered under the ESA in 1991 (56 *Federal Register* 54957, October 23, 1991). A recovery plan was approved on December 23, 1998 (USFWS 1998), and recovery goals were approved on August 1, 2002 (USFWS 2002d). Critical habitat was designated in 1994 (59 *Federal Register* 13374, April 20, 1994).

Historically, the razorback sucker occupied the mainstem Colorado River and many of its tributaries from northern Mexico through Arizona and Utah into Wyoming, Colorado, and New Mexico. Distribution and abundance of razorback sucker declined throughout the twentieth century over all of its historic range, and by the beginning of the twenty-first century, the species was reduced to a few small, discontinuous populations or as dispersed individuals. Recovery efforts throughout the basin helped restore reproducing populations in the Green River, upper Colorado River, San Juan River, and in Lake Mead and the lower Grand Canyon (Figure 2.31).

Spawning occurs on mid-channel cobble and gravel bars in May and June at temperatures of 6°C to 21°C. The razorback sucker is a broadcast spawner that releases and fertilizes its eggs near the river bottom so that incubation can take place in protected interstitial spaces of cobble and gravel substrates. The eggs incubate in 6 to 7 days in the spaces between cobble and gravel substrate, and the larvae emerge and become transported downstream, where they become entrained in floodplains that become inundated during spring runoff. These floodplains are rich, productive nursery habitats where the young feed on plankton, insects, crustaceans, and detritus. The young suckers may spend an extended time in these floodplains, or they may move back to the main channel with receding spring flows. Juvenile razorback suckers have been collected in very warm-water temperature (21.7°C–34.0°C), at shallow depth (0.1–0.2 m), in zero-velocity current, and over silt substrate. In riverine environments, adults are generally found in deep water, but can be found in a range of depths (0.18–3.40 m), with no consistent seasonal pattern (USFWS 2002d).

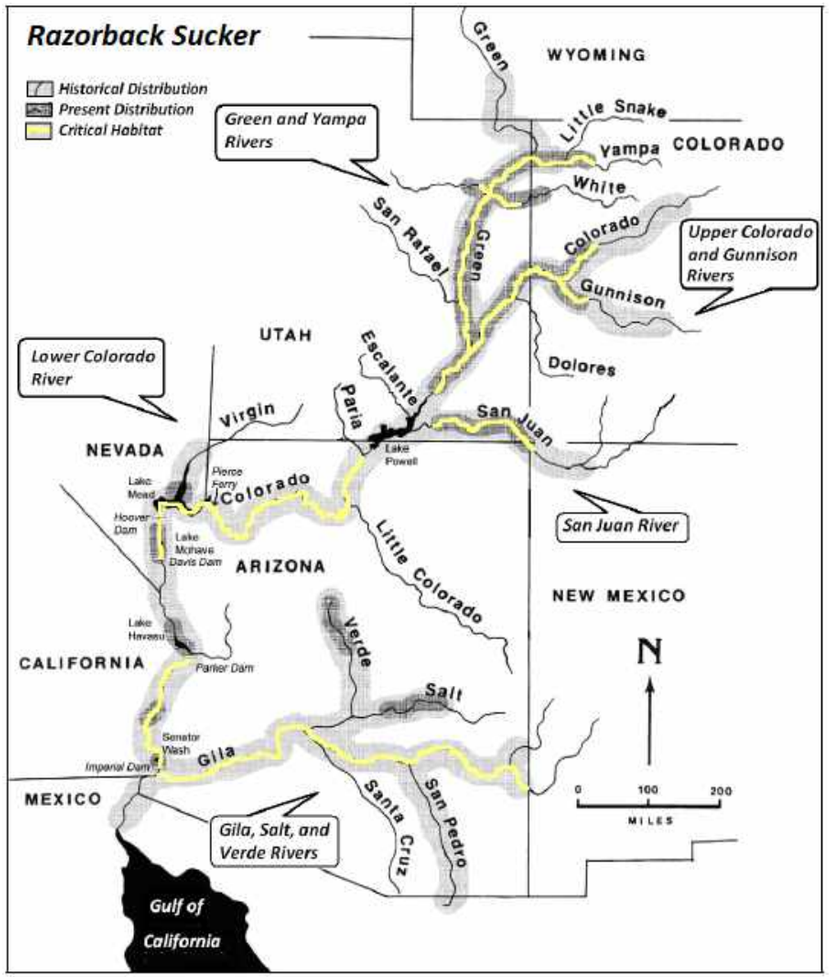

Figure 2.31. Historical and present distribution of the razorback sucker with designated critical habitat in the Colorado River system.

Source: Valdez et al. (2012). Used with permission.

CONSERVATION AGREEMENT FISH SPECIES

BLUEHEAD SUCKER

The bluehead sucker is a medium-size sucker (Figure 2.32) native to the Colorado River system. It can reach a size of approximately 360 mm TL. In 1991, the species was included as a category 2 candidate species for federal listing (56 *Federal Register* 225:58604–58836, November 21, 1991), but no action was pursued to list the species. A category 2 species is possibly appropriate to list as endangered or threatened, but lacks conclusive data on biological vulnerability and threats to support a proposed rule. The last time the status of the bluehead sucker was reviewed was in 1994, and it remains a candidate category 2 species (59 *Federal Register* 219:58982–59028, November 15, 1994). In Utah, the bluehead sucker is a species receiving special management under a conservation agreement in order to preclude the need for federal listing (DWR 2009).

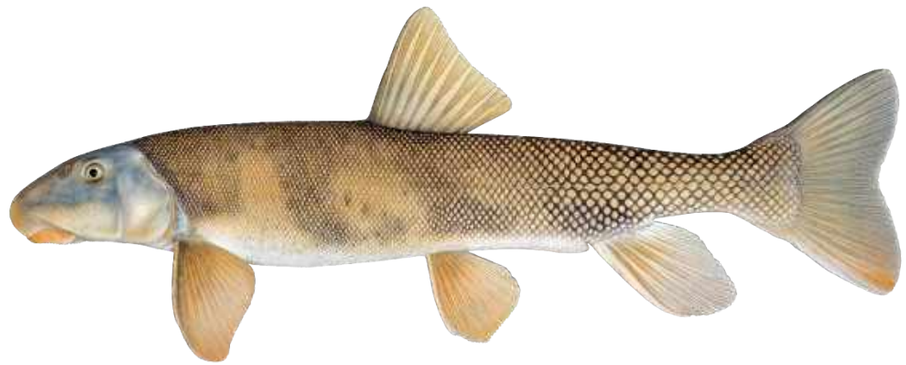

Figure 2.32. Adult bluehead sucker.

Illustration © Joseph R. Tomelleri. Used with permission.

The bluehead sucker was historically common in most small, medium, and large, middle to low elevation rivers of the upper basin (upstream of Lee's Ferry). It was found in similar habitats of the lower basin (downstream of Lee's Ferry), but in fewer numbers. Unlike the flannelmouth sucker, the bluehead sucker is related to the mountain suckers and is capable of living at higher elevations than the former and at cooler temperatures.

The bluehead sucker is associated with large rivers, but also occurs in small tributaries (Bestgen et al. 2017; Bezzerides and Bestgen 2002). The species is still widely distributed in small, medium, and large streams of the upper basin, including the mainstem Colorado River; numerous tributaries that drain a large portion of Colorado, Wyoming, and Utah; and the San Juan River drainage in New Mexico. The bluehead sucker is still found in most of its historical range in Colorado and Wyoming but is reduced in abundance in some areas because of predation and/or hybridization with the white sucker (*Catostomus commersonii*).

Bluehead suckers spawn in the spring at water temperatures of approximately 10°C to 15°C during and after spring runoff. Adults congregate and broadcast and fertilize their eggs over cobble and gravel bars. The eggs incubate in 5 to 7 days, and the larvae emerge after approximately 1 week and are transported downstream into quiet nursery habitats. Juvenile and subadults use habitats of shallow to medium depth generally with rocky substrate and over large mid-channel cobble and gravel bars. Adults are frequently found in large numbers on these bars.

Flannelmouth Sucker

The flannelmouth sucker is a large sucker (Figure 2.33) native to the Colorado River system. Adults can grow to a length of 660 mm TL and a weight of approximately 4.6 kg. In 1991, the species was included as a category 2 candidate species for federal listing (56 *Federal Register* 225:58604–58836, November 21, 1991), but no action was pursued to list the species. The last time the status of the flannelmouth sucker was reviewed was in 1994, and it remains a candidate category 2 species (59 *Federal Register* 219:58982–59028, November 15, 1994). In Utah, the flannelmouth sucker is a species receiving special management under a conservation agreement in order to preclude the need for federal listing (DWR 2009).

Figure 2.33. Adult flannelmouth sucker.

Illustration © Joseph R. Tomelleri. Used with permission.

The flannelmouth sucker was historically common in most medium to large, lower elevation rivers of the upper basin (upstream of Lee's Ferry). It was found in similar habitats of the lower basin (downstream of Lee's Ferry), but in fewer numbers. Although this species is typically associated with large rivers, it also occurs in small tributaries (Bestgen et al. 2017) and occasionally in lakes and reservoirs (Bezzerides and Bestgen 2002). The flannelmouth sucker is still widely distributed in medium to large streams of the upper basin, including the mainstem Colorado River; numerous tributaries that drain a large portion of Colorado, Wyoming, and Utah; and the San Juan River drainage in New Mexico. The flannelmouth sucker is still found in most of its historical range in Colorado and Wyoming but is reduced in abundance in some areas because of hybridization with the white sucker and predation.

Flannelmouth suckers spawn in the spring at water temperatures of approximately 11°C to 17°C during the descending limb of runoff. Adults congregate and broadcast and fertilize their eggs over cobble and gravel bars. The eggs incubate in 5 to 7 days, and the larvae emerge after approximately 1 week and are transported downstream into quiet nursery habitats. Juvenile and subadults use habitats of shallow to medium depth with cover or over large mid-channel cobble and gravel bars. Adults are frequently found in large numbers on these bars or near their downstream end.

Roundtail Chub

The roundtail chub is a medium-size cyprinid (minnow) fish species (Figure 2.34) native to the Colorado River system. It is part of the "robusta complex," which includes *Gila robusta*, *G. r. grahami*, and *G. r. seminude*. Roundtail chub can reach almost 490 mm and a weight of approximately 1 kg.

Figure 2.34. Adult roundtail chub.

In 1991, the species was included as a category 2 candidate species for federal listing (56 *Federal Register* 225:58604–58836, November 21, 1991), but no action was pursued to list the species. The last time the status of the roundtail chub was reviewed was in 1994, and it remains a candidate category 2 species (59 *Federal Register* 219:58982–59028, November 15, 1994). In Utah, the roundtail chub is a species receiving special management under a conservation agreement in order to preclude the need for federal listing (DWR 2009). In 2003, a petition was filed with the USFWS to list the roundtail chub as a distinct population segment (DPS) in the lower Colorado River basin and evaluated through a stipulated settlement agreement in 2005 (70 *Federal Register* 132:39981–39986, July 12, 2005).

In 2006, the USFWS found that listing the roundtail chub as a DPS in the lower basin was unwarranted (71 *Federal Register* 85:26007–26017, May 3, 2006). That decision was challenged and following a second stipulated settlement agreement, a second 12-month finding in 2009 determined that listing the roundtail chub as a DPS in the lower basin was warranted but precluded by higher priority actions (74 *Federal Register* 128:32352–32387, July 7, 2009). In 2015, a lower basin DPS was again proposed (80 *Federal Register* 194:60754–60783, October 7, 2015), but was withdrawn from further consideration in 2017 because the species was found to be the same taxa as other species of similar appearance in the Colorado River system (82 *Federal Register* 66:16981–16988, April 7, 2017).

The roundtail chub is a spring spawner. Adults aggregate over cobble and gravel substrates and broadcast eggs that are fertilized and incubate in the interstial spaces. The larvae hatch in approximately 5 days and emerge in approximately 1 week to drift downstream to quiet productive shoreline areas. The species has a high affinity for rocky substrate, and populations are often found intermittently where the river flows through a rocky substrate or a canyon area (Francis and Bestgen 2016). Young and juveniles use shallow sheltered shoreline areas, and subadults and adults prefer large deep pools and eddies, where they can position themselves next to the eddy line and feed on debris and insects drifting in the river. The roundtail chub can be a voracious predator, consuming large amounts of fish, crayfish, frogs, and insects. Roundtail chub adults primarily consume aquatic and terrestrial insects, other fishes, and sometimes algae. Roundtail chub juveniles eat smaller insects, crustaceans, and algae.

CRITICAL HABITAT IN THE PLANNING AREA FOR LISTED FISH SPECIES

Uinta Basin

This entire segment of the Green River is included in designated critical habitat for the Colorado pikeminnow and the razorback sucker. The segment receives high use from most life stages of Colorado pikeminnow and all life stages of razorback sucker (Table 2.9; see Figures 2.27 and 2.31). Spawning by Colorado pikeminnow occurs approximately 40 miles upstream from this segment, in the lower Yampa River, and newly hatched larvae drift downstream in June and July into sand-bed backwaters in this segment. Many juveniles (ages

0 and 1) remain in this area, as well as a few subadults, and adults are also common in this segment (USFWS 2002b). This segment is the most important nursery habitat for the Colorado pikeminnow in the Green River (Bestgen and Hill 2016).

The Uinta Basin segment receives high use for razorback sucker spawning, larvae, juveniles (ages 0 and 1), subadults, and adults (Zelasko et al. 2018). One of the most important spawning sites for razorback sucker is located at the upstream end of this segment (RM 311–312; USFWS 2002d). Spawning takes place during high spring flow (April and May) and the newly hatched larvae drift downstream into inundated riverside floodplains. These floodplains are located through much of this segment, and especially in and near Ouray National Wildlife Refuge (LaGory et al. 2017; Valdez and Nelson 2004). Coordination occurs annually between the USFWS, the USBR, and the Upper Colorado River Endangered Fish Recovery Program to time releases from Flaming Gorge Dam and flow of the Yampa River with the emergence of razorback sucker larvae (Upper Colorado River Endangered Fish Recovery Program 2012).

The Uinta Basin segment of the Green River is not used by the humpback chub, except for an occasional adult that may move downstream from a small disjunct population found from the lower Yampa River through Whirlpool and Split Mountain Canyons (USFWS 2002c). A population center with high use by humpback chub is in Desolation and Gray Canyons immediately downstream of this segment (Howard and Caldwell 2018).

Wild bonytail were reported historically in the Uinta Basin segment but were not found in the late twentieth century (USFWS 2002a). To increase recovery prospects, more than 500,000 bonytail have been stocked in the upper Colorado River basin since 2000, but adult survival has been low, and reproduction has not been detected. Adult bonytail were stocked in the Green River and accessed in Stewart Lake and Johnson Bottom (managed floodplain wetlands in this segment of the middle Green River) during high flows in May 2015 (Stewart Lake only) and 2016. Specimens recovered from these floodplains revealed successful reproduction by bonytail in 2016 in Stewart Lake (probable) and Johnson Bottom. Use of floodplain wetlands for reproduction may enhance the recovery of critically endangered bonytail in the upper Colorado River basin (Bestgen et al. 2017), and this segment of the Green River has one of the highest number of riverside floodplains used by bonytail, as well as by razorback sucker.

Green River Valley

This segment of the Green River is entirely within designated critical habitat of the Colorado pikeminnow and the razorback sucker. In addition, the northern end of the Green River Valley segment (approximately 0.25 mile) is designated critical habitat for humpback chub and bonytail. The segment receives high use from all life stages of Colorado pikeminnow and the larval and juvenile life stages of razorback sucker (Table 2.9; see Figure 2.31). This segment is located immediately downstream from one of two major spawning locales of Colorado pikeminnow: Three Fords Canyon-West (located 24 miles upstream). Newly hatched larvae drift downstream in June and July into sand-bed backwaters in this segment. This segment includes the second-most important nursery habitat for Colorado pikeminnow in the Green River (Bestgen et al. 2018; Bestgen and Hill 2016; Grippo et al. 2017). Many juveniles (ages 0 and 1) remain in this segment, as well as subadults and adults (USFWS 2002b).

There are no spawning sites for razorback sucker in this segment, but larvae drifting from upstream spawning sites become entrained during spring runoff in the few riverside floodplains that become connected by high flow (Bestgen et al. 2011; Zelasko et al. 2018). This segment also supports moderate use by subadult and adult razorback sucker.

The Green River Valley segment is not used by the humpback chub, except for an occasional adult that may move downstream from a self-sustained population found in Desolation and Gray Canyons immediately upstream (Howard and Caldwell 2018; USFWS 2002c). Small numbers of stocked bonytail are found in this segment, but there is no evidence of reproduction. The Price River is a tributary of this segment and is known to support small numbers of Colorado pikeminnow with larger numbers moving into and from the tributary at high water.

Labyrinth Canyon

This segment of the Green River is included entirely within designated critical habitat of the Colorado pikeminnow and the razorback sucker. It receives high use from all life stages of Colorado pikeminnow and the larval and juvenile life stages of razorback sucker (Table 2.9; see Figure 2.31). This segment is an extension of the Green River Valley segment as important nursery habitat for Colorado pikeminnow, with numerous sandy backwater habitats. Newly hatched larvae drift downstream in June and July into sand-bed backwaters in this segment, and campers are cautioned against disposing of wash water or other disposables into backwaters to avoid contaminating these contained habitats. This segment includes the second-most important nursery habitat for Colorado pikeminnow in the Green River (Bestgen et al. 2018; Bestgen and Hill 2016; Grippo et al. 2017). Many juveniles (ages 0 and 1) remain in this segment, as well as subadults and adults (USFWS 2002b).

There are no spawning sites for razorback sucker in this segment, but larvae drifting from upstream spawning sites become entrained during spring runoff in the few riverside floodplains that become connected by high flow (Bestgen et al. 2011; Zelasko et al. 2018). This segment also supports moderate use by subadult and adult razorback sucker. Remote passive integrated responder tag antennas in the San Rafael River, a tributary of this segment, have detected many native fish species using this tributary, including evidence of reproduction by razorback suckers, although its importance is not fully understood.

The Labyrinth Canyon segment of the Green River is not used by the humpback chub, except for an occasional adult that may move downstream from a self-sustained population found in Desolation and Gray Canyons (Howard and Caldwell 2018; USFWS 2002c). Small numbers of stocked bonytail are found in this segment, but there is no evidence of reproduction.

Table 2.9. Location and Relative Use of Planning Area Segments of the Green River by Life Stages of Colorado Pikeminnow, Humpback Chub, Razorback Sucker, and Bonytail

River Segment	Colorado Pikeminnow						Humpback Chub						Razorback Sucker						Bonytail					
	Critical Habitat	Spawn	Larvae	Juvenile (age 0–1)	Subadult	Adult	Critical Habitat	Spawn	Larvae	Juvenile (age 0–1)	Subadult	Adult	Critical Habitat	Spawn	Larvae	Juvenile (age 0–1)	Subadult	Adult	Critical Habitat	Spawn	Larvae	Juvenile (age 0–1)	Subadult	Adult
Uinta Basin	All	0	3	3	2	3	None	0	0	0	0	1	All	3	3	3	3	3	None	3	3	3	3	3
Green River Valley	All	3	3	3	3	3	Part	0	0	0	0	1	All	0	3	3	2	2	Part	0	0	0	0	1
Labyrinth Canyon	All	3	3	3	3	3	None	0	0	0	0	1	All	0	3	3	2	2	None	0	0	0	0	1

Notes: Adopted from LaGory et al. (2003) and Valdez and Widner (2011).

0 = no use (blank), 1 = little use (yellow), 2 = moderate use (green), and 3 = high use (red). Critical habitat for each species is shown as gray cells, where All, Part, or None of the river segment is included in designated critical habitat.

Bird Species

The planning area provides important habitat for many bird species. A portion of the Uinta Basin segment is well-known for bird species diversity and intersects the Ouray National Wildlife Refuge IBA. The Labyrinth Canyon segment is just north of the Canyonlands Area IBA.

Many groups, including the National Audubon Society, conduct bird monitoring along and near the river. One of the National Audubon Society's 15-mile-diameter count circles for their annual Christmas Bird Count (CBC) overlaps the Uinta Basin segment at the Ouray National Wildlife Refuge. Data from this circle are incorporated into Table 2.10. No other CBCs overlap the remaining two river segments.

Bird species data for specific locations in the planning area are available from eBird. eBird is a citizen-based global bird observation network that provides data sources for basic information on bird distribution and abundance at a variety of temporal and spatial scales. The presence or absence of species in addition to bird abundance are documented through checklist data. A birder fills out a checklist of all the birds seen or heard during a particular outing. Submissions are reviewed by automated data quality filters developed by regional birding experts before they are entered into the database, and unusual records are flagged by filters and reviewed by local experts. eBird data from 2017 and 2018 at five locations (hotspots) on the Uinta Basin segment and five locations on the Green River Valley and Labyrinth Canyon segments documented more than 170 bird species along these segments of the Green River (see Table 2.10).

Table 2.10. Bird Species Recorded along or near the Planning Area by Segment in 2017 and 2018

Common Name	Scientific Name	Location in the Planning Area by Segment*	
		Uinta Basin	Green River Valley and Labyrinth Canyon
DUCKS, GEESE, AND SWANS			
American wigeon	*Anas americana*	3, 5	7
Blue-winged teal	*Anas discors*	5	–
Bufflehead	*Bucephala albeola*	5	7
Canada goose	*Branta canadensis*	1, 2, 3, 4, 5,	6, 7
Canvasback	*Aythya valisineria*	5	7
Cinnamon teal	*Anas cyanoptera*	3, 4, 5	7
Common goldeneye	*Bucephala clangula*	5	7
Common merganser	*Mergus merganser*	2, 3, 4, 5	6, 7
Gadwall	*Anas strepera*	3, 4, 5	7
Greater scaup	*Aythya marila*	5	–
Green-winged teal	*Anas crecca*	1, 3, 4, 5	7
Lesser scaup	*Aythya affinis*	5	6, 7
Mallard	*Anas platyrhynchos*	1, 2, 3, 4, 5	6, 7
Northern pintail	*Anas acuta*	3, 5	–
Northern shoveler	*Anas clypeata*	5	6, 7
Redhead	*Aythya americana*	3, 5	7
Ring-necked duck	*Aythya collaris*	2, 5	7
Ruddy duck	*Oxyura jamaicensis*	5	7
Tundra swan	*Cygnus columbianus*	5	7
Wood duck	*Aix sponsa*	4, 5	–

Common Name	Scientific Name	Location in the Planning Area by Segment*	
		Uinta Basin	Green River Valley and Labyrinth Canyon
PHEASANTS, GROUSE, AND QUAIL			
California quail	*Callipepla californica*	3	7
Ring-necked pheasant	*Phasianus colchicus*	3	–
Wild turkey	*Meleagris gallopavo*	1, 2, 3, 5	–
LOONS AND GREBES			
Clark's grebe	*Aechmophorus clarkii*	5	–
Common loon	*Gavia immer*	4	–
Eared grebe	*Podiceps nigricollis*	5	–
Pacific loon	*Gavia pacifica*	5	–
Pied-billed grebe	*Podilymbus podiceps*	4, 5	7
Western grebe	*Aechmophorus occidentalis*	3, 5	7, 8
PELICANS AND CORMORANTS			
American white pelican	*Pelecanus erythrorhynchos*	3, 4, 5	–
Double-crested cormorant	*Phalacrocorax auritus*	2, 5	7
EGRETS AND IBIS			
American bittern	*Botaurus lentiginosus*	3, 5	–
Black-crowned night-heron	*Nycticorax nycticorax*	3, 5	–
Cattle egret	*Bubulcus ibis*	5	7
Great blue heron	*Ardea Herodias*	1, 2, 3, 4, 5	7
Great egret	*Ardea alba*	4, 5	–
Snowy egret	*Egretta thula*	5	–
White-faced ibis	*Plegadis chihi*	3, 4, 5	7

Common Name	Scientific Name	Location in the Planning Area by Segment*	
		Uinta Basin	Green River Valley and Labyrinth Canyon
VULTURES, HAWKS, AND EAGLES			
Bald eagle	*Haliaeetus leucocephalus*	1, 2, 3, 5	–
Cooper's hawk	*Accipiter cooperii*	3, 4, 5	6, 7
Golden eagle	*Aquila chrysaetos*	1, 5	7
Northern harrier	*Circus cyaneus*	3, 5	7
Osprey	*Pandion haliaetus*	3, 5	6
Red-tailed hawk	*Buteo jamaicensis*	1, 2, 3, 5	6, 7
Rough-legged hawk	*Buteo lagopus*	3, 5	–
Sharp-shinned hawk	*Accipiter striatus*	3, 5	7
Swainson's hawk	*Buteo swainsoni*	2, 3	7
Turkey vulture	*Cathartes aura*	1, 2, 3, 4, 5	6, 7, 8
RAILS AND CRANES			
American coot	*Fulica americana*	3, 4, 5	7
Sandhill crane	*Grus canadensis*	1, 3, 4, 5	6
Sora	*Porzana carolina*	3	–
Virginia rail	*Rallus limicola*	3, 5	–
PLOVERS, SANDPIPERS, AND GULLS			
American avocet	*Recurvirostra americana*	5	–
Baird's sandpiper	*Calidris bairdii*	5	–
Black-bellied plover	*Pluvialis squatarola*	5	–
Black-necked stilt	*Himantopus mexicanus*	5	–
Bonaparte's gull	*Chroicocephalus philadelphia*	5	–
California gull	*Larus californicus*	3, 5	7

Common Name	Scientific Name	Location in the Planning Area by Segment*	
		Uinta Basin	Green River Valley and Labyrinth Canyon
Caspian tern	*Hydroprogne caspia*	5	–
Common tern	*Sterna hirundo*	5	–
Forster's tern	*Sterna forsteri*	5	–
Franklin's gull	*Leucophaeus pipixcan*	5	7
Greater yellowlegs	*Tringa melanoleuca*	5	7
Herring gull	*Larus argentatus*	5	–
Killdeer	*Charadrius vociferus*	2, 3, 4, 5	7
Lesser yellowlegs	*Tringa flavipes*	5	–
Long-billed curlew	*Numenius americanus*	2, 5	–
Long-billed dowitcher	*Limnodromus scolopaceus*	5	7
Marbled godwit	*Limosa fedoa*	5	7
Pectoral sandpiper	*Calidris melanotos*	5	–
Red-necked phalarope	*Phalaropus lobatus*	5	–
Ring-billed gull	*Larus delawarensis*	5	7
Sanderling	*Calidris alba*	5	–
Spotted sandpiper	*Actitis macularius*	2, 5	7
Western sandpiper	*Calidris mauri*	5	–
Willet	*Tringa semipalmata*	5	–
Wilson's phalarope	*Phalaropus tricolor*	5	–
Wilson's snipe	*Gallinago delicata*	3	–

Common Name	Scientific Name	Location in the Planning Area by Segment*	
		Uinta Basin	Green River Valley and Labyrinth Canyon
PIGEONS AND DOVES			
Eurasian collared-dove	*Streptopelia decaocto*	2, 3, 4, 5	6, 7
Mourning dove	*Zenaida macroura*	2, 3, 4, 5	7
Rock pigeon	*Columba livia*	1, 3, 5	7
OWLS			
Long-eared owl	*Asio otus*	3	–
Great horned owl	*Bubo virginianus*	4, 5	7
Western screech owl	*Megascops kennicottii*	–	7
NIGHTJARS			
Common nighthawk	*Chordeiles minor*	3, 5	7
Common poorwill	*Phalaenoptilus nuttallii*	–	9
White-throated swift	*Aeronautes saxatalis*	3, 5	7, 8
HUMMINGBIRDS			
Black-chinned hummingbird	*Archilochus alexandri*	3, 5	7
Broad-tailed hummingbird	*Selasphorus platycercus*	3	7
Rufous hummingbird	*Selasphorus rufus*	3	7
KINGFISHERS			
Belted kingfisher	*Megaceryle alcyon*	2, 3, 5	7
WOODPECKERS			
Downy woodpecker	*Picoides pubescens*	–	7
Hairy woodpecker	*Leuconotopicus villosus*	5	10
Northern flicker	*Colaptes auratus*	2, 3, 5	7

Common Name	Scientific Name	Location in the Planning Area by Segment*	
		Uinta Basin	Green River Valley and Labyrinth Canyon
FALCONS			
American kestrel	*Falco sparverius*	1, 2, 3, 5	7
Merlin	*Falco columbarius*	5	–
Peregrine falcon	*Falco peregrinus*	3	–
Prairie falcon	*Falco mexicanus*	3, 5	7
FLYCATCHERS			
Ash-throated flycatcher	*Myiarchus cinerascens*	3	7, 8
Black phoebe	*Sayornis nigricans*	–	7
Cordilleran flycatcher	*Empidonax occidentalis*	–	7
Least flycatcher	*Empidonax minimus*	–	7
Olive-sided flycatcher	*Contopus cooperi*	3	7
Say's phoebe	*Sayornis saya*	3, 5	7
Western kingbird	*Tyrannus verticalis*	2, 3, 5	7
Western wood-pewee	*Contopus sordidulus*	2, 3, 4, 5	7
Willow flycatcher	*Empidonax traillii*	2, 3, 5	–
VIREOS			
Cassin's vireo	*Vireo cassinii*	3	–
Plumbeous vireo	*Vireo plumbeus*	–	7
Warbling vireo	*Vireo gilvus*	2, 4	7
SHRIKES			
Loggerhead shrike	*Lanius ludovicianus*	1, 5	7
Northern shrike	*Lanius excubitor*	3, 5	–

Common Name	Scientific Name	Location in the Planning Area by Segment*	
		Uinta Basin	Green River Valley and Labyrinth Canyon
JAYS AND CROWS			
American crow	*Corvus brachyrhynchos*	3, 5	7
Black-billed magpie	*Pica hudsonia*	1, 2, 3, 5	7
Common raven	*Corvus corax*	1, 2, 3, 5	6, 7, 8, 10
Pinyon jay	*Gymnorhinus cyanocephalus*	–	10
Western scrub-jay	*Aphelocoma californica*	5	–
Woodhouse's scrub-jay	*Aphelocoma woodhouseii*	3	–
LARKS			
Horned lark	*Eremophila alpestris*	1, 2, 5	–
SWALLOWS			
Bank swallow	*Riparia riparia*	3	7
Barn swallow	*Hirundo rustica*	2, 3, 4, 5	7
Cliff swallow	*Petrochelidon pyrrhonota*	1, 2, 3, 4, 5	7, 8
Northern rough-winged swallow	*Stelgidopteryx serripennis*	2	7
Tree swallow	*Tachycineta bicolor*	2, 3	7
Violet-green swallow	*Tachycineta thalassina*	–	7, 8, 9
CHICKADEES			
Black-capped chickadee	*Poecile atricapillus*	1, 3, 5	7
Bushtit	*Psaltriparus minimus*	5	7
Mountain chickadee	*Poecile gambeli*	3	–
NUTHATCHES AND CREEPERS			
Brown creeper	*Certhia americana*	5	–

Common Name	Scientific Name	Location in the Planning Area by Segment*	
		Uinta Basin	Green River Valley and Labyrinth Canyon
WRENS			
Canyon wren	*Catherpes mexicanus*	1, 5	7, 9
House wren	*Troglodytes aedon*	4, 5	–
Marsh wren	*Cistothorus palustris*	3, 5	–
Rock wren	*Salpinctes obsoletus*	3, 5	7, 10
KINGLETS AND GNATCATCHERS			
Ruby-crowned kinglet	*Regulus calendula*	3	7
Blue-gray gnatcatcher	*Polioptila caerulea*	4	7, 8
THRUSHES			
American robin	*Turdus migratorius*	1, 2, 3, 4, 5	7
Mountain bluebird	*Sialia currucoides*	2, 3, 5	10
Townsend's solitaire	*Myadestes townsendi*	1, 3, 5	–
THRASHERS			
Gray catbird	*Dumetella carolinensis*	3, 4	7
Northern mockingbird	*Mimus polyglottos*	2	7, 10
STARLINGS			
European starling	*Sturnus vulgaris*	1, 2, 3, 4, 5	6, 7
WAXWINGS			
Cedar waxwing	*Bombycilla cedrorum*	3	7
WARBLERS			
Common yellowthroat	*Geothlypis trichas*	3, 5	7
MacGillivray's warbler	*Geothlypis tolmiei*	3	–
Orange-crowned warbler	*Oreothlypis celata*	3, 5	7
Wilson's warbler	*Cardellina pusilla*	3, 5	–
Yellow-breasted chat	*Icteria virens*	2, 3, 4	7, 8, 9
Yellow warbler	*Setophaga petechia*	2, 3, 4, 5	7, 8
Yellow-rumped warbler	*Setophaga coronata*	3, 4, 5	7
SPARROWS			
American tree sparrow	*Spizelloides arborea*	3	–
Brewer's sparrow	*Spizella breweri*	3, 4	–
Chipping sparrow	Spizella passerina	3, 4, 5	–
Dark-eyed junco	*Junco hyemalis*	1, 2, 3, 5	6, 7
Lark sparrow	*Chondestes grammacus*	2, 3, 4, 5	7
Lincoln's sparrow	*Melospiza lincolnii*	3, 5	7
Savannah sparrow	*Passerculus sandwichensis*	3	–
Song sparrow	*Melospiza melodia*	3, 5	6, 7
Spotted towhee	*Pipilo maculatus*	2, 3, 4, 5	7, 9
Vesper sparrow	*Pooecetes gramineus*	5	7
White-crowned sparrow	*Zonotrichia leucophrys*	3, 5	6, 7, 8, 9
White-throated sparrow	*Zonotrichia albicollis*	–	7
TANAGERS, GROSBEAKS, AND BUNTINGS			
Black-headed grosbeak	*Pheucticus melanocephalus*	2, 3, 4, 5	7, 8
Blue grosbeak	*Guiraca caerulea*	2, 3, 5	7
Lazuli bunting	*Passerina amoena*	2, 3, 4	–
Western tanager	*Piranga ludoviciana*	5	7

Common Name	Scientific Name	Location in the Planning Area by Segment*	
		Uinta Basin	Green River Valley and Labyrinth Canyon
BLACKBIRDS AND ORIOLES			
Brewer's blackbird	*Euphagus cyanocephalus*	3	6, 7
Brown-headed cowbird	*Molothrus ater*	2, 3, 4	7
Bullock's oriole	*Icterus bullockii*	3	7
Red-winged blackbird	*Agelaius phoeniceus*	3, 4, 5	6, 7
Western meadowlark	*Sturnella neglecta*	1, 2, 3, 5	6
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	3, 4, 5	–
FINCHES			
American goldfinch	*Spinus tristis*	3, 4, 5	7
Black rosy-finch	*Leucosticte atrata*	5	–
Gray-crowned rosy-finch	*Leucosticte tephrocotis*	5	–
House finch	*Haemorhous mexicanus*	2, 3, 5	6, 7, 10
Lesser goldfinch	*Spinus psaltria*	3	7
Pine siskin	*Spinus pinus*	5	7
OLD WORLD SPARROWS			
House sparrow	*Passer domesticus*	3, 5	6, 7

Source: eBird (2017, 2018).

Note: Public information for sensitive species in eBird is restricted because of the potential harmful impact to these birds. Data for federally listed species are therefore not included in this table.

* 1 = Chew Ranch (RM 316.6), 2 = Jensen Bridge (RM 301.9), 3 = Stewart Lake Waterfowl Management Area (RM 300), 4 = State Route 45 and Green River Oxbow Pond (RM 289.7), 5 = Ouray National Wildlife Refuge – Leota Bottom and National Audubon Society CBC location (RM 259), 6 = Green River – Hastings Road (RM 124), 7 = Green River State Park and surrounding areas (RM 120), 8 = Green River – Ruby Ranch (RM 79.2), 9 = Green River - Bowknot Bend (RM 64.0), 10 = Green River – Mineral Bottom (RM 52.1).

Species of Management Concern

As demonstrated in Table 2.10, the list of bird guilds and bird species (> 170) observed along the planning area's three segments is extensive. Using DWR's list of key habitats (Utah Wildlife Action Plan Joint Team 2015) and specifically those found in the planning area—i.e., aquatic-forested and aquatic-scrub/shrub (riparian), emergent (wetland), and riverine (open water and aquatic)—the GRCMP recommends considering individual bird species, federally listed bird species, bird SPC, Utah Partners in Flight priority species (Parrish et al. 2002), and Utah Wildlife Action Plan SGCNs when trying to achieve habitat-related management goals, e.g., enhancement, restoration, and preservation. The following sections provide information about these habitats and bird species that depend on them.

LOWLAND RIPARIAN AND WETLAND HABITAT

Riparian and wetland habitats, like those adjacent to the Green River, are generally more productive and biologically diverse than surrounding upland habitats. Bird communities in particular have greater diversity in riparian and wetland habitats than in upland habitats (Skagen et al. 2005; Woinarski et al. 2000). Roughly 50% of the bird species in the American Southwest nest exclusively in riparian and wetland habitat, and another 21% nest in higher densities in these habitats than in surrounding habitats (Johnson et al. 1985; Skagen et al. 2005). Increasing evidence also highlights the importance of riparian habitats during bird migration. Structurally complex riparian areas appear to have a higher abundance of birds and a higher diversity of bird species than do less-complex areas (Krueper et al. 2003; Scott et al. 2003).

RIPARIAN SPECIES

The yellow warbler (*Setophaga petechia*), found throughout Utah (including the Green River), generally nests in small riparian trees. Given the yellow warbler's relative abundance in the area, its nesting habitat parameters can be used in the development of riparian habitat restoration projects. Similarly, the western yellow-billed cuckoo (*Coccyzus americanus*) (federally listed as threatened), bald eagle (Utah SPC), great blue heron (*Ardea Herodias*), black-crowned night-heron (*Nycticorax nycticorax*), and broad-tailed hummingbird (*Selasphorus platycercus*) (Utah Partners in Flight priority species) all nest in lowland riparian habitats and

can be the focus of habitat restoration efforts. Lowland riparian habitats are also used by mammals such as Allen's big-eared bats (SGCN). Proposed critical habitat for western yellow-billed cuckoo intersects the Ouray National Wildlife Refuge (and IBA), which is in the Uinta Basin segment.

Wetland Species

The American avocet (*Recurvirostra americana*) (Utah Partners in Flight priority species), which is found in northern Utah and has been observed along the Green River, inhabits shallow wetlands and mudflats (often saline or alkaline) during the breeding season. The presence of this species may be used as an indication that a certain level of habitat quality or wetland restoration success has been achieved. Other important wetland species include black-necked stilt (*Himantopus mexicanus*) (Utah Partners in Flight Priority Species), white-faced ibis (SGCN), American bittern (*Botaurus lentiginosus*) (SGCN), marsh wren (*Cistothorus palustris*), heron species, and common yellowthroat (*Geothlypis trichas*).

OPEN WATER (FLOWING AND STANDING)

Open water combines both flowing and standing aquatic habitats. It comprises approximately 2.6% of the total area of Utah (Utah Wildlife Action Plan Joint Team 2015) and includes lakes, reservoirs, streams, and rivers. Aquatic habitats on the Green River in many ways reflect the larger diversity of open water systems because there are areas of moderate to steep gradient (flowing water) and areas of extremely low gradient (standing water) along the three segments. Common types of birds seen in these habitats include ducks, geese, and swans. This family (Anatidae) of birds has evolved to float on the water's surface. Some species also dive for food in shallow areas. Several different species in this family can be observed on the Green River, including Canada goose (*Branta canadensis*), tundra swan (*Cygnus columbianus*), wood duck (*Aix sponsa*), scaups (*Aythya* spp.), mallard (*Anas platyrhynchos*), gadwall (*Anas strepera*), northern pintail (*Anas acuta*), northern shoveler (*Anas clypeata*), blue-winged teal (*Anas discors*), green-winged teal (*Anas crecca*), American wigeon (*Anas americana*), redhead (*Aythya americana*), ruddy duck (*Oxyura jamaicensis*), common goldeneye, and common merganser.

Also represented on the Green River are western grebe, Clark's grebe, eared grebe, and pied-billed grebe. These species in the Podicipediformes family can be seen floating on the water but dive underwater to forage for fish. The American white pelican (Utah Partners in Flight priority species and Utah SPC) and osprey also use certain open water segments of the Green River.

Further Reading

A Handbook of Riparian Restoration and Revegetation for the Conservation of Land Birds in Utah With Emphasis on Habitat Types in Middle and Lower Elevations (Gardner et al. 1999)

eBird Explore Hotspots website (eBird 2017, 2018)

First reproduction by stocked bonytail in the upper Colorado River basin (Bestgen et al. 2017)

Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam (Muth et al. 2000)

Green River Subbasin Floodplain Management Plan (Valdez and Nelson 2004)

Humpback chub (*Gila cypha*) in the Yampa and Green Rivers, Dinosaur National Monument, with observations on roundtail chub (*G. robusta*) and other sympatric fishes (Karp and Tyus 1990)

Population Status and Trends of Colorado Pikeminnow in the Green River Sub-Basin, Utah and Colorado, 2000–2013 (Bestgen et al. 2018)

Spawning and movements of razorback sucker, *Xyrauchen texanus*, in the Green River basin of Colorado and Utah (Tyus and Karp 1990)

Survival rates and movement of hatchery-reared razorback suckers in the upper Colorado River basin, Utah and Colorado (Zelasko et al. 2010)

The river continuum concept (Vannote et al. 1980)

Upper Colorado River Subbasin Floodplain Management Plan (Valdez and Nelson 2006)

Utah Field Office Guidelines for Raptor Protection from Human and Land Use Disturbances (Romin and Muck 2002)

Utah Partners in Flight Avian Conservation Strategy Version 2.0 (Parrish et al. 2002)

Utah Wildlife Action Plan: A Plan for Managing Native Wildlife Species and Their Habitats to Help Prevent Listing under the Endangered Species Act (Utah Wildlife Action Plan Joint Team 2015)

GIS Data Layers

eBird Locations (Hotspots), Important Bird Areas, U.S. Fish and Wildlife Critical Habitat, Utah Division of Wildlife Resources Habitat

2.3 Water Resources

Hydrology

Characterization of Hydrology

The Green River is the longest headwater tributary of the Colorado River, draining 39,200 square miles and flowing 730 miles from the Wind River Mountains in Wyoming through Colorado and Utah, to join the Colorado River in Canyonlands National Park. John Wesley Powell called the Green River "the true source of the Colorado" (Powell 1875). The Green River drains 40% more area than the upper Colorado River, but the mean annual flow of the Green River is less than that of the upper Colorado River. The flow regime of the river is dominated by spring snowmelt, and 57% of the total annual runoff occurs in May, June, and July (Figure 2.35). At their confluence, the upper Green and the Yampa Rivers have nearly the same mean annual flow and can be considered co-equal headwater sources of runoff. The Yampa is the last major free-flowing river in the upper Colorado River basin. There are no dams on the Green River in the 253 RM downstream of Flaming Gorge Dam.

The Green River's hydrology through the planning area includes several large tributary inflows, illustrated on Figure 2.36. Stream flow monitoring gages operated by the USGS are shown on Figure 2.36 because they provide important information on present and long-term trends in the ebb and flow of the river.

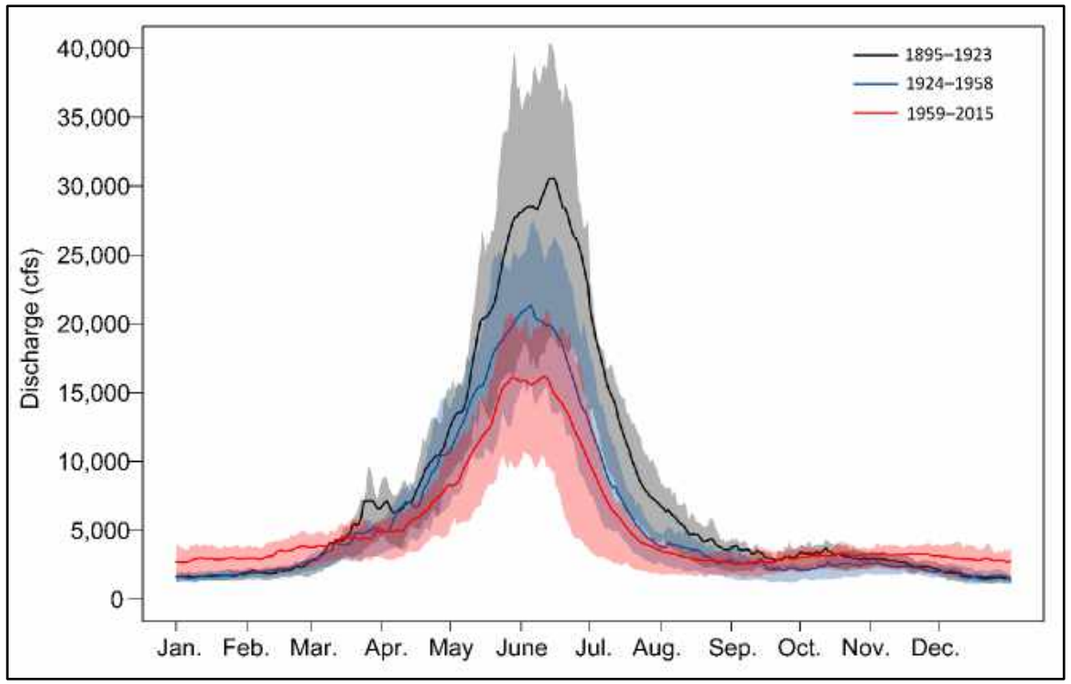

Figure 2.35. Annual hydrograph for the Green River at Green River, Utah (gage 09315000; see Figure 2.36) for different peak flow regimes.[1]

[1] The shaded areas represent the interquartile range for daily discharge data for each day of the year during each flow period. The dominance of snowmelt flooding is apparent, as are declines in peak annual flow and increases in summer base flow during the second half of the twentieth century. Sources: Pettitt (1979); USGS (2018a).

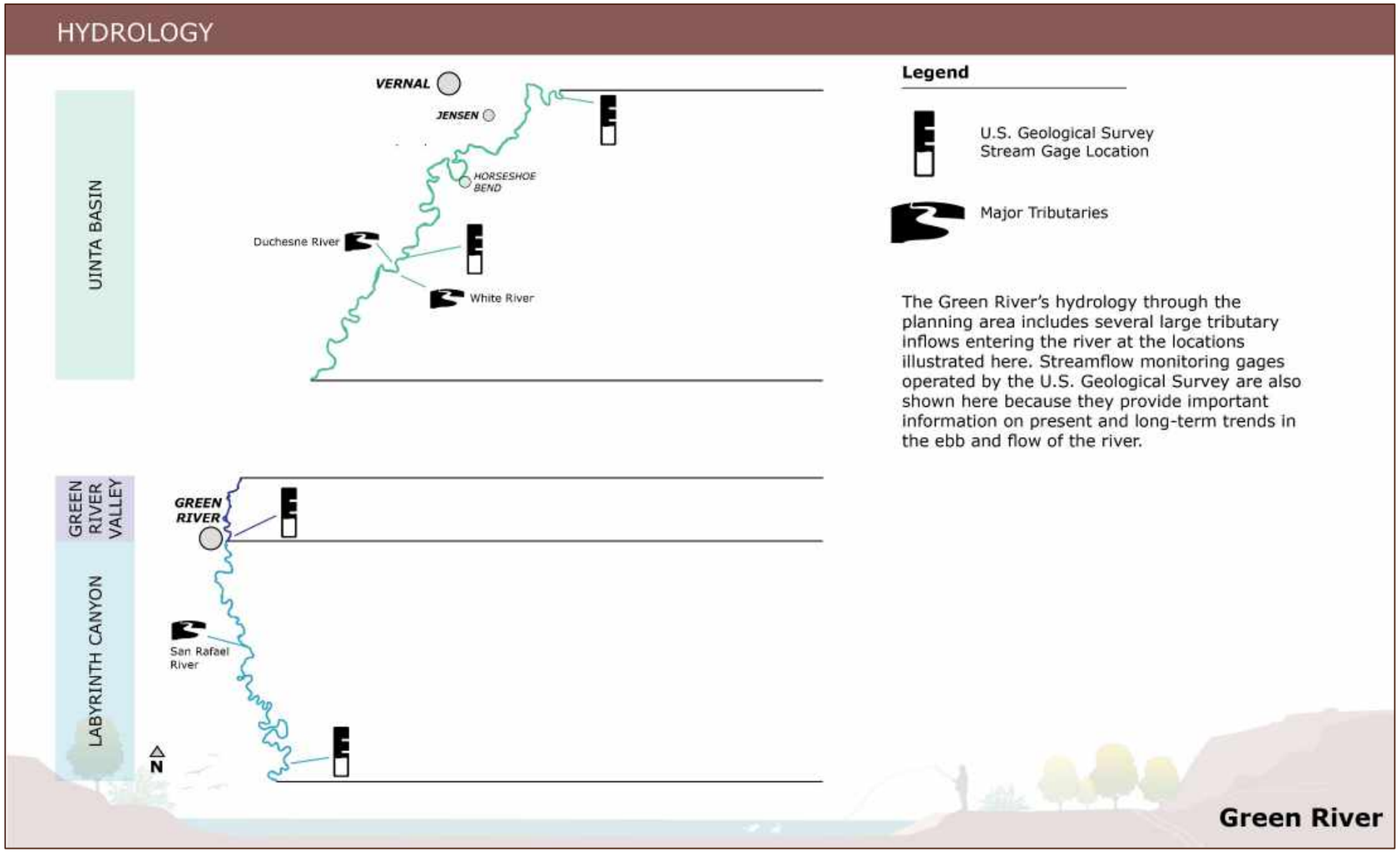

Figure 2.36. Major tributary inflows and stream flow monitoring gages in the planning area by river segment.

In the twentieth century, the flow regime, channel, and floodplain form of the Green River have been greatly impacted by dams and consumptive water use made possible by stream flow diversions. The construction of Fontenelle and Flaming Gorge Dams, trans-basin diversions from the Duchesne River basin, and irrigation withdrawals, especially in the Uinta Basin, have altered the flow regime, decreased annual peak flood magnitude, reduced total annual runoff, and increased base flow. Relatively little sediment is trapped by Flaming Gorge Dam. Most of the sediment delivery to the mainstem Green River comes from the Yampa River basin and other downstream tributaries (Grams and Schmidt 2005). Most of the Green River downstream from the Yampa River has been perturbed into sediment surplus. Dams further affect the thermal regime for native fishes, and hydropower operations impact the aquatic food web (Kennedy et al. 2016). Additionally, there have been widespread changes to riparian vegetation communities, the most visible being the spread of invasive tamarisk throughout the Colorado River basin (Auerbach et al. 2013; Graf 1978). Changes to riparian vegetation affect the formation and destruction of fluvial landforms (Diehl et al. 2017), and the widespread establishment of invasive tamarisk affects the distribution of native riparian species, particularly Fremont cottonwood (*Populus fremontii*) (Scott and Miller 2017).

Twentieth-century declines in stream flow have been linked to cycles of lower precipitation, especially in the Rocky Mountains. Changes to the flow regime of the Green River are driven by three major factors: dams, consumptive water use made possible by stream flow diversions, and climate change. Evidence of climatically driven changes during the last century is present on the regional streams of the Colorado Plateau (Fortney 2015; Graf et al. 1991; Hereford 1984, 1986). Stream flow records reconstructed from tree rings show that years of high annual runoff in the early 1900s were some of the wettest years in the past 5 centuries (Woodhouse et al. 2006). Further, hydrologic characteristics of the twentieth century do not represent the full range of variability present in the paleo-hydrologic record (Woodhouse et al. 2016), which documents numerous multi-year droughts with flows less than the lowest years of twentieth-century runoff (Woodhouse et al. 2010).

Warming temperatures have been the most significant contributor to declining stream flow in the twenty-first century (Udall and Overpeck 2017; Xiao et al. 2018), and warming temperatures are likely to play a greater role than changing precipitation in projected declines to stream flow in the coming decades (McCabe et al. 2017; USBR 2012).

The nature of the river and associated floodplain are depicted in a cross section and in a plan view in Figures 2.37 and 2.38, respectively.

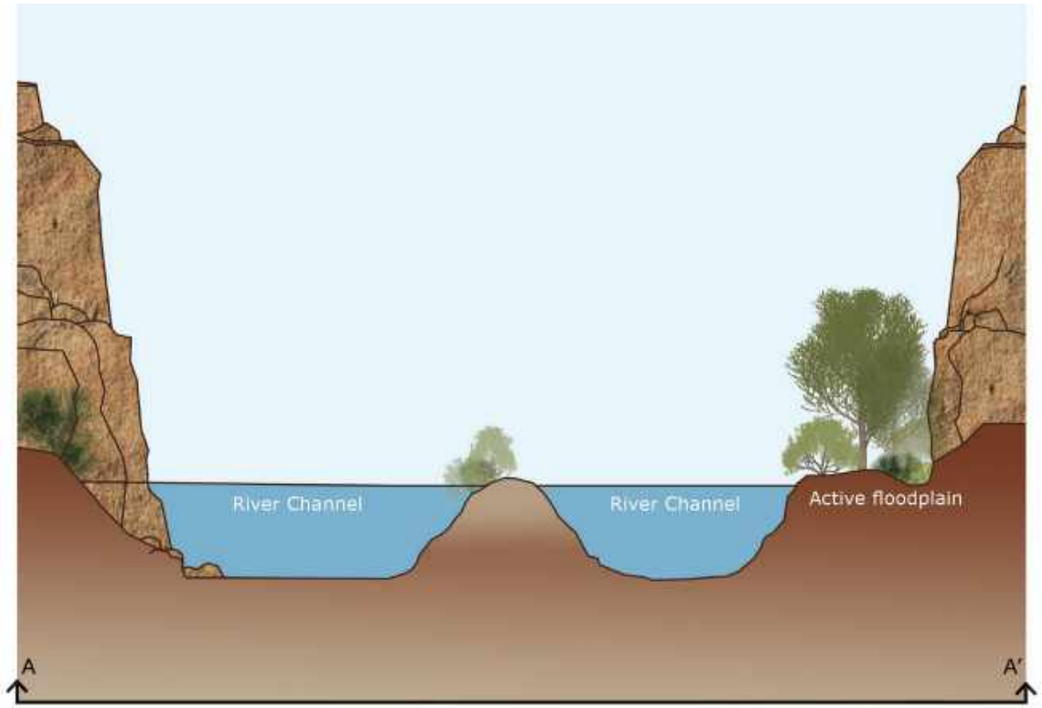

Figure 2.37. Green River cross section showing the active floodplain and river channel. Note: This cross section is a representation of the transect A to A' shown on the river plan view in Figure 2.38.

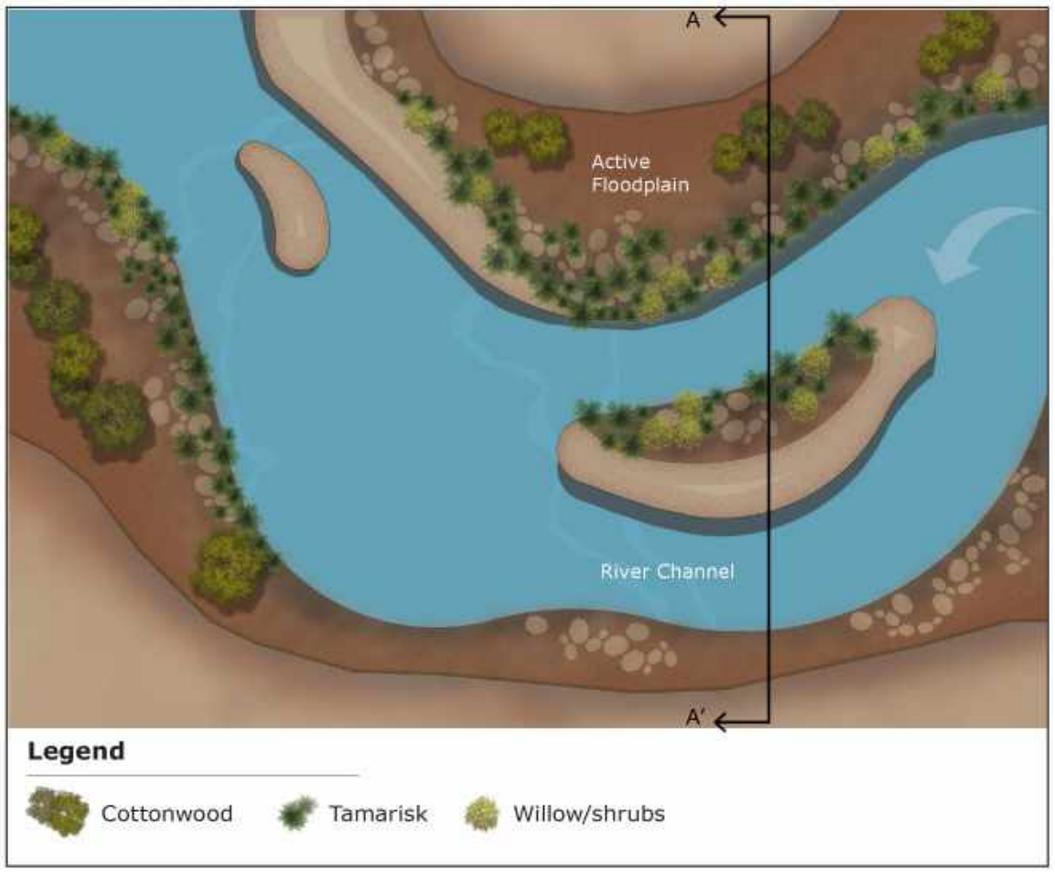

Figure 2.38. Green River plan view showing the active floodplain and river channel. Note: the transect A to A′ shown on this figure is depicted as a cross section of the river channel in Figure 2.37.

River Segments

FFSL has jurisdiction of the stream bed and banks of three segments of the Green River in Utah: Uinta Basin, Green River Valley,[2] and Labyrinth Canyon. All segments are influenced by upstream dams, diversions, and withdrawals. The hydrology, sediment, modern channel, and modern floodplain are described here for each segment.

UINTA BASIN

The Uinta Basin segment is a 102-mile segment that begins at the southern boundary of Dinosaur National Monument and flows past Jensen, Utah, through Ouray National Wildlife Refuge, before ending upstream of Ninemile Creek near Sand Wash.

Most stream flow in this segment comes from the upper Green River and Yampa River, although the Duchesne and White Rivers join the Green River near Ouray (see Figure 2.36). Prior to major river regulation, 72% of Green River stream flow entered the Green River upstream from Jensen (Iorns et al. 1965). The Duchesne River and the White River each contributed 12% of the basin's average annual runoff prior to major river regulation (Iorns et al. 1965). Contributions from the Duchesne River declined after the completion of the Strawberry Valley Project in 1913, which diverted water to the Wasatch Front (LaRue and Grover 1916). That trans-basin diversion reduced stream flow by 50% within the Duchesne River basin (Gaeuman et al. 2005), dimishing the flow of water to the mainstem Green River. The White River has seen declines in total runoff of 8% after the mid-1960s.

[2] The Gunnison Valley encompasses the entire Green River Valley segment and part of the Labyrinth Canyon segment, covering the upstream 23 RM between Green River State Park and the mouth of the San Rafael River.

The modern flow regime of the upper Green River at Greendale (upstream of the Yampa-Green confluence) is entirely controlled by the operation of Flaming Gorge Dam, which has a maximum power plant release of 4,600 cubic feet per second (cfs), and daily reservoir releases follow electricity demands. The Yampa River joins the Green River at Echo Park in Dinosaur National Monument. The Yampa River is the longest and largest free-flowing tributary in the upper Colorado watershed and still maintains a relatively natural flow regime, with yearly peak snowmelt flooding and low base flows during summer months. Flooding from the Yampa River provides 50% of the average annual peak flow of the lower Green River, as measured at the city of Green River. Therefore, the flow regime of the Yampa River maintains the current snowmelt-dominated flow regime of the Green River (Figure 2.39).

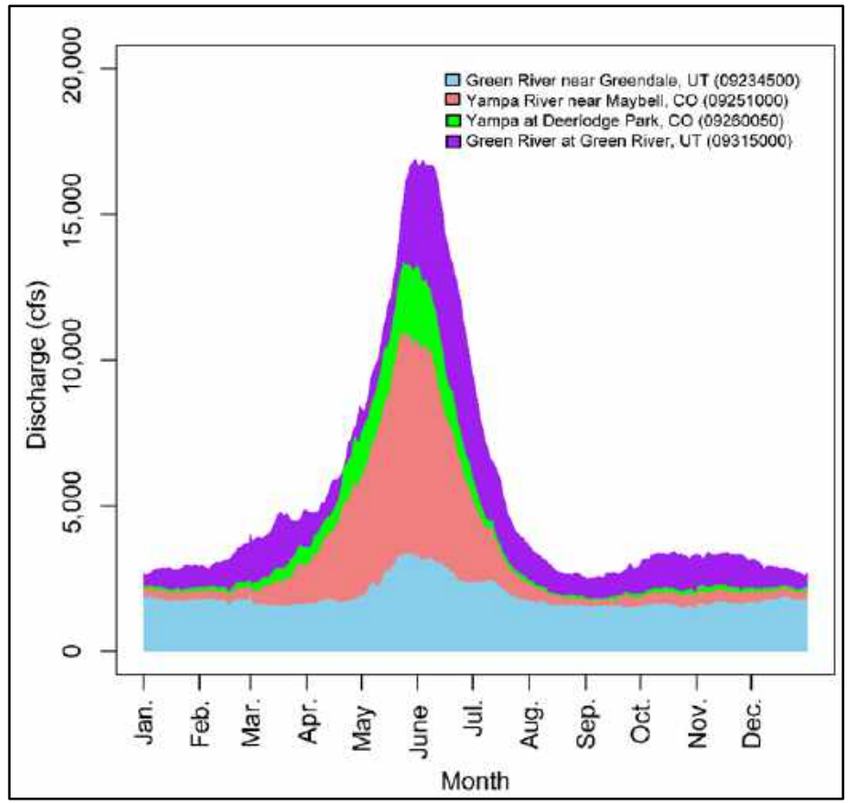

Figure 2.39. Mean daily discharge for the Green River at Green River, Utah, from 1982 to 2015, showing the contributions at each major upstream gage.[3]

[3] Shaded areas represent intervening flow from each gage. Pink and green shaded areas represent contributions from Yampa River. Deerlodge Park represents inflows from the Little Snake River. The purple shaded area incorporates contributions from the Duchesne, White, and Price Rivers. Source: USGS (2017b).

GREEN RIVER VALLEY AND LABYRINTH CANYON

The Green River Valley segment is a 12-mile segment of the Green River that begins at the downstream end of Gray Canyon and flows through the city of Green River to Green River State Park. In Gunnison Valley, the Green River has carved a wide alluvial valley into the erodible Cretaceous Mancos shale.

The Labyrinth Canyon segment is a 73-mile segment that begins at Green River State Park and flows southeast, entering Labyrinth Canyon proper approximately 2 miles downstream of the San Rafael River. Downstream from the Green River-San Rafael confluence, the lower Green River carves through progressively older Jurassic to Permian Mesozoic sedimentary rocks, forming canyons. Navajo Sandstone is first exposed at river level in the upstream end of Labyrinth Canyon. Flowing downstream, the river carves through progressively older Jurassic to Permian Mesozoic sedimentary rocks. The cliff-forming Wingate Sandstone is first exposed at RM 85 and the erodible Moenkopi Formation 15 miles downstream. The segment ends at the boundary of Canyonlands National Park. Both segments have similar geomorphic settings and hydrology, because stream flow has its source far upstream. Because of their similarities and because of the short length of the first segment, the two segments are discussed together.

Downstream of Green River State Park, approximately 98% of total annual flow comes from far upstream. The flow regime is dominated by spring snowmelt floods originating in the Yampa River basin. The Duchesne River, which enters the Green River in Ouray, has been almost entirely developed by agricultural diversions and trans-basin diversion into Utah Lake. Operations of Flaming Gorge Dam have affected the flow regime, reducing the magnitude of peak annual flow and raising September–February base flows by 30% (Walker 2017). Periodic August–November floods come from local ephemeral tributaries and can act as a source of sediment, but do not inundate the floodplain.

In the city of Green River, up to 25,000 acre-feet of water (approximately 5% of the total yearly runoff) is removed from the river at the Tusher Diversion Dam for irrigation, ranching, municipal use, and hydropower use. The diversion is a low head dam, allowing for water and sediment to pass over the top of the structure. Rehabilitation of the diversion dam (completed in 2016) provided upstream and downstream fish passage past the dam and downstream recreational boat passage through the dam.

Downstream of Green River State Park, less than 2% of the Green River's annual flow is contributed by the San Rafael River, the only major tributary in the local region (see Figure 2.36). The San Rafael River drains the east side of the Wasatch Plateau (drainage area of 3,887 square miles), joining the Green River 23 river miles downstream of the city of Green River. A large part of the San Rafael watershed is in the San Rafael Swell and San Rafael Desert where fine sediment yield is high (Fortney 2015). The flow of the San Rafael River was historically dominated by snowmelt but has been dramatically altered by dams in the headwaters and irrigation withdrawals in Castle Valley. Currently, the only high discharge events are during short-lived, summer thunderstorm–induced floods (Fortney 2015). The remaining flow is contributed by local ephemeral tributaries.

Control of the flow regime by dams and diversions has allowed rising consumptive use in the Green River basin throughout the twentieth century. Additionally, the average natural runoff has declined, exacerbating water supply issues in the basin (natural flows are the amount of runoff that would have occurred in the absence of dams, diversions, and withdrawals; USBR 2017a). Between 1904 and 1929, the average natural runoff of the Green River at the city of Green River was 630,000 acre-feet, and average natural runoff between 1930 and 2015 was 500,000 acre-feet, based on the Pettitt test analysis (Figure 2.40, part A). This temporal pattern of a shift in the average natural runoff has been previously observed (Allred and Schmidt 1999; Manners et al. 2014) and reflects changes in watershed-scale climate and land use that affect precipitation, evapotranspiration, and runoff ratio.

Measured total annual stream flow at the city of Green River is less than the natural runoff because of upstream consumptive losses (see Figure 2.40, part B). Before 1985, losses were approximately 95,000 acre-feet per year; however, losses increased to approximately 175,000 acre-feet per year thereafter. Application of the Pettitt test to the time series of measured total annual flow indicates that there have been two significant shifts in the average of measured total annual runoff and that the total average annual flow since 1985, 350,000 acre-feet, has been less than during any other part of the measured flow record.

The character of the annual snowmelt flood for the Green River at Green River, Utah, is divided into three distinct periods: 1895–1923, 1924–1958, and 1959–2015 (see Figure 2.40, part C). The 2-year recurrence flood during the early twentieth century was 42,000 cfs, declining to 28,600 cfs between 1924 and 1958, and then decreasing further to 22,000 cfs after 1958. The first decline in the flood magnitude is assumed to be related to the same drying pattern revealed in the natural flow estimates. However, the second decline in flood magnitude was caused by operations of Flaming Gorge Dam. Flood magnitude declined after 1958, the year of the last large flood prior to dam closure. The largest floods since 1958 occurred in 1983, 1984, and 2011, and the magnitude of those floods was less than the magnitude of the 5-year recurrence flood (54,700 cfs) of the early twentieth century.

Andrews (1986), Allred and Schmidt (1999), and Walker (2017) showed that base flows in the late twentieth century increased because of operations of Flaming Gorge Dam. Annual minimum flow increased by 18% between the periods 1985–1927 and 1988–2016 as total runoff and peak flood magnitude declined, and the difference between the magnitude of typical floods and base flows is presently less than at any previous time in the twentieth century. Water demand in the Green River basin is projected to increase in the coming decades (USBR 2012; Yampa/White/Green Basin Roundtable 2015), further altering the flow regime.

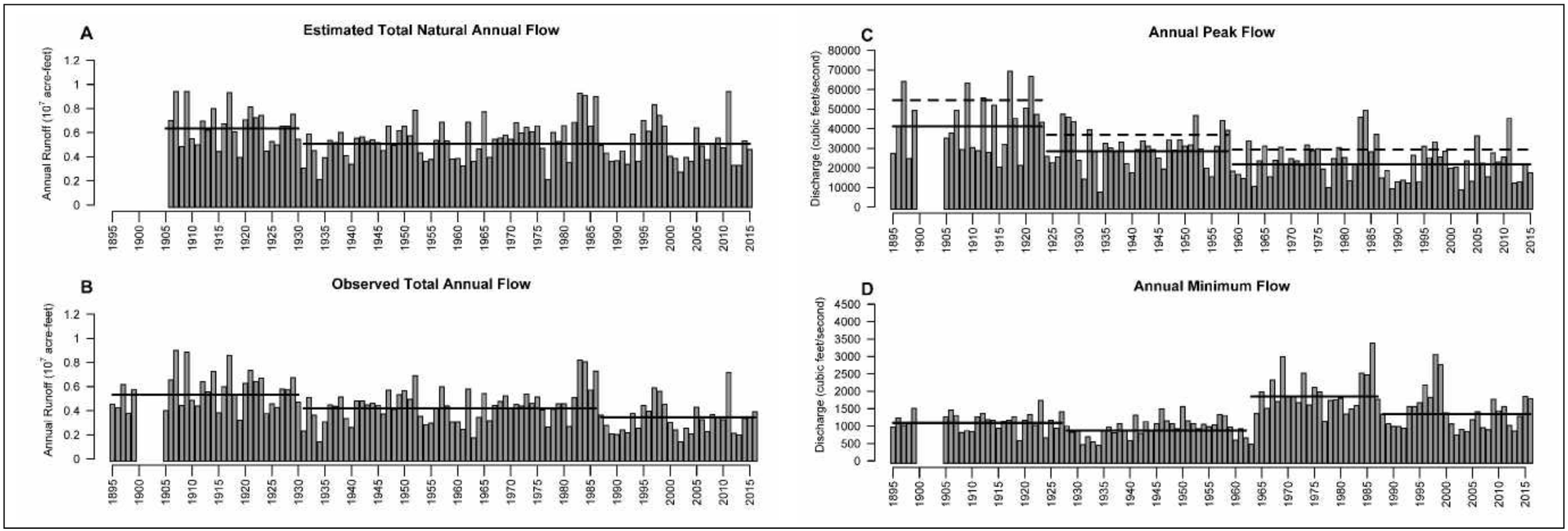

Figure 2.40. Hydrologic characteristics for the Green River at Green River, Utah (gage 09315000; see Figure 2.36) from 1895 to 2015.[4]

[4] A = estimated total unregulated annual flow from the USBR. B = observed total annual flow. C = time series of instantaneous annual peak flows. The 2-year (solid line) and 5-year (dashed line) recurrence intervals are shown for each period of flow regime determined by a Pettitt test. D = the annual minimum flow. Black lines represent the mean for each period. Periods of flow were identified using a Pettitt test for shifts in the mean of a data set. Sources: Pettitt (1979); USBR (2017a); USGS (2018b); Villarini et al. (2009). Graphs modified from Allred and Schmidt (1999).

Further Reading

Aspects of the Yampa River Flow Regime Essential for Maintenance of Native Fishes (Bestgen 2015)

Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam (Muth et al. 2000)

Twentieth Century Channel Change of the Green River in Canyonlands National Park, Utah (Walker 2017)

Updated streamflow reconstructions for the upper Colorado River basin (Woodhouse et al. 2006)

Upper versus lower Colorado River sub-basin streamflow: Characteristics, runoff estimation and model simulation (Fassnacht 2006)

Water Resources of the Upper Colorado River Basin (Iorns et al. 1965)

GIS Data Layers

FEMA Flood Zones, Major Tributaries, National Hydrography Dataset, Stream Alteration Permits, UPDES Permits, USGS Flow Gages, Watersheds (Hydrologic Unit Code 12)

Geomorphology and Sediment Supply and Transport

Fluvial Geomorphology

Fluvial geomorphology is the study of how flowing waters create and maintain landforms, focusing on the interaction between streams and the surrounding landscape. Stream channel form and channel size result from the forces exerted by the flux of water flowing through the channel network and by the characteristics of the sediment supplied to the channel and transported by flowing water. These elements act within the constraints provided by the geology and by the riparian vegetation. These fluxes of water and sediment are evaluated within a multi-dimensional framework: longitudinal, considering a river reach from upstream to downstream; transverse, looking at the gradient of interaction in a river valley perpendicular to a channel; vertical, related to groundwater exchanges and modifications of channel and floodplain by flows; and temporal, evaluating how fluxes of matter and energy alter the spatial dimensions over time (Corenblit et al. 2015).

The fundamental characteristics of fluvial geomorphology can change over time, and over long enough time scales, change is expected: reaches that appear stable under short-time scales are generally understood to still be undergoing long-term adjustments because of changes in sediment supply, watershed runoff, and/or flow regime (Schumm and Lichty 1965). Over millennia, variation in these inputs changes the sediment mass balance, altering the influx and efflux of transported sediment in a river (Lane 1955). In response, river channel form adjusts to optimize the conveyance of water and sediment so that the mass balance is achieved again. These elements all affect attributes of stream channel and floodplain form, including bed material size and distribution, cross-section width, depth, area and shape, planform configuration, floodplain characteristics, and channel slope.

Changes to channel and floodplain attributes of the Green River have occurred in response to changes in the mass balance of water and sediment. Downstream of Flaming Gorge Dam, the river has narrowed as a result of declining flow by the abandonment of pre-dam floodplains (Grams and Schmidt 2002). Further downstream, near Green River, Utah, channel narrowing was primarily a result of reductions in peak flow magnitude, decreasing connectivity between channel and floodplain (Allred and Schmidt 1999). New floodplains formed by vertical accretion with the margin of pre-dam channel. In Labyrinth Canyon and Canyonlands National Park (Walker 2017), similar findings were documented, with the addition of recent (post-1985) channel narrowing by inset floodplain formation initiated during years of low snowmelt flood magnitude. In all reaches where channel narrowing has been described, both new and old floodplains now have vegetation communities dominated by nonnative vegetation (Friedman et al. 2005), potentially promoting floodplain sediment deposition (Diehl et al. 2017). Finally, changes in agricultural and municipal land use alter the way floodplains interact with the river channel. The changes described above can affect the area of the channel in the planning area and affect management concerns.

River Segments

UINTA BASIN

The modern channel in this segment is wide, containing both invasive, nonnative vegetation and native cottonwood galleries on its banks. Regular snowmelt floods may still inundate floodplains, particularly in Ouray National Wildlife Refuge (Valdez and Nelson 2004), and releases from Flaming Gorge Dam are malnipulated to augment flood magnitude in years with small floods and extend flood duration in higher flow years to promote endangered fish nursery habitat. The modern channel has a low gradient, and the composition of the bed is largely sand. The geomorphic planform alternates between meanders with a wide alluvial valley (restricted meanders) and meanders with a narrow alluvial valley (fixed meanders) (Ikeda 1989; Schmidt and Brim Box 2004). Outside of bends, the river encounters bedrock or Pleistocene gravel terraces. The contemporary river contains numerous active sandbars, which provide important backwater habitat for the endangered Colorado pikeminnow (Grippo et al. 2017). Flows within the reach are monitored to increase larval survival of both the pikeminnow and razorback sucker (also endangered). Floodplain modifications, including levee removal, have occurred in Ouray National Wildlife Refuge to promote backwater razorback sucker habitat (Jahrsdoerfer 2018; Valdez and Nelson 2004; see the Fish Species section).

Upstream sediment supply to this segment was severely reduced by the Flaming Gorge Dam (Grams and Schmidt 2005), and most of the current sediment flux into this segment comes from the Yampa River. Suspended-sediment transport in the Yampa River declined because of bed sand coarsening following a large sediment-supplying event from Sand Creek 50 years ago, and silt and clay transport has also decreased in the Yampa River because of reductions in the supply of silt and clay from tributaries (Topping et al. 2018). Sediment supplies in the Duchesne River declined in the twentieth century, concurrent with an observed 50% decline in stream flow (Gaeuman et al. 2005). Gravel storage increased within the Duchesne River during the same time period (Gaeuman et al. 2003).

Real time sediment data are collected by the USGS Grand Canyon Monitoring and Research Center (GCMRC) near Jensen (2013–present; gages 09261000 and GCMRC-GR1) and Ouray (2017–present; GCMRC-GR2) (GCMRC 2018; Topping and Wright 2016). The data for Jensen show that sand transport peaks during spring snowmelt floods, and silt and clay transport is greatest in the summer and fall (Figure 2.41). Total suspended sand transport averaged 350,000 tons per year from 2013 to 2018; suspended silt and clay transport averaged 930,000 tons per year during the same time period. Average annual bedload transport was 59,000 tons per year from 2013 to 2018, representing 5% of the total sediment flux. The current annual average transport is 58% lower than the post-dam annual transport estimate of Andrews (1986).

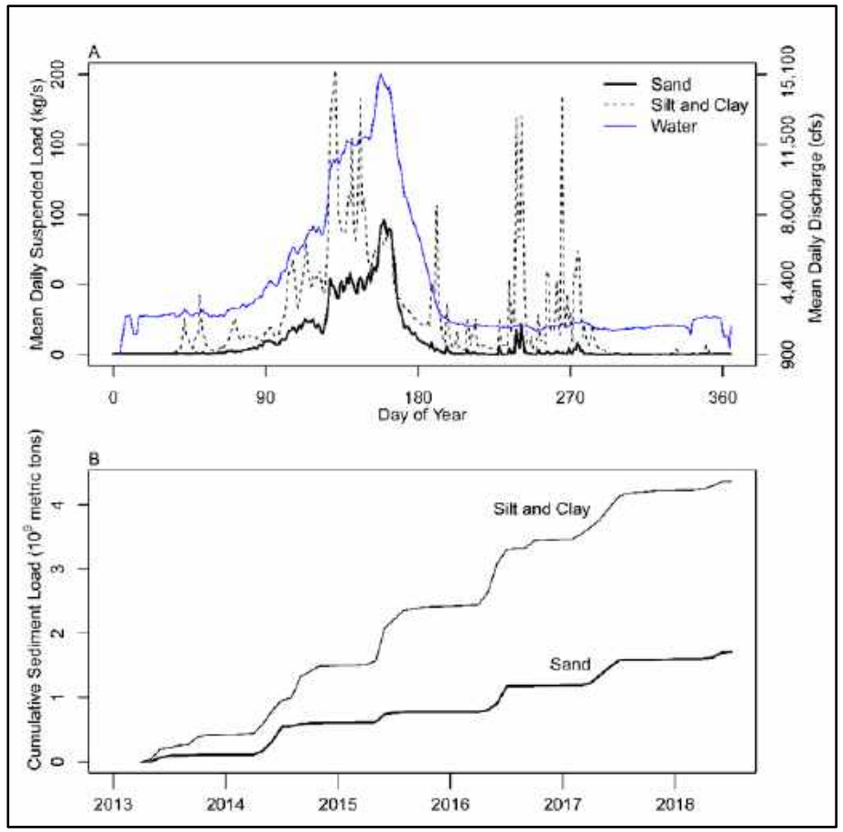

Figure 2.41. Sediment transport time series for the Green River near Jensen, Utah (gage 09261000/GCMRC-GR1).[5]

GREEN RIVER VALLEY AND LABYRINTH CANYON

In contrast to the upstream sources of stream flow, sediment is contributed to these segments by the semiarid, lower elevation parts of the basin, and proportionally, these parts contribute a greater percentage of sediment compared to water (Andrews 1986; Iorns et al. 1965). Much of this sediment is contributed to the Green River during summer thunderstorm floods (Figure 2.42). Real-time sediment data are currently collected by the USGS at Mineral Bottom (gage 09328920, RM 52; USGS 2018d). Annual sediment loads at Mineral Bottom have declined substantially, averaging 4.98×10^6 tons per year from 2015 to 2018, approximately 55% lower than previous post-dam estimates, which averaged 8.91×10^6 tons per year (Thompson, 1984; Andrews, 1986). Current data collected at Mineral Bottom show that sediment transport is highly variable throughout the year. Sand transport is greatest during snowmelt floods, whereas silt and clay transport is greatest in the late summer and fall (Walker 2017). Transport is also highly variable among years; total sand loads varied up to 52% among years, and silt and clay varied up to 54% (see Figure 2.42). An unknown proportion of sediment is transported downstream as bedload. For the years where both the Jensen and Mineral Bottom sediment gages collected sediment data, suspended sand transport at Mineral Bottom exceeded transport at Jensen by a factor of 4.7, and suspended silt and clay transport was greater by a factor of 3.8. Discharge at Mineral Bottom exceeded discharge at Jensen by a factor of 1.1.

[5] A = time series of mean daily suspended sand load, mean daily suspended silt and clay load, and mean daily discharge. Loads are plotted on the left y-axis and discharge is plotted on the right y-axis. B = cumulative sediment loads for the Green River at Jensen, Utah, from 2013 to 2018. Cumulative loading plots show the cumulative amount of sediment transported since measurement began. For each time step, the suspended load is added to previous loading value to get the new cumulative load. Sources: USGS (2016, 2018c).

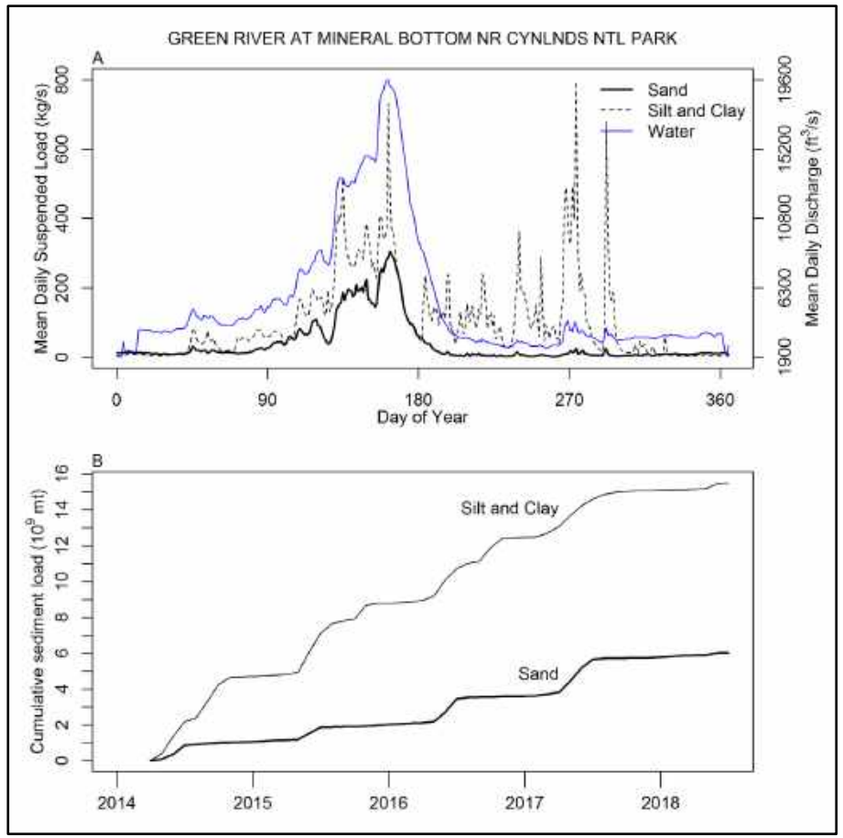

Figure 2.42. Sediment transport time series for the Green River at Mineral Bottom (gage 09328920).[6]

In both alluvial and canyon-bound portions of these segments, invasive tamarisk is widely established on floodplains (Figure 2.43). The exact date of tamarisk establishment is unknown; however, it is widely accepted that tamarisk was established in Gunnison Valley by 1938 (Clover and Jotter 1944). Tamarisk continued to grow on floodplains in the twentieth century, though native willow coexists with tamarisk near the banks. The dominance of tamarisk coincides with the decline of the native Fremont cottonwood, which suffered recruitment difficulties under the changing hydrologic regime and is often outcompeted by other riparian species (Mahoney and Rood 1998; Scott and Miller 2017).

The modern channel of the river can be distinguished in two parts: a wide alluvial part in the Gunnison Valley and the confined meanders of Labyrinth Canyon. Within the alluvial part, the bed of the river is primarily gravel, with some fine sediment (Allred and Schmidt 1999). At some point downstream of the city of Green River, the river transitions to a sand bed; the bed of the river is virtually all sand in Labyrinth Canyon. Pleistocene gravel terraces occur in both parts, above the bed of the current river (Allred and Schmidt 1999; Pederson et al. 2013). Islands exist within the main channel in portions of the segment.

During the twentieth century, decreasing river flow initiated channel narrowing by inset floodplain formation on formerly active channel bars. These inset floodplains vertically accreted after formation and are now only inundated by large snowmelt floods (Allred and Schmidt 1999; Walker 2017). Today, floodplains in this segment have minimal connectivity to the Green River and no longer provide backwater habitat to endangered native fishes (Gessler and Moser 2001).

The banks and floodplains have been developed near the city of Green River for agricultural and municipal purposes. Agriculture practices near the river removed riparian vegetation, and banks have been reinforced to protect bridges, buildings, and the city's water treatment

[6] A = time series of the Green River at Mineral Bottom from 2014 to 2018 for mean daily suspended sand load, mean daily suspended silt, and clay load and mean daily discharge. Loads are plotted on the left y-axis and discharge is plotted on the right y-axis. B = cumulative sediment loads. Source: USGS (2018d).

plant. In Labyrinth Canyon, permanent human modifications are rare. An unpaved airstrip near Mineral Bottom and the White Rim Road are the only major features; neither affects the banks of the river and only alters the floodplain to a minor extent.

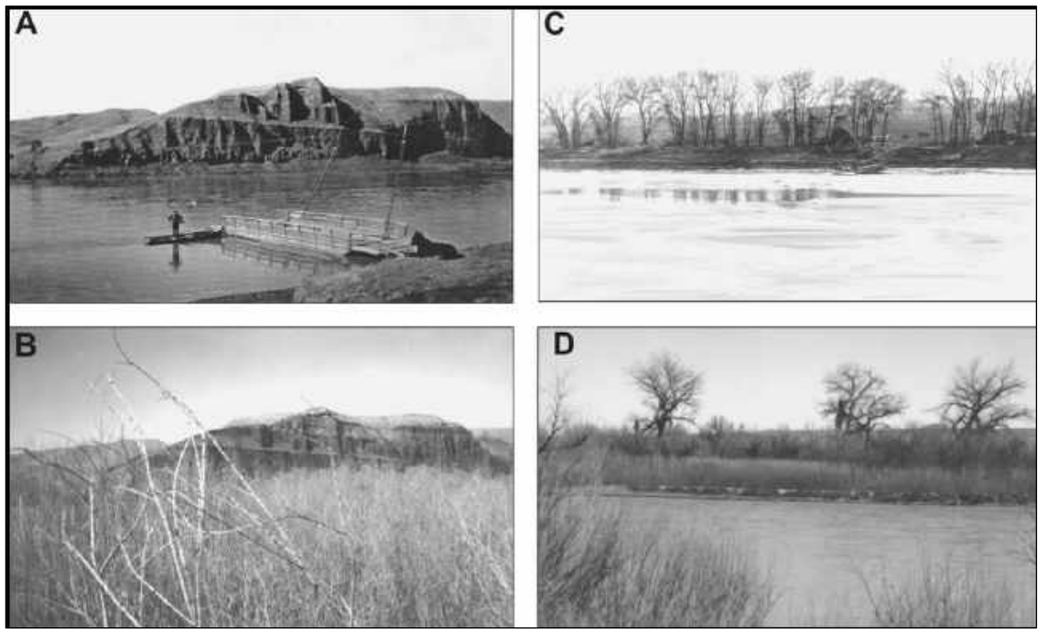

Figure 2.43. Matched set of photographs of the old ferry and U.S. Geological Survey cableway approximately 6 miles downstream of Green River, Utah, in the Labyrinth Canyon segment (Allred and Schmidt 1999).[7]

Changes to the River in the Twentieth Century

The contemporary Green River is not the same river it was at the turn of the twentieth century (Figure 2.44). A wider channel with numerous bare sandbars (Figure 2.45, part A) is now a narrower channel with banks lined by a mixed tamarisk-willow community (Figures 2.45 and 2.46). Formerly bare sandbars are now stable mid-channel islands. The channel is consistently narrower in the upper (Alexander 2007; Grams and Schmidt 2002), middle, and lower (Andrews 1986; Allred and Schmidt 1999; Walker 2017) Green River. Narrowing has been documented in tributaries, including in the Yampa River (Manners et al. 2014), Duchesne River (Gaeuman et al. 2005), and San Rafael River (Fortney 2015), concurrent with declines in total annual flow and peak annual flow.

[7] A = photograph taken on December 5, 1911, view facing west. B = photograph taken in 1997, match of A. C = photograph taken in 1911, view facing east. D = photograph taken in 1997, match of C.

Photographs A and C from the USGS Southwest Repeat Photography Collection, Green River stake locations (USGS 2018e). Photographs B and D from Allred and Schmidt (1999).

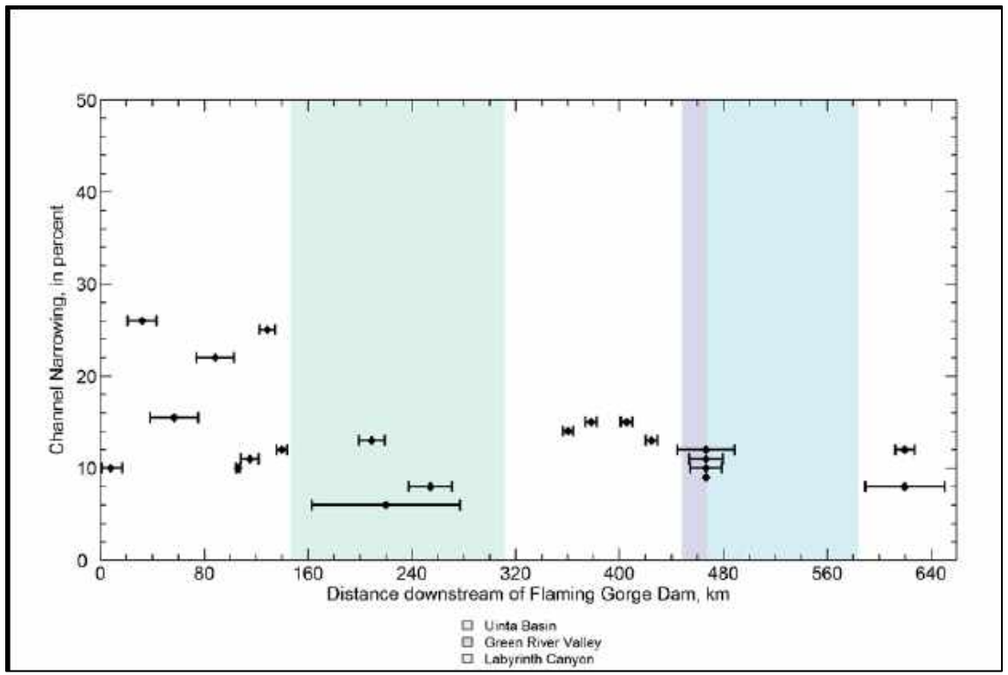

Figure 2.44. Channel narrowing in the Green River basin.[8]

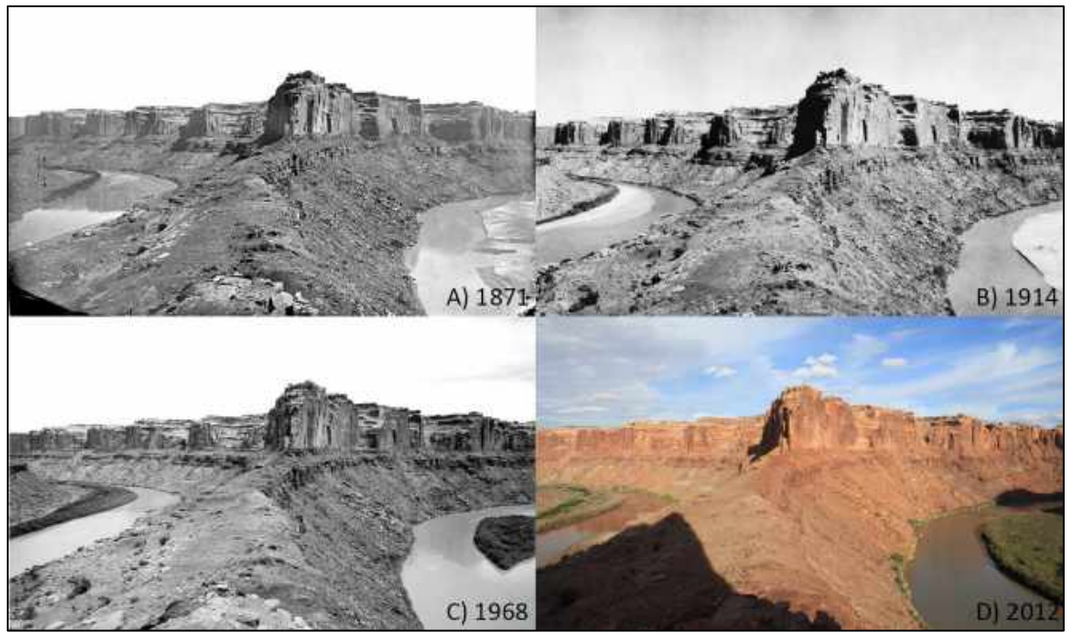

Figure 2.45. Matched set of photographs taken at Bowknot Bend (river mile 70) in the Labyrinth Canyon segment, 23 river miles upstream from Canyonlands National Park.[9]

[8] Each point represents a study of channel narrowing, and horizontal error bars show distance investigated by each individual study. Shaded regions are segments described in the plan.
Sources: Andrews (1986); Grams and Schmidt (2002); Grams and Schmidt (2005); Lyons et al. (1992); Mayers n.d. [1995]; Merritt and Cooper (2000); Orchard and Schmidt (1998); Walker (2017).

[9] A = photograph taken in 1871 by E.O. Beaman. B = photograph taken in 1914 by E.C. LaRue. C = photograph taken in 1968 by H.G. Stephens. D = photograph taken in 2012 by Mark Miller. The progression of photographs through time shows the formation of vegetated floodplains and vegetated islands from B to C, then the conversion of island to floodplain from C to D.
Photographs from the USGS Southwest Repeat Photography Collection, Green River stake locations (USGS 2018e).

Figure 2.46. Matched set of photographs taken at Bowknot Hell Roaring Canyon (river mile 55) in the Labyrinth Canyon segment.[10]

Changes to the flow regime and the establishment of invasive tamarisk have both been identified as the primary drivers of channel narrowing in the Green River basin (Andrews 1986; Allred and Schmidt 1999; Birken and Cooper 2006; Graf 1978; Walker 2017). The role of vegetation in promoting channel change is complex and cannot be completely disentangled from the flow regime. However, recent research on the interactions between flow and vegetation (Diehl et al. 2017) suggests that tamarisk can positively influence deposition under the right flow regime and sediment supply conditions. Changes in hydrology are considered the primary driver of changes to the form of the Green River, but the effects of vegetation on channel change must be considered.

Along with control of the flow regime by dams and diversions, increasing societal demand for water resulted in rising consumptive use in the Green River basin throughout the twentieth century. The water withdrawals to meet consumptive uses meaningfully alter the flow regime, decreasing total runoff and reducing peak annual flow magnitude and duration. The river channel of the Green River will continue to respond to these altered inputs, resulting in further changes that will likely negatively river form and function.

Further Reading

A watershed perspective of changes in streamflow, sediment supply, and geomorphology of the Colorado River (Schmidt 2010)

Cataract Canyon: A Human and Environmental History of the Rivers in Canyonlands (Webb et al. 2004)

Channel narrowing by vertical accretion along the Green River near Green River, Utah (Allred and Schmidt 1999)

Complex channel responses to changes in stream flow and sediment supply on the lower Duchesne River, Utah (Gaeuman et al. 2005)

Downstream effects of Flaming Gorge Reservoir on the Green River, Colorado and Utah (Andrews 1986)

Equilibrium or indeterminate? Where sediment budgets fail: Sediment mass balance and adjustment of channel form, Green River downstream from Flaming Gorge Dam, Utah and Colorado (Grams and Schmidt 2005)

Fluvial adjustments to the spread of tamarisk in the Colorado Plateau region (Graf 1978)

Green River Subbasin Floodplain Management Plan (Valdez and Nelson 2004)

Impact of humans on the flux of terrestrial sediment to the global coastal ocean (Syvitski et al. 2005)

Mechanisms of vegetation-induced channel narrowing of an unregulated canyon river: Results from a natural field-scale experiment (Manners et al. 2014)

Metrics for assessing the downstream effects of dams (Schmidt and Wilcock 2008)

Movement and storage of sediment in rivers of the United States and Canada (Meade et al. 1990)

Processes of Tamarix invasion and floodplain development along the lower Green River, Utah (Birken and Cooper 2006)

Streamflow regulation and multi-level floodplain formation: Channel narrowing on the aggrading Green River in the eastern Uinta Mountains, Colorado and Utah (Grams and Schmidt 2002)

GIS Data Layers

FEMA Flood Zones, Major Tributaries, National Hydrography Dataset, Stream Alteration Permits, UPDES Permits, USGS Flow Gages, Watersheds (Hydrologic Unit Code 12)

[10] A = photograph taken in 1889 by F.A. Nims. B = match photograph taken in 1999 by Steve Young.
Dense riparian vegetation growth on new floodplains blocks the previous view of cliffs and the canyon mouth.
Photographs from the USGS Southwest Repeat Photography Collection, Green River stake locations (USGS 2018e).

Water Quality

Designated Beneficial Uses and Impairments

The Clean Water Act requires every state to adopt water quality standards to protect, maintain, and improve the quality of surface waters. These water quality standards consist of three major components: beneficial uses, criteria, and the antidegradation policy. The Utah Water Quality Board is responsible for establishing water quality standards that are then administered by the DWQ. These standards are found in the Utah Administrative Code R317-2 (Standards of Quality for Waters of the State) and vary based on the beneficial use assignment of the waterbody (DWQ 2010). DWQ has developed four major beneficial use classifications to characterize the uses of surface waters within the state. Table 2.11 lists Utah's four major beneficial use classifications and sub-classifications. The beneficial use designations for the Green River planning area are 1C (domestic/drinking water), 2A (frequent primary contact recreation), 3B (warm water fishery/aquatic life), and 4 (agricultural uses) (see Figure 2.47).

Table 2.11. Major Beneficial Use Classifications in the State of Utah

Major Beneficial Use Classification	Beneficial Use Sub-Classification
1 Domestic/Drinking Water	1C Drinking Source Water
2 Recreational Use and Aesthetics	2A Frequent Contact Recreation
	2B Infrequent Contact Recreation
3 Aquatic Wildlife	3A Cold Water Aquatic Life
	3B Warm Water Aquatic Life
	3C Nongame Aquatic Life
	3D Waterfowl/Shorebirds
4 Agricultural	4 Agriculture

Source: Utah Administrative Code R317-2-6.

DWQ monitors the water quality of the Green River at several monitoring sites, mostly in the Uinta Basin segment near Jensen and near Ouray National Wildlife Refuge (see Water Quality layer in the GIS spatial data viewer). In the Green River Valley segment, there is one active water quality monitoring site. Numerous inactive monitoring sites are in the Labyrinth Canyon segment.

DWQ assigns an impairment status to a given waterbody when the concentration of a specific pollutant is above (or in some cases below) the numeric criteria associated with the beneficial use designated for the waterbody. Beneficial use designations and water quality impairments are detailed in DWQ's integrated report and on the interactive DWQ Beneficial Uses and Water Quality Assessment Map (DWQ 2016) and are depicted on Figure 2.47. The Green River from the Utah-Wyoming state line down to the confluence with the Duchesne River is listed as impaired for its 3B beneficial use (warm water fishery/aquatic life) because of elevated concentrations of selenium. The 2016 assessment for this segment of the Green River concludes that it should be listed on the 303d list of impaired waters and that a total maximum daily load would need to be done for selenium. For the remainder of the planning area, there are no known impairments, and the river is either supporting beneficial uses or no assessment has been done and more data are required (DWQ 2016).

Selenium is an essential micro-nutrient that is relatively abundant in Mancos shale–derived soils and landscapes. However, in elevated concentrations, selenium has been proven to cause mortality, deformity, and reproductive failure in fish and aquatic birds (EPA 1998). Natural processes such as erosion are responsible for transporting selenium into river. Erosion may be sped up by agriculture and other manipulation of the landscape.

Salinity and Other Issues

Salinity loading is a water quality concern in the Colorado River basin (which includes the Green River) because of the economic and environmental impacts the added salinity has downstream. Almost half of the salinity in the Colorado River system is from natural sources (USBR 2017b). In 1974, Congress enacted the Colorado River Basin Salinity Control Act, which resulted in numerous salinity-control efforts to prevent salt from reaching the river. As of 2017, salinity-control measures have prevented nearly 1.31 million tons of salt from reaching the Colorado River per year (USBR 2017a). To meet salinity water quality standards in the lower Colorado River, it is estimated that an additional 372,000 tons of salt will need to be prevented from reaching the river by 2035 using salinity-control measures. Future efforts to reduce salt loading would involve the implementation of projects in the Green River basin.

In portions of the Green River basin, such as the Uinta Basin, extraction activities for oil, gas, and shale pose additional risks to the water quality of the Green River. Although shallow groundwater is the water source most vulnerable to water quality degradation from these activities, this groundwater can mix with surface waters such as the Green River and its tributaries.

Further Reading

Quality of Water Colorado River Basin, Progress Report No. 25 (USBR 2017)

2016 Final Integrated Report (UDEQ 2017)

GIS Data Layers

Beneficial Uses Assessment Units, Wastewater Treatment Plants, Water Quality Monitoring Sites, Water Rights Regions

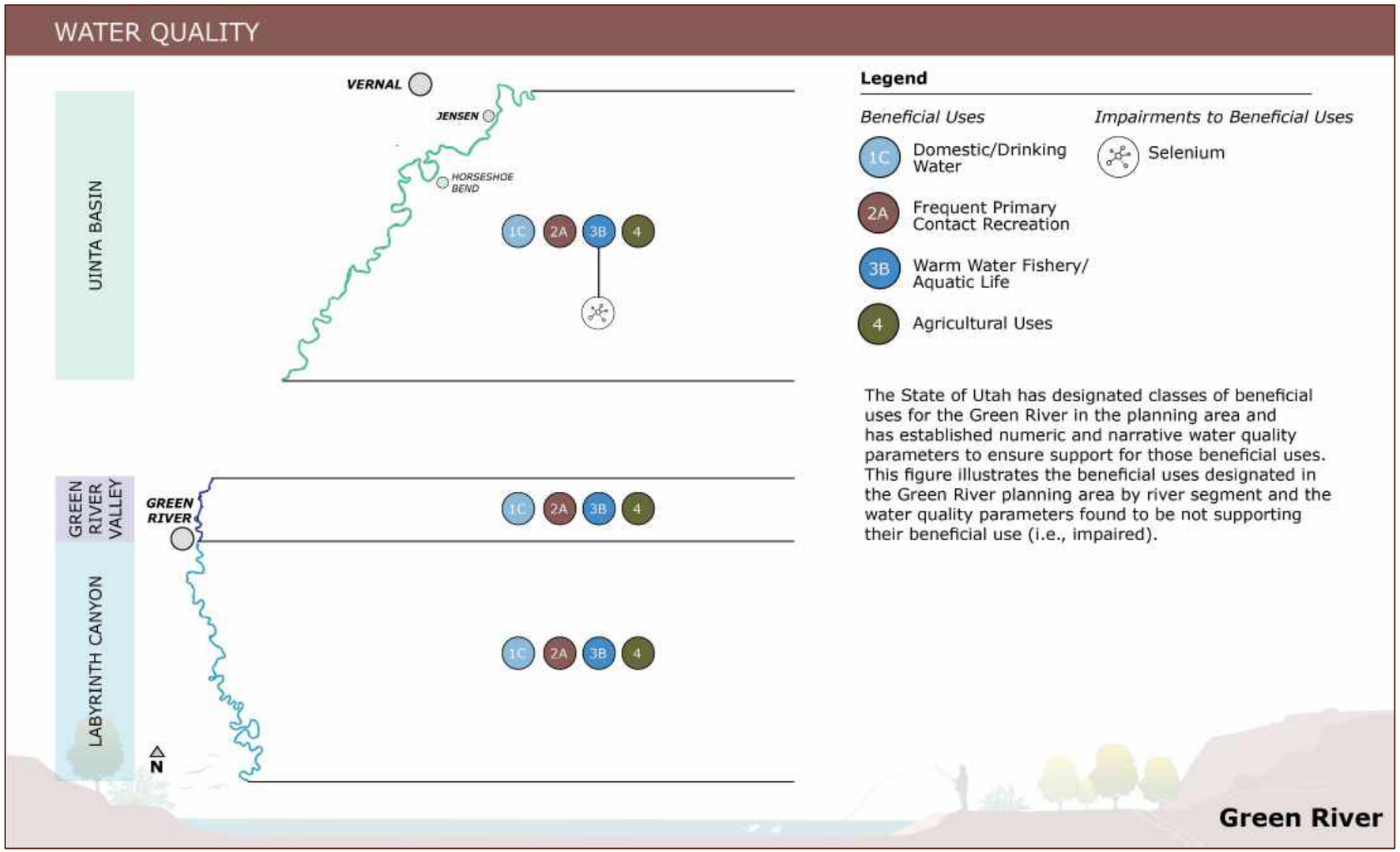

Figure 2.47. Beneficial uses and impairments in the planning area by river segment.

2.4 Geology, Paleontology, Oil and Gas, and other Mineral Resources

Geology

The Green River rises in the Wind River Range of western Wyoming, flows through northeastern Utah and northwestern Colorado, and then flows through and drains the Colorado Plateau physiographic province in Utah up to The Confluence. The Colorado Plateau province is a broad area of regional uplift in southeastern and south-central Utah characterized by essentially flat-lying Mesozoic and Paleozoic sedimentary rocks. In southeastern Utah, the Colorado Plateau province is distinguished by plateaus, buttes, mesas, and deeply incised canyons exposing flat-lying or gently warped strata (Utah Geological Survey [UGS] 2018a). The Colorado Plateau province is divided into geologically distinct subdivisions. These subdivisions include the Uinta Basin and Canyonlands subdivisions. Ancient Precambrian rocks exposed in its deepest canyons make up the basement of the Colorado Plateau. Younger, more familiar layered rocks of the Colorado Plateau have been deposited on the ancient Precambrian rocks over the past 500 million years, including layers of limestone, sandstone, siltstone, and shale (USGS 2017a).

Beginning ca. 70 million years ago, accelerating from ca. 20 to 25 million years ago, and accelerating even more ca. 5 million years ago, both the Basin and Range and Colorado Plateau provinces were uplifted by as much as 3 kilometers. Although the Basin and Range province was broken up into dropped-down valleys and elongated mountains, the Colorado Plateau province retained its structural integrity and remained a single tectonic block (USGS 2017a). The Colorado Plateau crust rose 1 kilometer higher than the Basin and Range, and streams cut deep stream channels, with the Colorado River being the most well-known of these streams (USGS 2017a).

The Uinta Basin subdivision of the Colorado Plateau is a geologic structural basin in eastern Utah, east of the Wasatch Range and south of the Uinta Mountains. The Uinta Basin is fed by creeks and rivers flowing south from the Uinta Mountains. Many streams and rivers in the Uinta Basin flow into the Duchesne River, which feeds into the Green River.

The Canyonlands subdivision of the Colorado Plateau is in the southeastern quarter of Utah. This area has been sculpted by the Colorado River and its tributaries (including the Green River), resulting in deep, sheer-walled canyons, plateaus, mesas, buttes, and badlands (McGinty and McGinty 2009). Much of the landscape is characterized by delicate rock forms, such as tall pinnacles, deep alcoves, natural bridges, and arches. The Canyonlands subdivision also includes isolated mountains, such as the Abajo, La Sal, and Henry Mountains.

The geologic units underlying the Green River planning area are listed in Table 2.12.

Table 2.12. Geologic Units Underlying the Green River Planning Area

River Segment	Geologic Units	Area (acres)
Uinta Basin	Alluvial fan deposits	92
	Brennan Basin Member of Duchesne River Formation	179
	Cedar Mountain and Morrison Formations	15
	Douglas Creek Member of Green River Formation	1
	Eolian deposits	2
	Flood-plain and channel alluvium	2,356
	Frontier Formation	8
	Frontier Sandstone, Mowry Shale, and Dakota Sandstone, undivided	24
	Green River	1,197
	Mancos Shale	17
	Member B of Uinta Formation	80
	Member C of Uinta Formation	8
	Mixed alluvium and colluvium	44
	Parachute Creek Member of Green River Formation	18
	Piedmont alluvium, undivided	67
	Sandstone and limestone facies of Green River Formation	22

River Segment	Geologic Units	Area (acres)
	Stream alluvium	192
	Talus deposits	22
	Terrace deposits	47
	Water	3,531
Green River Valley	Alluvial stream and wash deposits	8
	Alluvium	179
	Blue Gate Member of Mancos Shale	14
	Historical alluvial river channel deposits	15
	Pediment mantle	2
	Perennial waterbody	32
	Stream alluvium	18
	Terrace deposits	14.8
	Water	401
Labyrinth Canyon	Alluvial river or stream terrace deposits	22
	Alluvial stream and wash deposits	889
	Brushy Basin Member of Morrison Formation	36
	Cedar Mountain Formation	51
	Chinle Formation	109
	Chinle Formation, undivided	76
	Curtis Formation	6
	Eolian and alluvial deposits	3
	Eolian deposits	101
	Eolian sand deposits	59
	Ferron Sandstone Member of Mancos Shale	1
	Historical alluvial river channel deposits	7
	Intermittent water body	2
	Kayenta Formation	69
	Limestone beds in Navajo Sandstone	<1
	Lower Juana Lopez Member of Mancos Shale	2
	Lower Member of Carmel Formation	3
	Mass-movement talus and colluvial deposits	29
	Moenkopi Formation	109
	Moenkopi Formation, undivided	82
	Moenkopi, Dinwoody, Woodside, Thaynes and other Formations	1
	Navajo Sandstone	146
	Perennial waterbody	2,190
	Salt Wash Member of Morrison Formation	86
	Slick Rock Member of Entrada Formation	24
	Slick Rock Member of Entrada Sandstone	32
	Stream alluvium	648
	Summerville Formation	11
	Talus and colluvium	20
	Terrace deposits	36
	Tidwell Member of Morrison Formation	17
	Tidwell Member of Morrison Formation and Summerville Formation, undivided	5
	Tununk Shale Member of Mancos Shale	24
	Upper Member of Carmel Formation	26
	Water	2,497
	Wingate Sandstone	66

Source: UGS (2019a).

Geologic Hazards

As depicted in Figure 2.48, there is a relatively low seismic hazard within the Green River corridor (USGS 2014). In this figure, peak ground acceleration (ground motion effect) is a measure of the maximum force experienced by a small mass located at the surface of the ground during an earthquake. The forces caused by the shaking can be measured as a percentage of gravity or %g. The %g can range from 0% to greater than 80%. The three river segments are in areas with no greater than 30%g. In comparison, Salt Lake City is in an area of 40%g to 80%g.

Figure 2.49 depicts the locations of Quaternary faults overlapping the Green River planning area. There are two Quaternary faults along the Green River (Ten Mile Graben faults); both overlap the Green River approximately 7.0 miles and 7.5 miles south of Interstate 70 along the Labyrinth Canyon segment, respectively (UGS 2018b). Both faults are identified as Class B faults. Class B faults are structures that are likely too shallow to be a source of significant earthquakes, or the evidence for a tectonic origin is not strong enough for the structures to be classified as Class A (Crone and Wheeler 2000). Class B faults, which include faults of uncertain earthquake potential, may be related to processes such as salt deformation and dissolution, landsliding, lateral spreading, or subsidence following volcanic activity (Willis 2019).

Many of the geologic processes that have shaped the canyons and valleys along the Green River over millions of years are still active today and present geologic hazards to property and lives. Besides earthquakes, these geologic hazards include rock falls, landslides, flooding, debris flows, piping, slumping due to river undercutting, and collapse or settling of soils (Hylland and Mulvey 2003; Mulvey 1992).

Rock falls happen when erosion and gravity dislodge rocks from cliffs or slopes. Outcrops in some rock units are disrupted by bedding surfaces, joints, or other discontinuities that break rock into loose fragments, blocks, or slabs. Rock falls can damage structures, block roads, and threaten personal safety.

Landslides are common natural hazards in Utah and are often associated with rising groundwater levels due to rainfall, snowmelt, and landscape irrigation. Therefore, landslides in Utah typically occur in March, April, and May (UGS 2019b). Landslides primarily present threats to structures and developments on slopes or at the base of slopes.

Flooding can occur as a result of seasonal snowmelt and during cloudburst storms. When cloudburst storms drop large volumes of water in a short period of time, flooding can occur with little advance warning. Flash floods can contain debris flows that include boulders, cobbles, sand, silt, organic material, and other solid debris. Debris flows can present a threat to public safety and create property damage.

Piping is subsurface erosion caused by groundwater that moves in permeable, non-cohesive layers in unconsolidated materials and exits at a free face that intersects the layer (Hylland and Mulvey 2003). The eroded channel or “pipe” becomes enlarged as more water is intercepted until it collapses to form a gully on the surface that continues to enlarge. This process can cause damage to roads, earth-fill dams, farmland, bridges, culverts, and buildings.

Collapsible soils are common in Utah, particularly in alluvial fans that have shale in their source areas (Hylland and Mulvey 2003). These soils generally consist of fine sand and silt held together by small amounts of clay. The soil collapses when it is saturated and the clay bonds dissolve. Collapsing soils can damage structures and can also contribute to debris flows during flooding events.

Radon is another geologic hazard in the planning area. Radon is an odorless, tasteless, colorless, naturally occurring radioactive gas produced from the radioactive decay of uranium. Sources of radon include granite, metamorphic rocks, black shales, volcanic rocks, uranium mines, and uranium tailings from uranium mills (Hylland and Mulvey 2003). When present near the ground surface or beneath well-drained, porous, and permeable soil, radon gas can migrate into buildings. Radon decay products are a significant cause of lung cancer when inhaled over a long period of time (Hylland and Mulvey 2003).

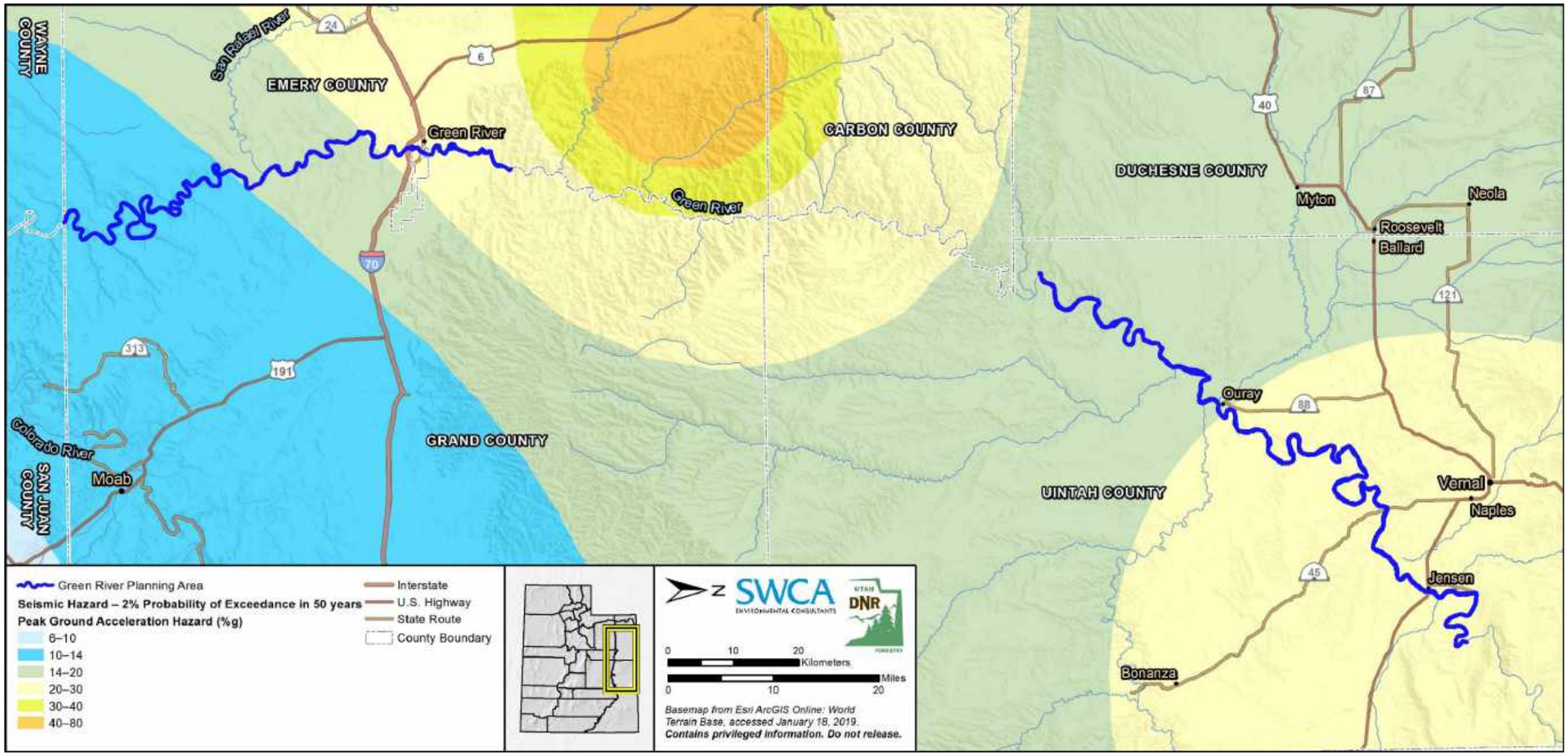

Figure 2.48. Seismic hazards along and near the Green River planning area.

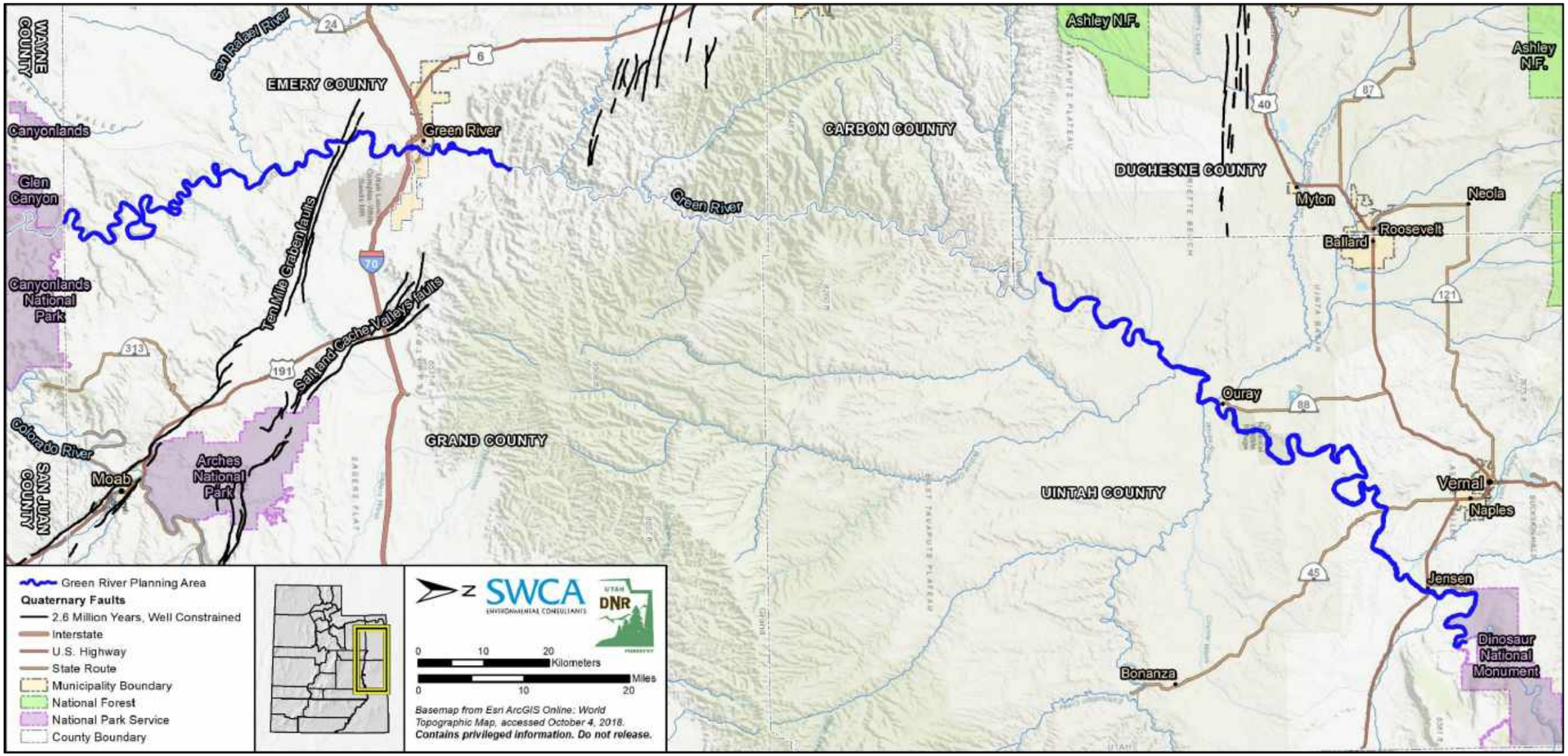

Figure 2.49. Quaternary faults overlapping the Green River planning area.

Paleontology

The Green River crosses the Uinta Basin, which has a geologic history of several orogenies (mountain-building events) and a series of sea level changes evidenced in the various rock formations and in the fossil record. The rock outcrops in the Uinta Basin are primarily sedimentary and were formed and deposited in a variety of ancient environments more than 65 million years ago. These sedimentary deposits include Precambrian marine clastics; Paleozoic shelf deposits; Mesozoic terrestrial deposits; Tertiary basin fill and lake deposits; and Late Tertiary and Quaternary basin fill, glacial deposits, and alluvium (BLM 2008a).

Geologic formations and sediments exposed at the surface of the Colorado Plateau along the Green River south of the Uinta Basin range from Precambrian to Recent in age. Fossil-bearing sedimentary rocks on the Colorado Plateau range in age from Pennsylvanian to Quaternary and include parts of the three great periods of earth history during the Phanerozoic eon: the Paleozoic, Mesozoic, and Cenozoic. Fossils preserved in these deposits include invertebrate, vertebrate, and plant fossils. Vertebrate fossils include the body remains of fish, amphibians, reptiles (including dinosaurs), mammals, and birds, as well as their tracks and traces. These fossils occur in rocks of Pennsylvanian, Permian, Triassic, Jurassic, Cretaceous, Tertiary, and Quaternary age and include specimens unique to this area (BLM 2008b).

The BLM's Potential Fossil Yield Classification (PFYC) System for Paleontological Resources on Public Lands provides baseline guidance for predicting, assessing, and mitigating paleontological resources. The PFYC classes, as defined in the BLM Instruction Memorandum 2016-124 (BLM 2016), are described below:

Class 1 – Very Low. Geologic units that are not likely to contain recognizable fossil remains. Management concerns for paleontological resources in Class 1 units are usually negligible or not applicable.

Class 2 – Low. Geologic units that are not likely to contain paleontological resources. Except where paleontological resources are known or found to exist, management concerns for paleontological resources are generally low and further assessment is usually unnecessary except in occasional or isolated circumstances.

Class 3 – Moderate. Sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence. Management concerns for paleontological resources are moderate because the existence of significant paleontological resources is known to be low. Common invertebrate or plant fossils may be found in the area, and opportunities may exist for casual collecting.

Class 4 – High. Geologic units that are known to contain a high occurrence of paleontological resources. Management concerns for paleontological resources in Class 4 are moderate to high, depending on what action is being proposed.

Class 5 – Very High. Highly fossiliferous geologic units that consistently and predictably produce significant paleontological resources. Management concerns for paleontological resources in Class 5 areas are high to very high.

Table 2.13 lists the acres of PFYC within the Green River planning area.

Table 2.13. Potential Fossil Yield Classifications of the Green River Planning Area

River Segment	Potential Fossil Yield Classification	Area (acres)
Uinta Basin	Data not available	11
	2	5,864
	3	33
	4	935
	5	872
Green River Valley	2	607
	3	< 1

River Segment	Potential Fossil Yield Classification	Area (acres)
Labyrinth Canyon	2	2,459
	3	270
	4	621
	5	394

Note: Acreage calculations account for lands between the banks of the river.
Source: UGS (2000).

Oil and Gas

Currently, all oil and gas fields near the Green River planning area are along the Uinta Basin segment and overlap the following geologic formations: Uinta, Green River, Wasatch, Mesaverde Group, Dakota Sandstone, and Frontier (Wood and Chidsey 2015). The oil and gas production from these fields over the past 5 years, as well as cumulative lifetime production, are listed in Tables 2.14 and 2.15. The totals in these tables reflect production from the entire fields and not just the portions of the fields underlying the planning area. However, the production totals provide an indication of the oil and gas potential of the planning area.

Table 2.14. Oil Production (barrels) from Oil and Gas Fields near the Uinta Basin Segment of the Green River Planning Area

Oil and Gas Field	Oil Production					Cumulative Lifetime Production
	2018 (through May)	2017	2016	2015	2014	
Horseshoe Bend	11,018	16,216	18,371	35,049	40,638	2,286,056
Brennan Bottom	134,122	275,367	314,143	332,734	339,932	4,543,418
Three Rivers	646,350	1,895,787	1,518,539	2,156,265	2,507,213	9,809,303
Natural Buttes	453,092	1,170,886	1,358,728	1,530,881	1,905,980	30,314,687
West Willow Creek	2,185	7,909	9,793	6,256	7,094	1,159,726
Pariette Bench	19,223	56,069	55,510	80,783	84,933	2,170,913
Uteland Butte	20,390	48,024	55,163	71,809	101,353	2,249,231

Note: 1 barrel = 42 U.S. gallons.
Source: DOGM (2018a).

Table 2.15. Natural Gas Production (MCF) from Oil and Gas Fields near the Uinta Basin Segment of the Green River Planning Area

Natural Gas Field	Natural Gas Production					Cumulative Lifetime Production
	2018 (through May)	2017	2016	2015	2014	
Horseshoe Bend	85,065	221,213	240,932	311,473	341,637	30,561,778
Brennan Bottom	76,178	222,322	260,563	219,789	198,778	4,143,261
Three Rivers	1,205,670	2,833,605	2,810,376	3,416,528	2,291,855	13,316,202
Natural Buttes	61,223,699	157,376,034	188,718,789	212,688,463	257,295,507	3,943,728,401
West Willow Creek	7,096	35,749	36,015	88,304	103,319	12,245,754
Pariette Bench	1,406,188	3,213,056	3,802,788	4,730,314	3,747,205	62,557,189
Uteland Butte	247,897	631,690	697,502	821,345	917,573	12,464,664

Note: 1 MCF = 1,000 cubic feet.
Source: DOGM (2018b).

The largest known oil shale deposits in the world are in the Eocene Green River Formation, which covers portions of Utah, Colorado, and Wyoming, including the Uinta Basin (Vanden Berg 2008). Approximately 50% of the total oil shale resource in the Uinta Basin is located on lands administered by the BLM, followed by approximately 20% on tribal land, approximately 16% on private land, and approximately 9% on land administered by SITLA (Vanden Berg 2008). Approximately 25% of the Uinta Basin's oil shale resource is covered by conventional oil and gas fields. However, many oil shale deposits that are under less than 1,000 feet of cover (overlying material) currently do not contain significant oil and gas activity (Vanden Berg 2008).

Other Mineral Resources

Other mineral resources that underlay or are adjacent to the Green River planning area include the following:

- Uranium occurrences south of the city of Green River (along the Labyrinth Canyon segment), as well as a uranium operation and occurrences near Ouray (along the Uinta Basin segment) (Gloyn et al. 2005; UGS 2018c)
- Deeply buried Cretaceous strata, possibly coal bearing, stretching northeast from the Book Cliffs across the Uinta Basin (along the Uinta Basin segment) (Gurgel et al. 1983)
- Cretaceous outcrops with thin coal seams that overlap a section of the Labyrinth Canyon segment south of the city of Green River (Gurgel et al. 1983)
- A gold mining operation southeast of the city of Green River (along the Labyrinth Canyon segment), as well as two small, inactive placer gold operations along the Uinta Basin segment (Bon and Heuscher 2008)
- Several small, inactive sand and gravel operations along the Uinta Basin segment (Bon and Heuscher 2008; UGS 2018c)
- Four small tar sands mining operations along the Uinta Basin segment near the town of Vernal (Bon and Heuscher 2008)
- A landscape rock mining operation along the Uinta Basin segment near the town of Vernal (Bon and Heuscher 2008)
- Precious and base metal occurrences in the northern portion of the Uinta Basin along the Uinta Basin segment, northeast of Castle Peak (Doelling and Tooker 1983)
- Phosphate north and east of Vernal, Utah, along the Uinta Basin segment
- Bitumen deposits within Uintah and Ouray Indian Reservation and near Pariette Draw along the Uinta Basin segment
- Gilsonite veins that trend north to southeast across the Uinta Basin along the Uinta Basin segment

There is a moderate potential for the occurrence of economically valuable coal deposits within the Uinta Basin; however, it is unlikely that coal exploration or development will occur in the foreseeable future because of the lack of demand and the generally low-grade quality of the coal (BLM 2008a).

In September 2004, then–Secretary of the Interior, Gale Norton, signed the Three Rivers Withdrawal, which became effective on October 6, 2004 (Wait 2004). The Three Rivers Withdrawal withdrew nearly 200 miles of river corridor along portions of the Colorado, Dolores, and Green Rivers, including the portion of the Green River in Labyrinth Canyon, from the locating of any new hard rock mining claims. Designated wilderness and wilderness study areas along the Green River are also closed to mineral entry.

Leasing of Oil and Gas and Other Mineral Resources

FFSL is the executive authority for the management of sovereign lands and is required to prescribe standards and conditions for the authorization and development of surface resources on sovereign lands. Mineral leases issued by FFSL must be in compliance with state law, administrative rules, and the Public Trust Doctrine and must adhere to multiple-use, sustained-yield principles. In addition, each mineral lease must also comply with this CMP and the *Green and Colorado Rivers Mineral Leasing Plan* (SWCA 2020).

All sovereign lands on the Green River not closed for leasing are classified as no surface occupancy (NSO). All mineral leases issued on sovereign land will contain an NSO stipulation. NSO stipulations prohibit surface occupation for development and exploration of mineral resources but allow subsurface resources to be legally available so that they can be accessed by means other than occupying the surface. As a result of the NSO stipulation, development of oil and gas resources can only take place if adjacent lands are leased and the resources are legally developed through directional drilling. This development is contingent on applicable land management agency decisions (e.g., DOGM, BLM, SITLA) or on the initiative of private landowners.

Further Reading

Energy Resources Map of Utah (Gurgel et al. 1983)

Large Mines in Utah 2008 (Bon and Wakefield 2008)

Oil and Gas Fields Map of Utah (Wood and Chidsey 2015)

Physiographic Provinces (UGS 2018a)

Utah Quaternary Fault and Fold Map (UGS 2018b)

GIS Data Layers

Coal, Geology, Large and Small Mines, Oil and Gas, Potential Fossil Yield Classifications, Quaternary Faults, Tar Sands, Uranium

2.5 Community Resources

Community resources are those resources associated with the Green River that are valued, enjoyed, used, or needed by the general public. The general public is varied and includes stakeholder groups who participated in the planning process (see Appendix A). Community resources in the planning area are discussed in seven sections: Agriculture, Infrastructure, Cultural Resources, Recreation, Access, Public Safety, and Education.

Agriculture

Agriculture and Water Resources

The NRCS identifies important farmlands to ensure that the productive capacity of American agriculture is not impaired. The agency prepares statewide lists of soil mapping units that meet the criteria for 1) prime farmland, 2) unique farmland, 3) farmland of statewide importance, or 4) farmland of local importance (7 CFR 657). Table 2.16, as inventoried by the NRCS and using 2015 soil series data, provides the total acreage of each of these farmland types in the planning area relative to the total acreage of each county. Prime farmland has the best combination of physical and chemical characteristics for producing crops. Unique farmland is land other than prime farmland that is used for production of specific high-value crops. Farmland of state and local importance considers parameters such as location, high yields for specific crops, and growing season, among others. Farmland classes are also shown in the GIS spatial data viewer.

Table 2.16. Acres of Farmland Classes within 0.5 Mile of the Planning Area in Emery, Grand, Uintah, and Wayne Counties

Farmland Classes	Emery County (acres)	Grand County (acres)	Uintah County (acres)	Wayne County (acres)
Prime farmland (percentage of county acres)	0 (0%)	38 (< 1%)	0 (0%)	0 (0%)
Prime farmland if irrigated (percentage of county acres)	2,237 (< 1%)	596 (< 1%)	10,444 (< 1%)	0 (0%)
Unique farmland (percentage of county acres)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Farmland of statewide importance (percentage of county acres)	409 (< 1%)	9,128 (< 1%)	0 (0%)	0 (0%)
Farmland of local importance (percentage of county acres)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Not mapped or not available	19,365 (< 1%)	237 (< 1%)	6,316 (< 1%)	38 (< 1%)
Total county acreage	2,840,960	2,360,960	2,871,680	1,591,040

Source: NRCS (2015a).

For hundreds of years, indigenous populations farmed and raised animals along Utah's water bodies, including the Green River. By the mid-1800s, Utah settlers began raising livestock, growing crops, and diverting water to their lands (Envision Utah n.d. [2018]). In Emery County, livestock growers brought cattle and sheep into Castle Valley to graze in 1875. Livestock and farming remained the mainstay of Emery County's economy throughout much of its history. Most of Grand County's agricultural history consists of small family farms, small family orchards, and livestock. Large sheep and cattle companies found livestock forage in the county's canyons and in the La Sal Mountains (Utah State Historical Society 1988). In Uintah County, ranchers and farmers had moved to the Ashley Valley by 1880. Irrigation canals were constructed and small towns such as Jensen were then founded (Utah State Historical Society 1988). In Wayne County, raising livestock is the oldest and most important industry. Beef cattle, dairy cows, sheep, and poultry have all contributed to the

local Wayne County economy in the past (Utah State Historical Society 1988). Agricultural census data and irrigated land by crop for Emery, Grand, Uintah, and Wayne Counties are summarized in Tables 2.17 and 2.18, respectively.

Table 2.17. 2012 Census of Agriculture Data for Emery, Grand, Uintah, and Wayne Counties

Agricultural Parameters	Emery County	Grand County	Uintah County	Wayne County
Land in farms (acres)	156,229	W	W	42,361
Percentage of total county area	5.5%	N/A	N/A	2.7%
Percentage use	Pastureland: 52.4% Cropland: 26.6% Woodland: 8.1% Other uses: 12.8%	W	W	Pastureland: 55.3% Cropland: 36.1% Other uses: 8.6%
State rankings	**Value of sales:** Poultry and eggs (6) Vegetables, melons, potatoes, and sweet potatoes (7) **Top crop items:** Oats for grain (5) Corn for grain (8) Vegetables harvested (8) **Top livestock inventory:** Pheasants (2)	**Value of sales:** Vegetables, melons, potatoes, and sweet potatoes (8) Fruits, tree nuts, and berries (8) **Top crop items:** Vegetables harvested (9) Oats for grain (9) **Top livestock inventory:** Goats (25)	**Value of sales:** Cut Christmas trees and short rotation woody crops (1) Aquaculture (2) **Top crop items:** Vegetables harvested (4) Corn for grain (5) **Top livestock inventory:** Goats (3)	**Value of sales:** Aquaculture (6) Fruits, tree nuts, and berries (7) **Top crop items:** Apples (6) Peaches (7) **Top livestock inventory:** Sheep and lambs (13)

Sources: U.S. Department of Agriculture (2012a, 2012b, 2012c, 2012d).

Notes: The numbers in parentheses reflect state rankings from 1 to 29 with 1 being the top ranking for that category.

W = Withheld in the census of agriculture to avoid disclosing data for individual farms.

N/A = not applicable.

Table 2.18. Irrigated Land by Crop in Emery, Grand, Uintah, and Wayne Counties

Irrigated Land	Emery County (acres)	Grand County (acres)	Uintah County (acres)	Wayne County (acres)
Surface Irrigated Crops				
Orchard/fruit/nursery	59	136	30	34
Vineyards	nr	31	nr	nr
Grain	2,741	33	3,356	2,671
Corn	2,088	50	3,019	33
Vegetables	116	3	2	0
Alfalfa	14,648	1,657	30,963	9,832
Grass hay	2,778	43	6,864	147
Pasture	23,098	831	28,908	2,733
Fallow	622	nr	nr	46
Pasture subject to spring flooding	nr	0	nr	nr
Sub-Irrigated Crops				
Sub-irrigated pasture	4,563	0	1,970	3,322
Hay/grass	nr	nr	4,788	nr
Total Irrigated Crop Lands	**50,713**	**2,784**	**79,900**	**18,818**

Sources: DWRe (1999, 2000a, 2000b).

nr = not reported.

In the southeast Colorado River basin, which consists of most of Grand and San Juan Counties, agriculture is the largest water user in the area. There is 8,929 acres of irrigated cropland, and the most common crops are alfalfa and pasture grass for livestock (DWRe 2000a). The average annual quantity of water diverted for cropland irrigation is 34,950 acre-feet, of which 18,430 acre-feet is depleted. A depletion is a human-caused loss of water from a surface-water system (e.g., when water is diverted for agriculture in Grand County, it reduces the amount of water available in the downstream Green River watershed). During

the late part of the growing season, there is a shortage of water for irrigated cropland. Because of increasing agricultural costs, it would not be feasible to develop additional agricultural water in the southeast Colorado River basin except as part of a municipal and industrial water project. The best opportunity to increase water supply in this basin is to more efficiently use currently available water (DWRe 2000a).

Irrigated agriculture has primarily been established in areas of the southeast Colorado River basin with adequate water supplies and fertile soil conditions (i.e., in the Spanish Valley near Moab and in the areas around Monticello and Blanding). Entities that manage agricultural water include conservation and conservancy districts; irrigation, ditch, and canal companies; and in some cases, reservoir and pipeline companies (DWRe 2000a). Irrigation companies deliver most of the agricultural water to farmers, although there is a significant amount delivered by individuals. Individual irrigators with water rights can pump directly from the Green River after obtaining FFSL authorization. Agricultural water use is expected to stay about the same in this basin, although a small amount of the existing supply could be reallocated to municipal and industrial demands which are expected to increase (DWRe 2000a). Table 2.19 presents agricultural diversions and depletions for 1996 and 2020 in Grand County.

Table 2.19. Agricultural Diversion and Depletions for 1996 and 2020 (acre-feet) in the Southeast Colorado River Basin by County

Southeast Colorado River Basin County	1996		2020 (projected)	
	Diversions	Depletions	Diversions	Depletions
Grand County	13,800	6,910	11,890	5,950

Source: DWRe (2000a).

In the west Colorado River basin, which consists of most of Carbon, Emery, Wayne, Garfield, and Kane Counties (along with small portions of other counties), much of the economy is centered around agriculture. The primary agricultural operation is cow/calf and beef production (DWRe 2000b). Most of the irrigated agriculture supports this production. Total diversions for agricultural irrigation in the west Colorado River basin are 295,050 acre-feet, of which 162,000 acre-feet is depleted annually. The main crops are pasture, alfalfa, small grains, grass hay, and corn silage (DWRe 2000b). This basin does not have a full water supply for all its irrigable lands. The water deficit could be diminished in many cases by reducing seepage and evaporation and improving irrigation efficiencies (DWRe 2000b).

The primary use of water, which is diverted from most rivers and streams flowing into valley areas, is crop irrigation in the west Colorado River basin (DWRe 2000b). Incorporated mutual irrigation companies serve most of the irrigated land; private irrigation systems serve approximately one-third. These companies and systems manage almost 90% of the developed water supply. Over the long term, existing irrigated acreage is projected to decline slightly because of increased population pressures while some new lands (several thousand acres) may be brought under irrigation in the Green River and western Wayne County areas (DWRe 2000b). Table 2.20 presents agricultural diversions and depletions for 1990 and 2020 in the west Colorado River basin.

Table 2.20. Agricultural Diversions and Depletions for 1990 and 2020 (acre-feet) in the West Colorado River Basin by Drainage

West Colorado River Basin River Drainage (related county)	1990		2020 (projected)	
	Diversions	Depletions	Diversions	Depletions
Price (Emery)	84,450	43,000	80,000	45,000
San Rafael (Emery, Wayne)	81,700	52,700	78,000	55,000
Dirty Devil (Emery, Wayne)	83,400	43,600	80,000	42,000
Lower Green (Emery, Wayne)	14,650	6,500	40,000	22,000

Note: Additional river drainages in the west Colorado River basin are not included here because they are not in the four counties in the planning area.

Source: DWRe (2000b).

The Uinta Basin, which consists of most of Uintah and Duchesne Counties and small parts of adjacent counties, is predominantly a rural agricultural area. The basin is also rich in energy resources developed by the oil and gas industry. Waters of the Uinta Basin support a significant agricultural industry; approximately 97% of the basin's developed surface water is

used for irrigation (822,000 acre-feet per year) (DWRe 2016). More than 90% of farms are used for cattle grazing and associated agriculture (DWRe 1999). Principal crops are pasture, alfalfa, and grass hay (DWRe 1999). Irrigation depletions constitute 340,000 acre-feet from the Uinta Basin's total available supply of approximately 1,173,600 acre-feet. There are generally sufficient water supplies available to meet growing demands but there is a need for additional local community infrastructure (DWRe 2016).

Irrigated land is located in a variety of locations in the Uinta Basin, such as river bottoms and plateau tops (see Figure 2.50). Management of agricultural water is provided by numerous mutual irrigation companies and water conservancy districts (DWRe 2016). There are also four major water management entities that deliver federal reclamation project water. In the long term, there may be pressure to convert agricultural water to municipal and industrial use, or to oil shale and tar sands production. There is also the potential for more agricultural land to be added to the Uinta Basin (DWRe 2016). Agricultural diversion and depletion data for the Uinta Basin comparable to that presented for Emery, Grand, and Wayne Counties were not found.

Figure 2.50. Irrigated agriculture in the Uinta Basin segment.

Agriculture and Water Rights

A water right is a right to the use of water based on 1) quantity, 2) source, 3) priority date, 4) nature of use, 5) point of diversion, and 6) physically putting water to beneficial use (DWRi 2011). The three basic beneficial uses of water for water rights are domestic, stock watering, and irrigation, which are allocated based on an annual requirement or "duty" as described in Table 2.21; other beneficial uses include municipal, industrial, and instream flows (Reid et al. 2008).

Table 2.21. Basic Beneficial Uses of Water and their Associated Requirements for Water Rights

Basic Beneficial Uses of Water	Requirements for Water Right (acre-feet)
Domestic: Domestic use is any use of water inside the home.	0.45
Stock watering: Stock watering is quantified based on equivalent livestock unit. An equivalent livestock unit is one horse and foal or cow and calf, or equivalent number of sheep, goats, pigs, chickens, etc. The beneficial use period for these uses is generally year-round, but can vary with specific needs.	0.028
Irrigation: Irrigation is the act of applying water to any plant to obtain optimal growth and maintenance of that plant. Although not always harvested as crops, lawns, gardens, shrubs, pastures, and nonnative trees and plants are all considered plants that require irrigation.	Range: 3.0 to 6.0 per irrigated acre Average: 4.0 per irrigated acre This "duty" is based on the highest water consuming crop, which is alfalfa, during the growing season of the region and surface irrigation practices.

Source: Reid et al. (2008).

DWRi regulates the appropriation and distribution of water in the State of Utah, pursuant to Title 73 of the Utah Code. The State Engineer, who is the director of DWRi, gives approval for the diversion and use of any water, regulates the alteration of natural streams such as the Green River, and has the authority to regulate dams to protect public safety. Because FFSL does not regulate water rights, the GRCMP does not outline management strategies for water rights. However, an applicant must have a valid water right before FFSL can authorize pumping equipment in the planning area.

Irrigation

IRRIGATION COMPANIES

Irrigation companies can own the right to use water from a surface and/or groundwater source, which is delivered to users by a canal, ditch, or pipeline. Individual shareholders in an irrigation company do not legally own the water right. This right is allocated based on the number of shares in an irrigation company owned by an individual shareholder. The value or quantity of water allocated to a share of water is not constant throughout the state and varies considerably from one irrigation company to another. In some canal companies, a share of water is allocated per acre, whereas in others, three or four shares may be needed to provide sufficient irrigation water for 1 acre of alfalfa (Reid et al. 2008).

IRRIGATION SYSTEMS

Small irrigators in the Green River watershed may obtain a permit to use irrigation pumps to withdraw water directly from the river and apply it to crops or rangeland. Methods for withdrawing water include securing hoses in the river, installing floating pumps, and constructing pumping plants. Irrigation equipment may present an impediment to navigation or degrade water quality by causing bank erosion, resulting in harm to Public Trust values. FFSL's authorization process for irrigation equipment helps protect the Public Trust on sovereign lands. Common terms for irrigation equipment are provided in Table 2.22.

Table 2.22. Common Terms for Irrigation Equipment

Irrigation Term	Definition
Pumping plant	A facility that delivers water at a designated pressure and flow rate. Includes the required pump(s), associated power unit(s), plumbing, and appurtenances, and may include on-site fuel or energy source(s) and structures.
Pump unit	Any mechanism used to withdrawal, displace, or discharge a volume of water.
Power unit	Any mechanism that supplies the necessary energy, force, or work required to operate a pump unit.
Support structure	Any building, structure, or appurtenance that supports the loads or forces placed on a streambank by a pumping plant. Support structures include flat concrete pads, scaffolding, boom arms, tracks, and struts.
Pump house	A support structure that meets the definition of confined space* and is associated with a pumping plant or activity
Sump	A configuration of pumping plant where the pump unit exists in or on the water source and where power from the power unit is delivered to the pump unit.
Discharge hose/pipe	Any hose, pipe, or plumbing used as a vessel to transport water from a pump unit.
Intake line (suction hose)	Any hose, pipe, or plumbing used as a vessel to transport water from a water source to a pump unit.
Foot valve	A mono-directional valve placed at the end of a suction hose to prevent water from draining out of the hose.
Screen	Any appurtenance of the pumping plant that removes or prevents undesirable material from entering the intake line. May be installed on the suction end of the intake line or may confine the entire pumping plant (more often associated with pump houses).

*Confined space is defined as an area large enough for employees to enter and perform work but with limited or restricted means for entry or exit and is not designed for continuous occupancy (Occupational Safety and Health Administration n.d. [2018]).

FFSL typically authorizes four common configurations of pumping plants on sovereign lands of the Green River: 1) intake lines that lie on sovereign lands without a support structure (with or without a foot valve or screen), 2) sumps, 3) intake lines or sumps with support structures, and 4) pump houses.

Other agricultural infrastructure built on sovereign lands includes irrigation distribution systems that may include diversions, canals, and return flow structures. Figure 2.51 shows a photograph of an intake channel along the Green River. When properly designed and sited, structures such as intake channels pose no problem to navigation, nor do they degrade bank condition. However, poorly designed and sited structures can result in increased erosion of the bed and bank. In addition, irrigation water distribution systems are efficient weed vectors, either from or to the Green River. FFSL recognizes the importance of weed control on and adjacent to sovereign lands.

Figure 2.51. Intake channel along the Green River.

Tile Drains (Field Drains)

Tile drains are installed to allow water in wet or saturated ground to rapidly drain away from an area, to lower the groundwater table, or to relieve hydrostatic pressure. They are typically underground linear structures oriented to land contours and are often used in agriculture because saturated soils do not provide enough aeration for crop root development. In the planning area, tile drains may conduct surplus water into the Green River.

FFSL recognizes that tile drains—historically buried clay pipes or tiles, but more recently plastic conduit—may have been in place for many decades. Exact locations of each tile drain are not always available or known, and it is important to note that these drains may not have been installed by the current landowner. Landowners installing new tile drain systems that extend on or over sovereign land must apply for authorization from FFSL. FFSL will work with landowners to improve bed and bank conditions if existing tile drain systems are actively causing degradation. Similar in function to tile drains but more often associated with commercial or residential development and construction are modern land drains. An example of a poorly designed and cited land drain on sovereign lands is shown in Figure 2.52.

Figure 2.52. Poorly designed and cited land drain on sovereign lands.

Livestock Watering

Livestock watering, when linked with a water right and associated point-to-point diversion, is a recognized use of sovereign lands. However, livestock watering directly in the Green River can have negative impacts on bank stability and water quality, as shown in Figure 2.53. FFSL currently works with, and will continue to work with, landowners on strategies to bring water to livestock at locations away from the river. FFSL will partner with agencies such as UDAF and NRCS during this process.

Figure 2.53. Green River riverbank showing impacts from livestock watering.

FENCES

Fences are a necessary and practical component of livestock management. Fences may extend riverward only to the water's edge or reasonably beyond to restrain livestock so that navigation and recreation in the river are not compromised, as shown in Figure 2.54. All fences on sovereign lands require authorization from FFSL. Fencing in the river has been an identified problem in the past, and FFSL will work with owners of existing fences to bring them into compliance.

Figure 2.54. Fence in the Green River.

Agricultural Management Concerns

Agricultural issues and themes raised during the public outreach process include concern about the authorization process in general; concern about authorization fees and the potential for increases; how to permit specific equipment and situations; river access for livestock; concern about trespassing, graffiti, and littering on private property by river users; fencing in or near the river; changing riverbanks; and better education for river users about river etiquette (e.g., boating regulations, private property).

Agriculture by River Segment

Agricultural activities and related infrastructure are permitted uses of sovereign lands (i.e., the bed and bank of the Green River). Figure 2.55 provides a river plan view of typical agricultural infrastructure seen along the Green River. Figure 2.56 presents agricultural data for the planning area by river segment (e.g., prime farmland).

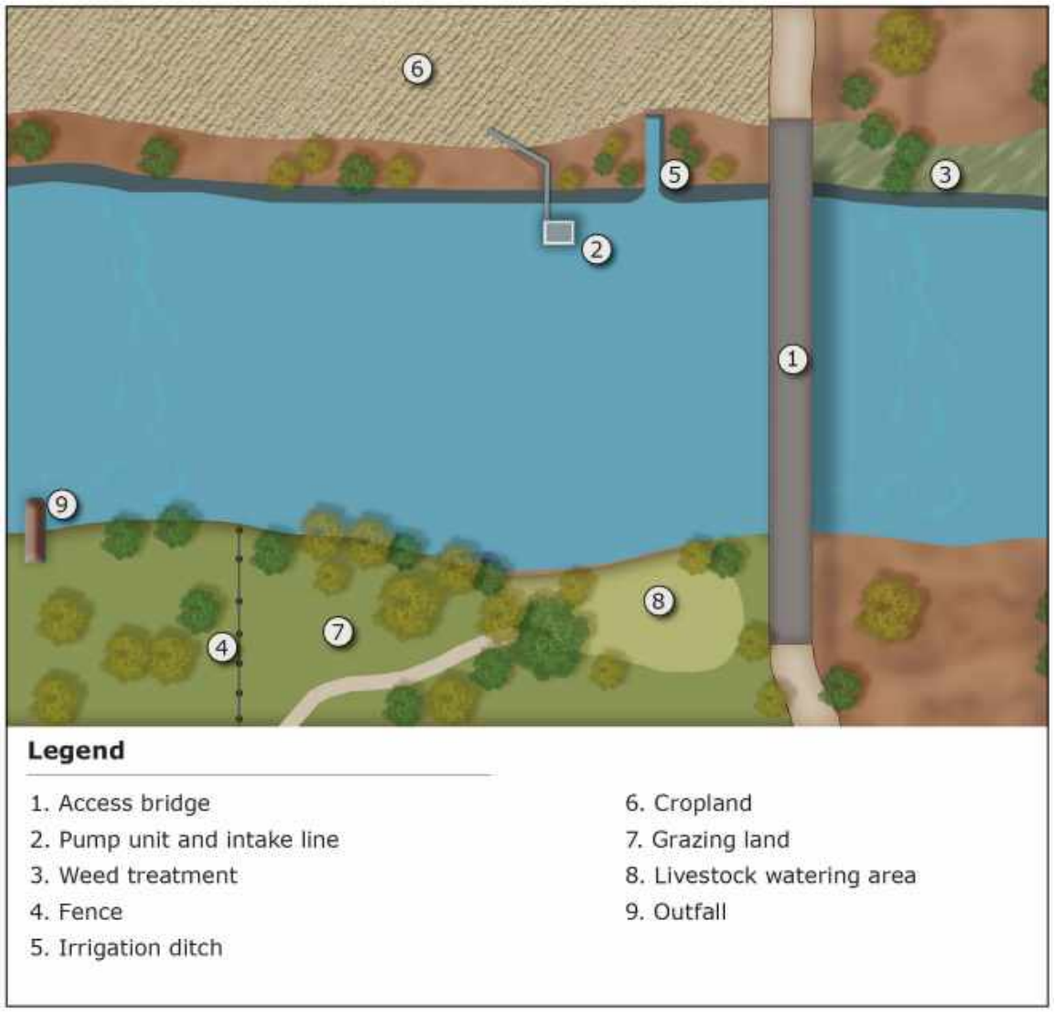

Figure 2.55. Plan view of typical agricultural infrastructure in the planning area.

Further Reading

Background: Agriculture in Utah (Envision Utah n.d. [2018])

Beehive History 14. Utah's Counties (Utah State Historical Society 1988)

Irrigation Pumping Plants (NRCS 2016)

Utah State Water Plan. Southeast Colorado River Basin (DWRe 2000a)

Utah State Water Plan. Uintah Basin (DWRe 2016)

Utah State Water Plan. West Colorado River Basin (DWRe 2000b)

Water Rights in Utah (Reid et al. 2008)

GIS Data Layers

Canals, Farmland Classes, FFSL Authorizations, Grazing Allotments, Landownership, Points of Diversion, Soil Types, Water-Related and Agricultural Land Use

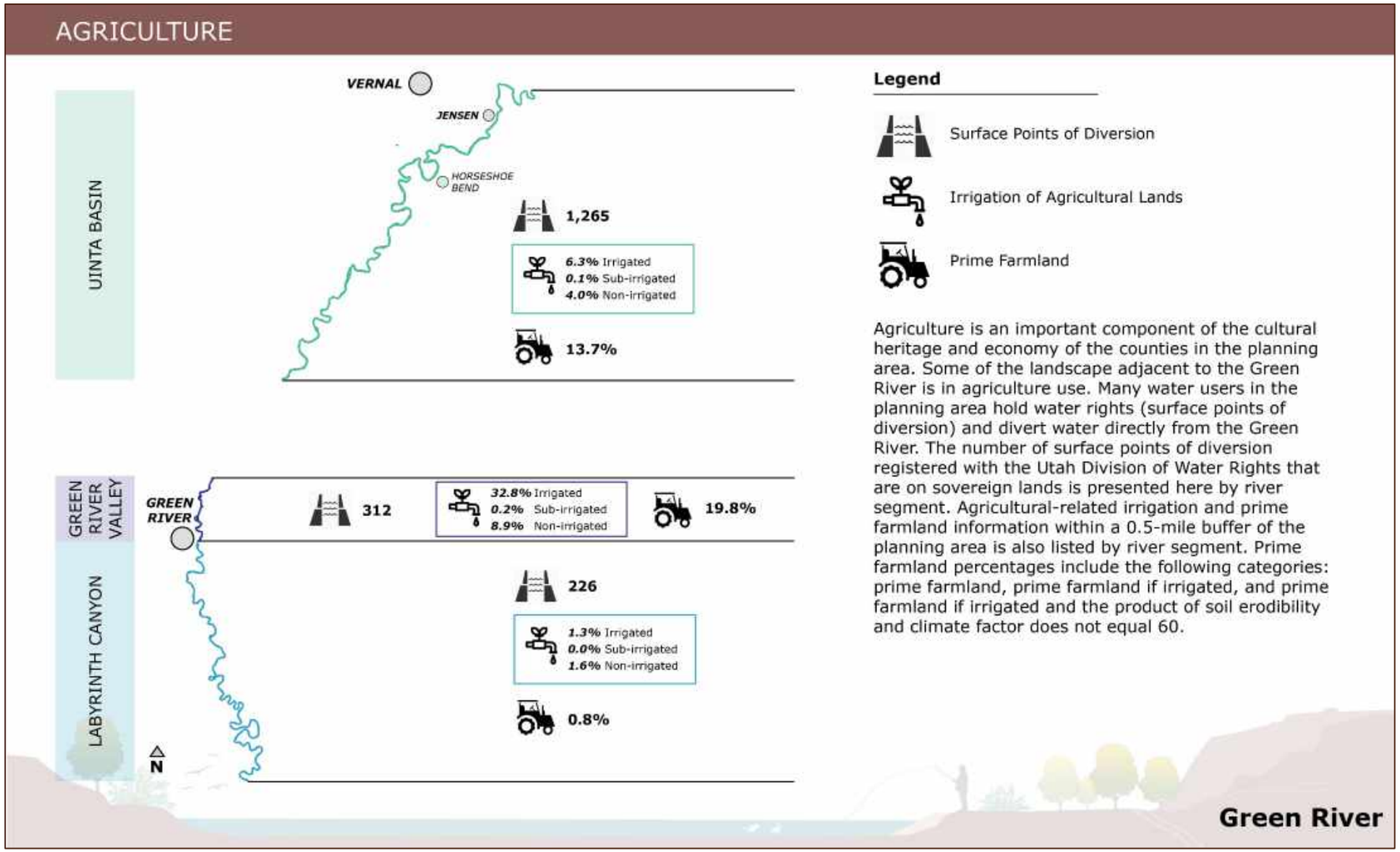

Figure 2.56. Agricultural data for the planning area by river segment.

Infrastructure

Infrastructure in the planning area either treats the river as an obstacle to be crossed (e.g., bridges and utility crossings) or as a resource to be used (e.g., outfall structures and dams). Infrastructure in the planning area includes bridges, roads on the banks of the river, utility crossings, outfall structures, tile drains, dams, and canals and irrigation ditches. Each of these infrastructure elements is described in more detail below.

When considering infrastructure development and construction, project proponents must operate in accordance with the FFSL authorization process and other applicable federal, state, and county requirements. Some of the existing infrastructure in the planning area is sanctioned with an associated FFSL authorization; however, some infrastructure, especially older infrastructure, is not. Some bridges and other infrastructure improvements are deemed eligible for the National Register of Historic Places (NRHP) because of their age and local significance (see the Cultural Resources section of Chapter 2). Chapter 1 of the GRCMP describes the FFSL authorization process and provides information on what to do when considering construction of new infrastructure or permitting facilities that do not have current authorizations. The Infrastructure section of Chapter 3 describes design specifications for certain types of infrastructure. Infrastructure data layers are also available in the GIS spatial data viewer.

Infrastructure for recreation users in the planning area, such as boater access points, is discussed in the Recreation section of Chapter 2. Infrastructure for agricultural uses, such as irrigation pump units, is discussed in the Agriculture section of Chapter 2.

Infrastructure, if not designed and maintained appropriately, can negatively affect navigation, fish and wildlife habitat, aquatic beauty, public recreation, and water quality. For example, dams can change river hydrology, present navigational and safety hazards, alter aesthetic beauty, change flow and sediment transport below the dam, and alter fish and wildlife habitats. Proper infrastructure design and installation are important in preventing the creation of navigational and safety hazards. Careful placement of infrastructure, such as bridges along the Green River, is important, because poorly spaced infrastructure can damage the resource, inhibit navigation, and detract from aquatic beauty and the public recreation experience.

Bridges

Bridges serve as transportation links across the river for vehicles, trains, bicycles, and pedestrians (Figure 2.57). Bridges spanning the Green River are of various ages, design, and construction materials. Newer bridges generally cross the main channel without obstructions, whereas older bridges may have piers and constrict the main channel. Low clearances and bridge piers can present obstructions to navigation, can change river hydraulics, and can cause large woody debris to accumulate behind them. Bridges in the planning area are shown in the GIS spatial data viewer.

Figure 2.57. Bridge over the Green River (East Main Street in the city of Green River).

Roads

In some locations in the planning area, roads may have been constructed adjacent to the banks of the Green River because of space restrictions. For example, Hastings Road parallels the Green River near the north end of the city of Green River (see Figure 2.58). Roads that are placed close to or on the banks of the river may contribute to bank erosion and be at risk for flood damage. Any work to construct, improve, or repair roads below the OHWM of the Green River should be approved through the FFSL authorization process. Roads in the planning area are shown in the GIS spatial data viewer.

Figure 2.58. Hastings Road adjacent to the Green River.

Utility Crossings

Utility crossings include water pipelines, sewer pipelines, gas pipelines, fiber optic lines, and powerlines. Crossing types are below grade and above grade. Below-grade crossings cross the river below the bed of the river and are generally not visible. Above-grade crossings are either stand-alone (such as powerlines) or are attached to an existing bridge (Figure 2.59). Some older utility crossings that rest on the bed of the channel are considered above grade.

Figure 2.59. Stand-alone above-grade crossing on the Green River.

Figure 2.60. Typical outfall structure on the Green River.

Outfall Structures

Outfall structures include storm drain outlets, irrigation return flows, and cooling water outlets. Figure 2.60 shows a typical outfall structure on the Green River.

The Clean Water Act prohibits the discharge of pollutants through point sources such as outfall structures into waters of the United States without a National Pollutant Discharge Elimination System (NPDES) permit. In Utah, the NPDES program is administered by DWQ. DWQ issues Utah Pollutant Discharge Elimination System (UPDES) permits for point source discharges. The permits define discharge limits, monitoring and reporting requirements, and other specified conditions. DWQ has issued one UPDES permit in the planning area, Green River Wastewater Treatment Facility (UT0025771), for occasional discharge of treated wastewater into the Green River.

Tile Drains (Field Drains)

Tile drains (field drains) are discussed in the Agriculture section of Community Resources.

Dams

One dam is located in the Green River Valley segment approximately 6 miles upstream of the city of Green River: the Tusher Diversion Dam, also known as the Green River Diversion (see Figure 2.61). The Tusher Diversion Dam was constructed in the early 1900s. It spans the width of the river and diverts water to water rights holders on both sides of the river. The dam is designed to raise the water surface elevation to divert water for the Green River and Thayn Canals, the Thayn hydropower plant, the East Side Canal, and a privately owned water wheel (McMillen, LLC 2014).

Figure 2.61. Tusher Diversion Dam on the Green River (photograph taken April 2018).

On the west side of the river, water diverted from the Tusher Diversion Dam travels down the West Side Raceway approximately 0.4 mile to the entrance of Green River and Thayn Canals and the Thayn hydropower plant. From the hydropower plant, most of the water passes back into the Green River. On the east side of the river, an inlet upstream of the dam directs water into the East Side Canal, which has a siphon system to pass water under Tusher Wash and transports water to the south. A 28-foot welded steel water wheel, located at the east side of the dam, can divert water for irrigation on approximately 60 acres of cropland (McMillen, LLC 2014).

Green River flows severely damaged the Tusher Diversion Dam and compromised its structural integrity during 2010 and 2011 flood events, which prompted rehabilitation of the dam under the NRCS Emergency Watershed Protection Program. The rehabilitation included replacing the existing diversion dam, improving the West Side Raceway and the East Side Canal, dredging an area of heavy deposition at the mouth of Tusher Wash, providing upstream and downstream fish passage past the dam, installing a fish screen and bypass at the East Side Canal, improving sediment movement through the system, maintaining floodwater conveyance, and providing downstream recreational boat passage through the dam (NRCS 2015b). The rehabilitation was completed in 2016.

No other dams span Green River sovereign lands. However, dams located upstream of the planning area (e.g., Flaming Gorge Dam, Fontanelle Dam) affect river characteristics such as flow, sediment, erosion, and water levels in the planning area. Dams on tributaries of the Green River can also affect sovereign lands.

Small irrigation dams, inactive dams, or other dams may be present near the planning area. For example, Sheppard Bottom is an inactive dam located near the Green River just north of Ouray, and Pariette East Dike is a 13-foot structural dam located on the Pariette Draw tributary south of Ouray (DWRi n.d. [2018]).

Canals and Irrigation Ditches

Canals are artificial waterways constructed for irrigation or navigation purposes. Irrigation ditches are small trenches typically constructed for irrigation or drainage. Canals have altered the flow regime of the Green River in the planning area. In some cases, intake canals divert water out of the Green River and into an irrigation system. Figure 2.62 shows the East Side Canal associated with the Tusher Diversion Dam. Table 2.23 lists the canals in the river, as identified by DWRi. Small irrigation ditches may also be present in the planning area.

Figure 2.62. East Side Canal associated with the Tusher Diversion Dam on the Green River.

Table 2.23. Canals in the Planning Area

Canal Name	Location	Purpose	Owner
East Side Canal	Tusher Diversion Dam to approximately 1800 North, City of Green River, Grand County	Irrigation	East Side Irrigation Company
East Side Canal Banasky	South of Brock Lane to approximately 1800 North, City of Green River, Grand County	Irrigation	East Side Irrigation Company
Thayn Canal	Tusher Diversion Dam to approximately 1800 North, City of Green River, Emery County	Irrigation	Lee Thayn
Green River Canal	Tusher Diversion Dam to Silliman Lane, City of Green River, Emery County	Irrigation	Green River Canal Company

Source: DWRi (n.d. [2018]).

Flood Control

There are no known FEMA-permitted levees for flood control in the planning area. FEMA flood zones are available on the GIS spatial data viewer.

Pre-disaster hazard mitigation plans (HMPs) are developed by counties to reduce their susceptibility to natural hazards. Emery County's HMP identifies multiple natural hazards, including flooding, that could affect the county (Emery County 2018). In the HMP, flooding is assigned a moderate to likely probability of occurring in the county at a potentially critical magnitude. The city of Green River is listed as susceptible to flooding from the Green River. Some of the HMP objectives include identifying additional flood-prone areas in the county; reducing the threat of flooding from unstable canals (including those owned by the Green River Canal Company and East Side Irrigation Company in Green River); promoting purchase of national flood insurance; evaluating Dike West near the city of Green River for upgrades; and improving roads, culverts, and dips that do not properly channel flood waters (Emery County 2018). The city of Green River also has a flood-control ordinance (Green River City Code, Title 12) that requires development permits and specifies construction standards in areas of special flood hazard as identified by FEMA.

In Grand County's HMP, the risk of county flooding is identified as highly likely with a potentially severe magnitude (Grand County 2018). Flooding occurs mainly near the Green and Colorado Rivers and their tributaries. Some of the HMP objectives include encouraging 100% participation in the National Flood Insurance Program, reducing the threat of unstable canals throughout the county, and ensuring the emergency operations center is equipped to coordinate a timely response to flooding (Grand County 2018). In addition, Grand County has an ordinance that specifies avoidance of development in 100-year floodplains, and in natural or historic drainageways. The county also has a flood damage prevention ordinance, adopted in 2014, that applies to areas of special flood hazard.

Uintah County is part of the Uintah Basin Association of Governments, which has developed an HMP for three counties and the Uintah and Ouray Indian Reservation (Uintah Basin Association of Governments 2012). In the HMP, Uintah County's risk of flooding is identified as likely with a potentially critical magnitude. Mitigation strategies include implementing storm drainage plans throughout residential areas of Uintah County, and identifying areas of high risk along waterways and applying for stream alteration permits with the state and USACE (Uintah Basin Association of Governments 2012). Chapter 17.84 of Uintah County's code of ordinances outlines provisions for flood hazard reduction, including construction standards for areas of special flood hazard.

Wayne County is part of the Six County Association of Governments, which developed the *Pre-Disaster Mitigation 5-Year Plan* (Six County Association of Governments 2015). In this 5-year plan, flooding is listed as one of the natural hazards in Wayne County, mostly occurring on the Fremont River and its tributaries. The Green River is not discussed as a potential flood threat in the HMP. In Wayne County, land use applications for any land area with the potential for flood may be required to submit a geotechnical report.

Further Reading

Emery County Pre-Disaster Hazard Mitigation Plan 2018 (Emery County 2018)

Final Environmental Impact Statement. Green River Diversion Rehabilitation Project. Emery and Grand Counties, Utah (McMillen, LLC 2014)

Grand County Pre-Disaster Hazard Mitigation Plan 2018 (Grand County 2018)

Pre-Disaster Mitigation 5-Year Plan. Sections 1 and 7 (Six County Association of Governments 2015)

Uintah Basin Regional Pre-Disaster Mitigation Plan 2012 (Uintah Basin Association of Governments 2012)

GIS Data Layers

Bridges, Canals, Dams, FEMA Flood Zones, Points of Diversion, Stream Alteration Permits, Uintah Baseline Inventory, UPDES Permits

Cultural Resources

A *cultural resource* is defined as "a building, structure, district, [archaeological] site, or object that is historically significant" (Hardesty and Little 2000:161). A cultural resource that is referred to as a *historic property*, as defined in the National Historic Preservation Act, is "any prehistoric or historic district, site, building, structure, or object included on, or eligible for inclusion on, the National Register of Historic Places (NRHP), including artifacts, records, and material remains relating to the district, site, building, structure, or object" (54 United States Code 300308). Before a property is listed on the NRHP, a formal nomination must be written and approved by the Utah State Historic Preservation Office and the State National Register Review Board. Approved nominations are then sent to the Keeper of the NRHP for final review and listing on the NRHP. Section 9-8-404 of the Utah Code Annotated requires that state agencies (e.g., FFSL) consider the effects of their actions on historic properties.

Cultural resources in the planning area generally fall into one of two categories: prehistoric or historic. Prehistoric cultural resources refer to any site, feature, structure, or artifact that predates Euro-American contact in Utah (anno Domini [A.D.] 1776). Based on existing inventory data, prehistoric sites along the Green River consist of open campsites, artifact scatters, storage and habitation structures, and rock art. The prehistoric Fourmile Tower (42UN1242) is a popular cultural resource located along the Green River in the Uinta Basin segment of the planning area; it consists of a partially collapsed tower structure similar to those found in the Fremont heartland to the north (see Spangler 2013). Access to this site is by a narrow sandstone causeway or ledge, and although difficult to access, it appears to be popular with river runners in the area.

Historic cultural resources, as defined in the United States, refer to any site, feature, structure, or artifact that dates from A.D. 1500 through 50 years before present (Hardesty and Little 2000) (Figure 2.63). In Utah, the Historic period dates from A.D. 1776, when Dominguez and Escalante reached Utah Lake, to 50 years before present based on Euro-American contact. Existing inventory data indicate that previously recorded historic sites on the Green River consist of farms and homesteads, bridges, grade-control structures, transmission lines, buildings and storage structures, historic signatures, mines, and artifact scatters. A good example of the type of historic resources likely to be encountered along the Green River in the planning area is the historic Sand Wash or Stewart Ferry and associated Hank Stewart Cabin. These sites are in the Uinta Basin segment near the bottom of Sand Wash Road on the Green River floodplain just west of the river. The cabin consists of a large, well-preserved, four-room log structure constructed in the 1920s by Hank Stewart and occupied by the Stewart family and subsequent owners through the early 1950s. The associated ferry operated until the early 1920s, when conflicts with the local Utes prompted Stewart and his 15-year-old bride Elsie to re-locate it downstream nearer the mouth of Sand Wash (Spangler 2007).

Figure 2.63. Irrigation water wheel historic cultural resource near the Green River.

Generally speaking, a resource is something that is valued because it is or can be useful; it is something that "lies ready for use or can be drawn upon for aid" (King 2002:5). Therefore, the starting point for considering cultural resources from a management perspective is considering what resource values sites might have and how management can enable these values to be realized as public benefits (Lipe 2009:41). Historic and prehistoric sites along the Green River are occasionally used recreationally, especially near Dinosaur National Monument.

Cultural Resources by River Segment

All cultural resources data examined for the Green River planning area were obtained from the Utah Division of State History's web-based data management system (Preservation Pro), preservation files, NRHP files, and published archaeological reports. Recent cultural resources–related information on the Green River is limited because few archaeological and architectural surveys have taken place along the river within the last 10 years, although inventories near Dinosaur National Monument and both Nine Mile and Desolation Canyons are robust and serve well as extrapolative data for the rest of the planning area.

Figure 2.64 provides a river plan view of the types of cultural resources that could be encountered during development authorized with an FFSL authorization. This figure shows multiple cultural resources in one area for the purposes of illustration. In practice, cultural resources are usually not this condensed. Figure 2.65 lists some of the most culturally or historically significant cultural resources in the planning area by river segment.

Further Reading

Ancient Peoples of the Great Basin and Colorado Plateau (Simms 2008)

Archaeological values and resource management (Lipe 2009)

Nine Mile Canyon: The Archaeological History of an American Treasure (Spangler 2013)

Thinking about Cultural Resource Management: Essays from the Edge (King 2002)

GIS Data Layers

Archaeological Sites, National Scenic and Historic Trails

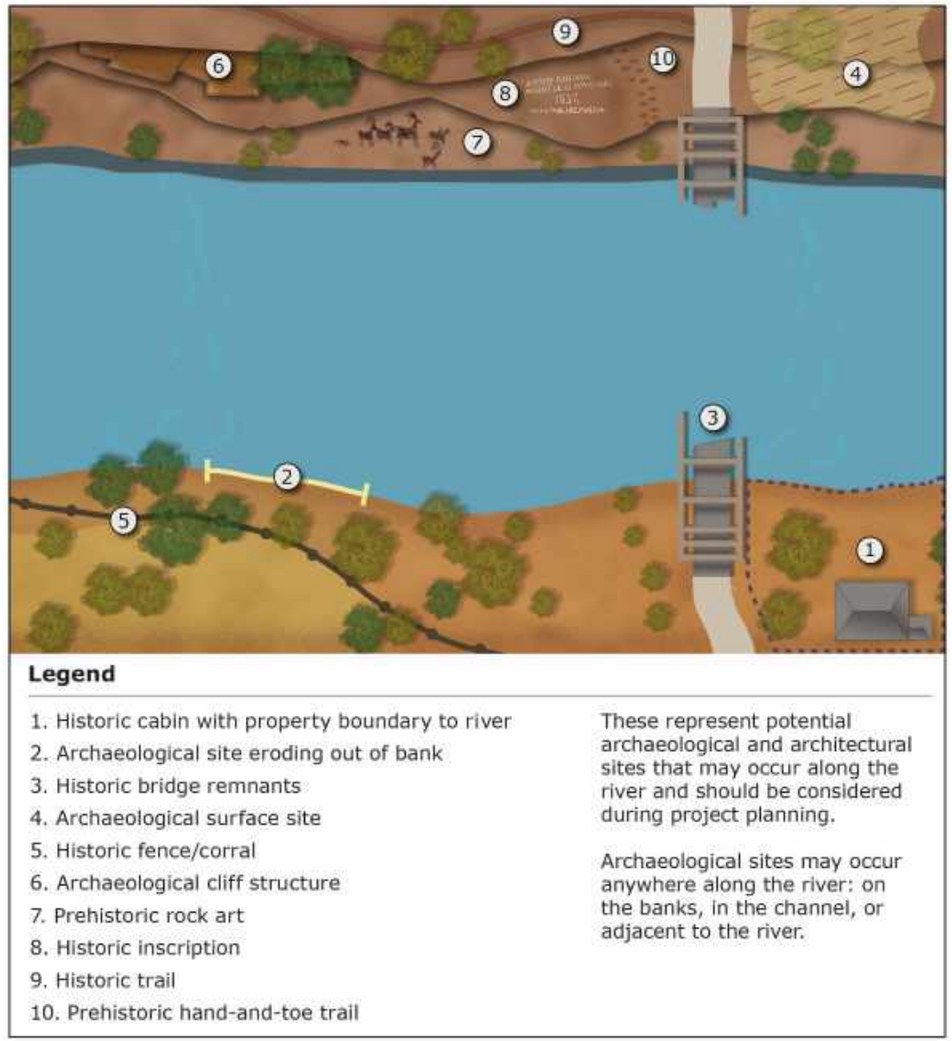

Figure 2.64. Plan view showing types of possible cultural resources in the planning area.

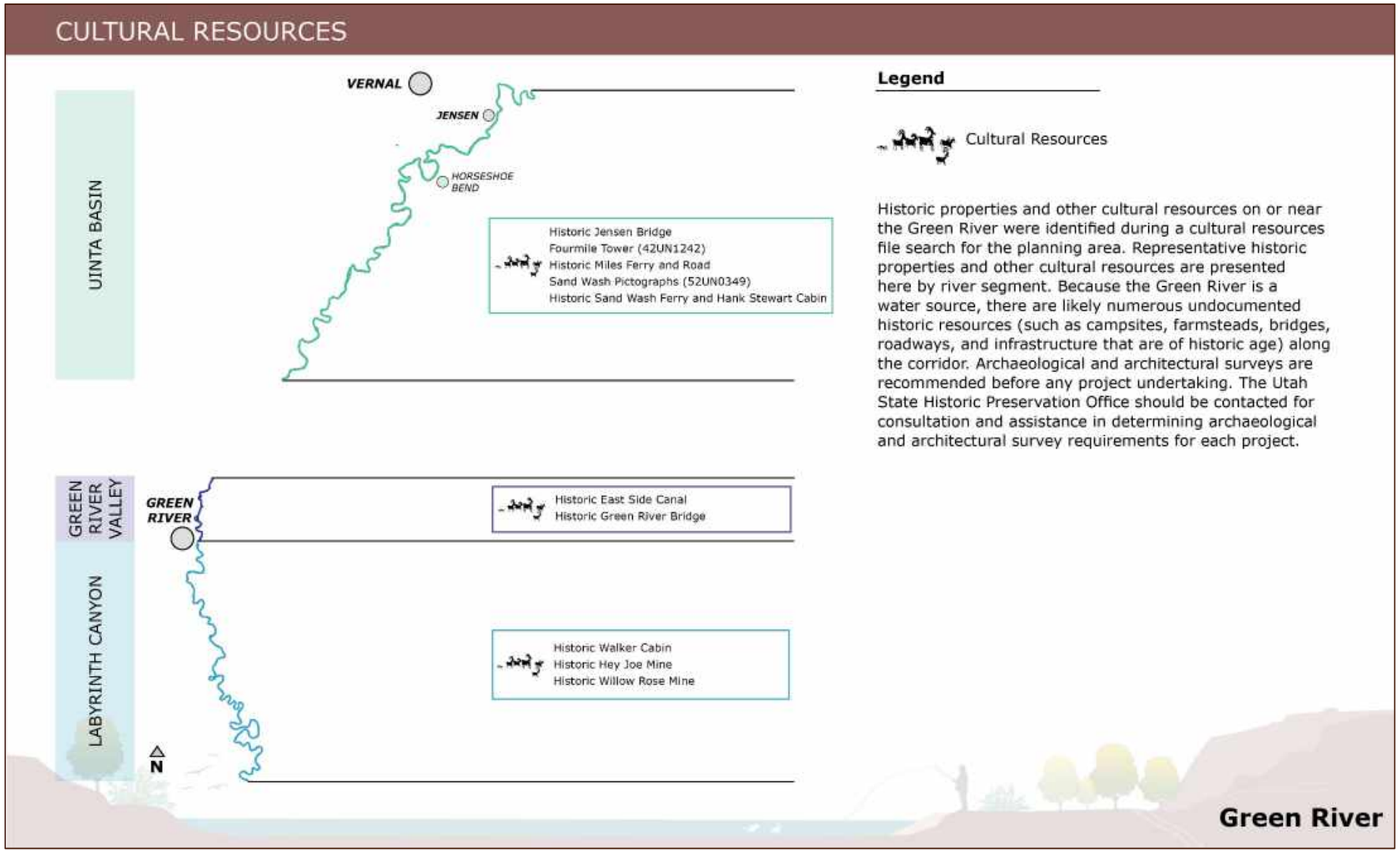

Figure 2.65. Cultural resources by river segment in the planning area.

Recreation

Recreation activities in and adjacent to the planning area consist of boating, camping, fishing, hunting, hiking, mountain biking, wildlife watching, interpretation of the Colorado Plateau landscape (e.g., geology, cultural resources, and paleontology), climbing, swimming, photography, and viewing the scenic beauty of the landscape, as shown in Figure 2.66. The discussion of recreation here focuses on the primary recreation activities on or adjacent to the planning area: boating and camping, hunting, fishing, hiking, and biking on trails.

The planning area is divided into three commonly used river segments: Uinta Basin, Green River Valley, and Labyrinth Canyon (see Table 1.2). The Green River Valley and Labyrinth Canyon segments are contiguous.

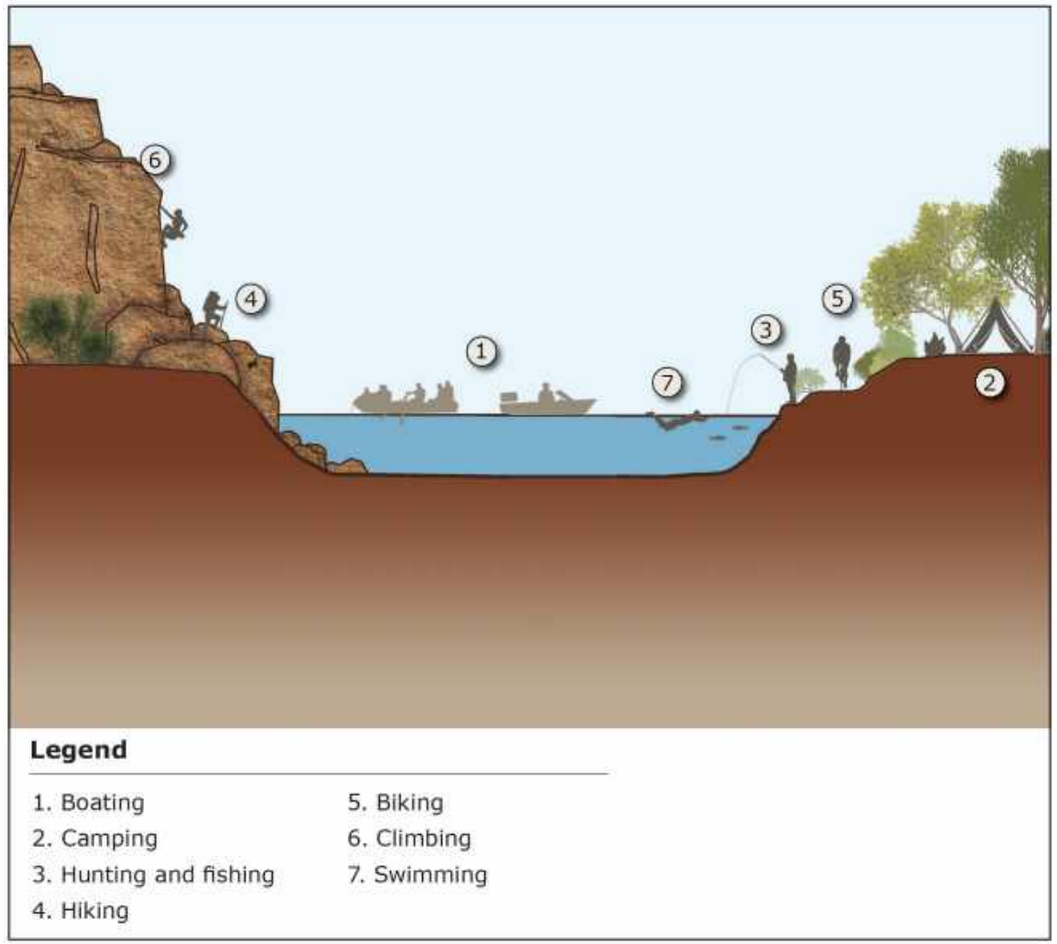

Figure 2.66. Cross section showing recreation types in the planning area.

Boating and Camping

Boating in the planning area consists of motorized watercraft such as jet boats and jet skis and non-motorized watercraft such as stand-up paddle boards, kayaks, canoes, oar-powered rafts, and inflatables. Boaters typically require areas where they can launch and remove their craft from the river. These areas, known as put-ins, take-outs, boat ramps, and boat launches, are described as "boater access points" in the plan. The river distance between boater access points dictates the time spent boating for non-motorized users. Therefore, the longitudinal distribution of boater access points can be a determinant for the type of river activity and amount of non-motorized use for a given section of the river. Figure 2.67 shows non-motorized boat use on the Green River.

Motorized river recreation typically relies on two-way navigation, both upstream and downstream, and uses the same boater access point to start and end a trip. Boater access points for motorized river recreation need to accommodate trailered watercraft. In addition, motorized river recreation depends on sufficient water depth to protect prop motors from damage, particularly during upstream travel when more power is required. Figure 2.68 shows a motorized boat on the Green River. Figure 2.69 illustrates which segments of the river are limited to non-motorized use and which segments allow non-motorized and motorized uses.

For the purposes of this CMP, a *private boater* is defined as a non-commercial (not for profit) user of the river. A *commercial outfitter* or *commercial operator* carries passengers for hire (for profit) and receives compensation for providing service, safety, and responsibility on the river.

Figure 2.67. Non-motorized boat use on the Green River.

Figure 2.68. Motorized boat use on the Green River.

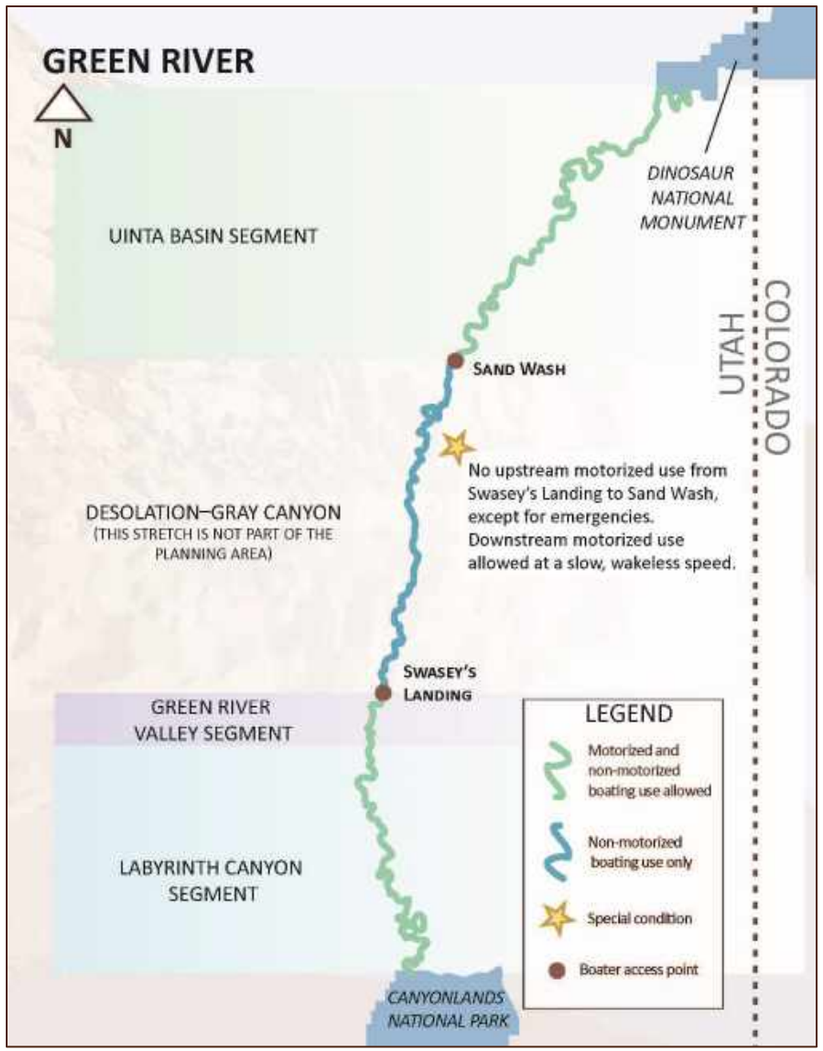

Figure 2.69. Motorized vs. non-motorized river segments on the Green River.

BOATING AND RECREATIONAL USE REGULATIONS

Motorized boats must be properly registered with the Utah Division of Motor Vehicles and must carry liability insurance while operating on Utah waters (motorboats with engines less than 50 horsepower are exempt from the insurance requirement). Utah's State Boating Act requires all boats to have at least one wearable, approved personal flotation device (life jacket) for each person on board (Utah Code 73-18-8). Children under 13 years of age are required to wear a life jacket. Life jackets are also required for boaters engaged in towing, people driving personal watercraft (jet skis), and people in any type of vessel on river sections that are not designated as flatwater. The boating act also requires that an extra oar or paddle be on board for those engaged in paddle sports, as well as a bailing device.

Utah's State Boating Act provides vessel navigation and steering laws for avoiding collisions, passing, overtaking another vessel, driving in narrow channels, sailboats, and persons riding on the bow of a boat. The following regulations on wakeless speed are also provided in the boating act (Utah Code 73-18-15.1):

> The operator of any vessel may not exceed a wakeless speed when within 150 feet of the following:
>
> - Another vessel
> - A person in or floating on the water
> - A water skier being towed by another boat
> - A water skier that had been towed behind the operator's vessel unless the skier is still surfing or riding in an upright stance on the wake created by the vessel
> - A water skier that had been towed behind another vessel and the skier is still surfing or riding in an upright stance on the wake created by the other vessel
> - A shore fisherman
> - A launching ramp
> - A dock
> - A designated swimming area

In addition, the operator of a motorboat is responsible for any damage or injury caused by the wake produced by the boat. Wakes from boat traffic can cause bank erosion (Bauer et al. 2002; Laderoute and Bauer 2013). Wake effects can be significant in areas of restricted depth and width, and where the distance between the vessel and bank is small (approximately a few hundred meters) (Fitzgerald et al. 2011).

The DSPR has primary responsibility for boating safety and enforcement on Utah waters under Utah's State Boating Act. However, FFSL has developed recreational use rules for its navigable rivers (Utah Administrative Code R652-70-2400). These rules are as follows:

- Overnight float trips must use a washable, reusable toilet system that allows for disposal of solid human waste through an authorized sewage system.
- Garbage, human waste, and pet waste must be carried off the river and disposed of properly.
- The maximum group size for overnight river trips is 25 people. Two or more groups may not camp together if the group size exceeds 25 people.
- Overnight float trips must use a durable metal fire pan at least 12 inches wide, with a lip of at least 1.5 inches around its outer edge, to contain campfires.
- Only driftwood may be used as firewood. No cutting of firewood is allowed except in designated areas. Ashes and charcoal from fires must be carried out and disposed of properly.
- An ROE from FFSL and a special recreation permit from the managing federal agency are required for commercial float trips.
- For the Green River from Green River State Park to Canyonlands National Park, each noncommercial group floating the river must have a valid interagency noncommercial river trip permit and must abide by its terms. The permit is issued by FFSL, DSPR, the BLM, authorized outfitters, and authorized private landowners.

In areas where the BLM or NPS issue river permits, additional rules apply to river users. Particular river stretches often have their own river use stipulations (e.g., Labyrinth Canyon). FFSL prohibits camping on the beds of navigable rivers except in posted or designated areas (Utah Code 65A-3-1).

For recreationists, part of boating safety is anticipating the type of water conditions that will be experienced during a trip. According to the International Scale of River Difficulty, whitewater rapids are rated on a scale of I (easy) to VI (extreme and exploratory) based on their combination of difficulty and danger (American Whitewater 2005). The scale is not exact because river difficulty can change with water flow and rivers do not always fit easily into one category. Class I water is fast-moving water with riffles, small waves, and few obstructions. Class VI water exemplifies the extremes of difficulty, unpredictability, and danger, and is for experts only (Figure 2.70). The following descriptions of the three river segments include International Scale of River Difficulty classes, where applicable.

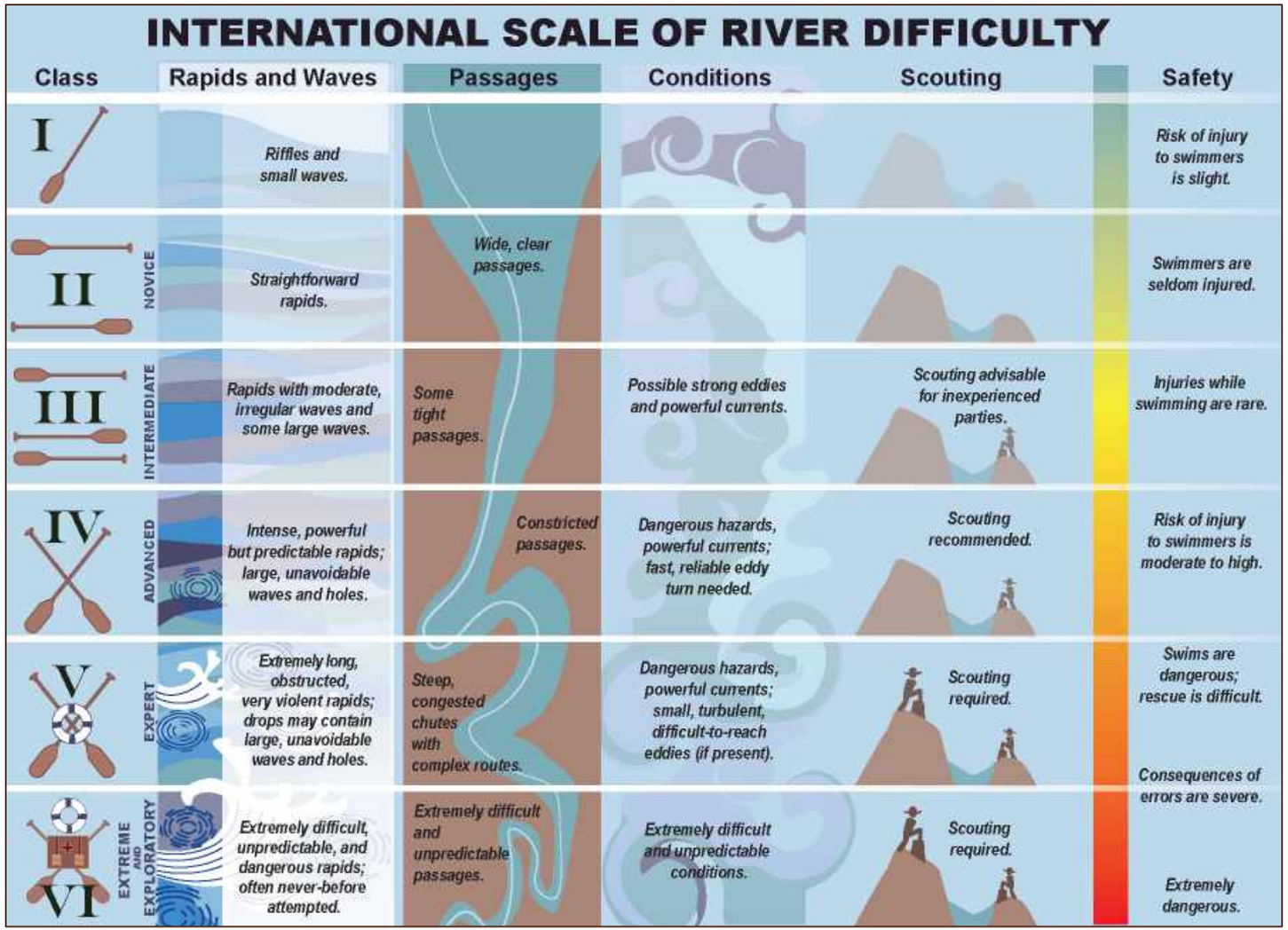

Figure 2.70. International Scale of River Difficulty.

Graphic adapted from American Whitewater (2005).

RIVER SEGMENTS

As discussed in Chapter 1, a small portion (less than 0.5 RM) of the Green River Valley segment north of Swasey's Landing boater access point (near RM 132) and a 49.2-mile portion of the Labyrinth Canyon segment (approximately RM 47 to RM 93) were recently added to the National Wild and Scenic Rivers System. In addition, the BLM has designated a portion of the Uinta Basin segment as suitable for recommendation into the National Wild and Scenic Rivers System as scenic. Portions of all three river segments have been determined to be eligible for recreational or scenic designation.

UINTA BASIN

The Uinta Basin segment begins at the border of Dinosaur National Monument (RM 317.7) and ends at the mouth of Sand Wash (RM 215.8), with an approximate length of 102 miles (Figure 2.71). This meandering segment consists of slow-moving flatwater for its entire length and includes a ribbon of green riparian vegetation that contrasts with the adjacent arid landscape. Irrigated agricultural lands are present where the floodplain widens, especially along the river corridor near the communities of Jensen and Ouray. Most of the Uinta Basin segment is remote with few amenities.

Four highways cross the Uinta Basin segment: Utah State Route 149, U.S. Route 40, Utah State Route 45, and Utah State Route 88 (in order from upstream to downstream). Formal, designated river access is not available near the Utah State Route 149 and U.S. Route 40 bridges. An informal boater access point is present downstream of the Utah State Route 45 bridge; this access appears to accommodate trailered boats. Recreationists also use informal boater access points directly upstream and downstream of the Utah State Route 88 bridge near Ouray, which are described as starting points for rafters in an online trip report (American Whitewater 2017). The informal boater access points at this location also appear to accommodate trailered boats.

Two formal boater access points (Rainbow Park and Split Mountain Gorge) located in Dinosaur National Monument upstream of Green River sovereign lands can be used to access the Uinta Basin segment. The Split Mountain Gorge boater access point is closest to sovereign lands; it primarily serves as a take-out for boaters finishing a trip through Dinosaur National Monument on the Green or Yampa Rivers. Split Mountain Gorge has trailered boat access, restrooms, and a campground.

In addition to Rainbow Park and Split Mountain Gorge, two formal boater access points are present in the Uinta Basin segment: Ouray (located at approximately RM 248) and Sand Wash (located at approximately RM 216). Additional informal boater access points likely exist along this segment but may be located on private land. As a result, access to the river in this segment is limited. The Sand Wash boater access point primarily serves boaters embarking on a popular multi-day river trip through Desolation and Gray Canyons (downstream of this segment). Boaters traveling downstream of Sand Wash must have a Desolation Canyon river permit obtained from the BLM. Sand Wash amenities include a primitive campground, ranger station, and toilets.

Motorized and non-motorized watercraft are allowed on the Uinta Basin segment of the Green River. Multi-day boating trips are not common on this segment, except for a small number of groups that start the Desolation Canyon trip upstream of Sand Wash. Permits are not required for day use or overnight camping upstream of Sand Wash. This segment is also used intermittently by hunters and fishermen.

Figure 2.71. Uinta Basin segment.

Green River Valley

The Green River Valley segment, approximately 12 miles long, starts a short distance upstream of Swasey's Landing boater access point (RM 132.2), and ends at Green River State Park (RM 120.1) (Figure 2.72). This segment provides a day trip for non-motorized boaters and can be combined with the Labyrinth Canyon segment for a multi-day trip. The Green River Valley segment is slow-moving flatwater (Class II–III rapids), mostly bordered by irrigated agricultural lands on both sides of the river.

The Swasey's Landing boater access point consists of a concrete boat ramp, parking, restroom, and trash receptacles. Swasey's Landing also serves as a take-out for boaters finishing a multi-day trip through Desolation and Gray Canyons. Swasey's Beach, just north of the Swasey's Landing boater access point, has a primitive campground. Six trips are permitted to launch per day on Desolation Canyon during the high-use period from May 15 through August 14. In 2011, the BLM estimated a total of 5,482 people launched in Desolation Canyon (BLM 2012). Boaters attempting to launch at Swasey's Landing to float the Green River Valley segment may encounter crowding because of the high use in Desolation Canyon.

Approximately 6 miles downstream from the start of the Green River Valley segment is the Tusher Diversion Dam. As described in the Infrastructure section, the dam was recently rehabilitated. FFSL worked with members of the boating community to incorporate boat passage in the center of the dam as part of the rehabilitation. The boat passage is designed to be fully functioning at flows greater than 1,300 cfs and could be more difficult to navigate or unnavigable at lower flows (American Whitewater 2017). Boaters are encouraged to scout the boat passage before continuing downstream. Informational signs are posted at Swasey's Landing and upstream of the dam. A portage trail and emergency boat landing may be located upstream of the dam on river left. Motorized boat use is uncommon between Swasey's Landing and Tusher Diversion Dam because of the dam (Ford 2018).

Green River State Park, located in the city of Green River, maintains a boater access point. Use of the boater access point requires a Utah State Parks day pass or annual pass. Amenities at Green River State Park include a developed campground with full hookups for recreational vehicles, cabin rentals, restrooms, showers, overnight parking, and a nine-hole golf course and club house. The park is operated by DSPR. An annual event called the Friendship Cruise has attracted motorized boaters to the park on Memorial Day weekend for a tour down the Green River and up the Colorado River to Moab. This event attracted approximately 300 motorized boats at its peak, but only one or two boats have participated in recent years to keep the event's special use permit active. The recent low participation is likely due to increased fuel costs, low flows on the Colorado River, changes in jet boat hull design, and the cost of managing the event (Ford 2018).

FFSL authorizes commercial recreational use on Green River sovereign lands. In 2018, 24 commercial outfitters were permitted for non-motorized use in the Green River Valley segment (Leech 2018). No permits are required for private day use on the Green River Valley segment. Multi-day boating trips floating past Green River State Park into the Labyrinth Canyon segment must obtain a BLM permit for overnight camping.

Overnight trips are not common on the Green River Valley segment because of its short length, adjacent private land, and lack of dispersed camping opportunities. Dispersed camping likely occurs at adjacent pull-outs on the road close to the river. Motorized and non-motorized watercraft are allowed on this segment. Motorized boats are not allowed to travel upstream from Swasey's Rapid to Sand Wash; downstream travel is allowed at a slow, wakeless speed (BLM 2012).

Figure 2.72. Green River Valley segment.

Labyrinth Canyon

The Labyrinth Canyon segment is approximately 73 miles long, starts at Green River State Park (RM 120.1), and ends at the Canyonlands National Park boundary (RM 46.7) (Figure 2.73). This is a remote section of the Green River, except for the first mile in and near the city of Green River. The northern portion of this river segment is partly bordered by a narrow ribbon of riparian vegetation. Downstream, the river cuts a sinuous path into the tall canyon walls of Labyrinth Canyon.

The Labyrinth Canyon segment contains flatwater boating opportunities (Class I rapids) on slow-moving water for motorized and non-motorized watercraft (e.g., canoes, kayaks, rafts). For non-motorized boaters, this typically consists of a multi-day trip, although some groups plan day trips between boater access points at Green River State Park, Crystal Geyser, and

Ruby Ranch upstream of Labyrinth Canyon. Multi-day trips cover 15 to 20 miles per day during high water or 10 to 15 miles per day during low water. Most non-motorized boaters hire a shuttle service in advance because of the remoteness of the southern portion of this segment. Non-motorized day trips comprise approximately 10 trips per month in spring and summer (Ford 2018).

The Green River State Park boater access point marks the start of this segment. Some boaters launch from Crystal Geyser located approximately 4.5 miles downstream from Green River State Park. Crystal Geyser has a primitive dirt boat launch but no restrooms or amenities. There is no fee to launch at Crystal Geyser. The Ruby Ranch boater access point is located on private land approximately 23 miles downstream from Green River State Park and charges a fee. Labyrinth Canyon begins downstream of Ruby Ranch.

The Mineral Bottom boater access point, near the southern end of the Labyrinth Canyon segment, has a boat ramp and vault toilet. It is accessed via a dirt road (best for vehicles with high clearance) from Utah State Route 313. Mineral Bottom intersects the White Rim Trail, which is a 100-mile loop popular with four-wheel drive vehicles, motorcycles, and mountain bikers. Mineral Bottom also has an airstrip for small aircraft that provides alternative transportation for some private boaters and commercial guests.

FFSL authorizes commercial recreational use on the Labyrinth Canyon segment. In 2018, 34 commercial outfitters were permitted for non-motorized use of this segment (Leech 2018). Multi-day trips continuing past Mineral Bottom and the planning area require a river permit from Canyonlands National Park (this section of the river in Canyonlands National Park is called Stillwater Canyon). Green River visitor use numbers in Canyonlands National Park are provided in Table 2.24. These numbers provide an estimate of visitor use on sovereign lands in Labyrinth Canyon but would not include river users that leave the river before Canyonlands National Park.

Table 2.24. 2017 Visitor Use Estimates for the Green River in Canyonlands National Park

Green River Destination	Commercial	Non-commercial	Total Visitors
Spanish Bottom	N/A*	2,230	2,230
Cataract Canyon	19	342	361
Total	**19**	**2,572**	**2,591**

Source: Young (2018).

N/A = not available.

*Two jet boat companies operate in Canyonlands National Park on the Colorado River. NPS estimates these commercial operators shuttle 90% of non-motorized users back upstream on the Colorado River from Spanish Bottom.

Canyonlands National Park currently has 17 commercial river outfitter contracts authorized to use the Green and Colorado Rivers to Cataract Canyon and two commercial jet boat shuttle contracts on the Colorado River to Spanish Bottom (Young 2018). Non-motorized boaters ending their Green River trip at Spanish Bottom use commercial jet boat shuttles on the Colorado River and return to Moab.

Most individuals with motorized boats use outboard motors with propellers, although users should use caution to avoid sandbars. Jet boats with an in-board jet-propelled drive are also used in this river segment. Jet boat use has declined in the Labyrinth Canyon segment for several reasons, including permit requirements, the cost of fuel, and boat design changes from flat hulls used when shallow drafts are required to more V-shaped hulls often used in lakes (Ford 2018). *Draft* is the minimum depth of water a boat can safely navigate.

River recreation in Labyrinth Canyon is jointly managed under a formal agreement between the BLM and FFSL. The agreement establishes an interagency river permit for non-commercial trips with applicable river rules. Special recreation permits are required for all commercial boating trips. Group size is limited to a maximum of 25 people (BLM 2008b). There are no designated campsites in Labyrinth Canyon. During late summer and fall, sandbar campsites are often available; however, campsites can be scarce during periods of high water.

Figure 2.73. Labyrinth Canyon segment.

Photograph by Taylor Zanelotti. Used with permission.

Hunting and Fishing

Hunting and fishing on the Green River are regulated by the DWR. Hunting opportunities in the planning area include big game species (e.g., deer [*Odocoileus hemionus*], desert bighorn sheep [*Ovis canadensis nelsoni*], and pronghorn [*Antilocapra americana*]), upland game bird species (Wilson's snipe [*Gallinago delicata*] and wild turkey [*Meleagris gallopavo*]), and waterfowl species (e.g., several species of ducks and geese). At a minimum, all hunters must possess a basic hunting license to hunt game animals on private or public lands in Utah. Waterfowl hunters over the age of 16 must also possess a federal migratory bird hunting and conservation stamp. Some Utah game species require special licenses in addition to the basic license. Hunters are advised to consult the DWR's website to determine special license requirements or closures for respective game species for areas adjacent to Green River sovereign lands.

Anyone 12 years old or older must have a license to fish in Utah. The planning area offers opportunities to catch fish such as channel catfish (*Ictalurus punctatus*), common carp (*Cyprinus carpio*), walleye (*Sander vitreus*), and largemouth bass (*Micropterus salmoides*). Fishing is typically a secondary activity for recreation visitors to the Green River Valley and Labyrinth Canyon segments (Ford 2018). The DWR has established specific fishing regulations for the Green River from the Utah-Colorado state line downriver to The Confluence (DWR 2018b).

The DWR also manages a limited number of hunting and fishing access areas in Utah. Two types of access areas are managed by the agency:

- Walk-in-access (WIA) areas are tracts of private land on which the agency has leased hunting, trapping, or fishing privileges for public recreation. Landowners enrolled in the WIA program receive monetary compensation and may also qualify for habitat restoration projects. In most cases, access to WIA properties is limited to foot traffic only.
- Wildlife management areas (WMAs) are single tracts of land owned by the DWR, or two or more tracts of land owned by the DWR, that are close to each other and managed as a single unit. WMAs are often managed to protect wildlife habitat and public access.

One WIA property, LRThayn, is located along Green River sovereign lands. LRThayn is a 2,500-acre hunting area in the Green River Valley segment located approximately 1.7 miles north of the city of Green River (from approximately RM 123 to RM 128). It consists mainly of alfalfa and corn fields. Fishing is allowed at the north end of the property. Wildlife that may be present include band-tailed pigeon (*Patagioenas fasciata*), California quail (*Callipepla californica*), mule deer, ring-necked pheasant (*Phasianus colchicus*), wild turkey, waterfowl, channel catfish, common carp, and northern pike.

Two WMAs are located along Green River sovereign lands: Stewart Lake WMA and Lower San Rafael River WMA. The Stewart Lake WMA (from approximately RM 299.5 to RM 301) consists of 688 acres of lowland riparian and wetland habitat downstream from Jensen, Utah, in the Uinta Basin segment. It provides year-round habitat for upland game such as California quail, ring-necked pheasant, and wild turkey. Mule deer are also present on the WMA. Wetland areas provide seasonal habitat for migratory bird species and habitat for the endangered razorback sucker. Elevated concentrations of selenium have been measured in the water, bottom-sediment, and biota at Stewart Lake WMA (Rowland et al. 2003). The selenium contamination has been attributed to irrigation drainage and is being actively remediated (DWR n.d. [2018]; Rowland et al. 2003).

The Lower San Rafael WMA, located at RM 98 in the Labyrinth Canyon segment, consists of three historic ranches along the banks of the San Rafael River: Hatt Ranch, Frenchman Ranch, and Chaffin Ranch. A portion of this WMA parallels the planning area. The WMA includes lowland riparian, wet meadow, flowing water, cliffs, and high desert scrub. It provides stream habitat for three native fish species (flannelmouth sucker, bluehead sucker, and roundtail chub). It also provides habitat for mule deer, upland game, and other native species. Hunting is allowed for mule deer, mountain lion (*Felis concolor*), pronghorn, mourning dove (*Zenaida macroura*), ring-necked pheasant, and wild turkey, depending on the season. Wildlife watching is also permitted.

The three DWR-managed properties are shown on the GIS spatial data viewer.

Trails

Portions of multiple hiking and biking trails are present along or near the planning area (generally not on sovereign lands). These trails are designated for bicycles and hikers (unless noted) and include the Josie Morris Ranch Road, Collier Draw Road, Horseshoe Bend (bike), and Twelve Mile Wash Road in the Uinta Basin segment; Price and Green River Trail (hike and horseback ride) and Long Canyon (hike and horseback ride) in the Green River Valley segment; and Crystal Geyser, Middle Green River, Trin Alcove, Three Canyon (hike only), Tenmile Point, Bowknot Bend, Hell Roaring, and White Rim in the Labyrinth Canyon segment. Hiking and biking trails can be viewed on the GIS spatial data viewer.

Other Recreational Activities

The Ouray National Wildlife Refuge is located along 16 miles of the Uinta Basin segment of the Green River (from approximately RM 251 to RM 265.5). Refuge habitats support more than 350 fish and wildlife species and include lush bottomland areas along the Green River, high-elevation upland benches, clay bluffs, and alkali flats. Outdoor recreation activities for visitors to the refuge include wildlife viewing, photography, hiking, biking, horseback riding, hunting, fishing, canoeing, kayaking, rafting, and motorized boating. Hunting is permitted in

the appropriate season for waterfowl, pheasant, turkey, mule deer, and elk (*Cervus canadensis*). The refuge has a fish hatchery; fishing is permitted in the Green River only. A fishing platform provides a handicap-accessible fishing opportunity on the Green River at Sheppard Bottom. Camping is not permitted in the Ouray National Wildlife Refuge.

Recreation Management Concerns

Recreation issues and themes identified by individuals and organizations during the GRCMP public outreach process include the following:

- Heavy use of the Labyrinth Canyon segment. Some users are not aware they need a permit.
- Support for recreational access and use of the river corridor in the Green River Valley segment, including access to and maintenance of trails. Protection of the Green River canyons and viewsheds for the recreation experience.
- Improvement of existing boater access points and creation of new boater access points. Specific locations mentioned by the public include Mineral Bottom (Figure 2.74), near Irvine Ranch Road, and near Fossil Point Road.
- Bank erosion, primarily from motorized wakes.
- Noxious weeds (e.g., tamarisk).
- Illegal off-highway vehicle use on sandbars in the Uinta Basin segment.
- Conflicts between motorized and non-motorized use (e.g., support for continued motorized use, opposition to the use of jet skis in areas used by non-motorized recreationists).

Figure 2.74. Existing conditions at Mineral Bottom boater access point.

The Green River Valley and Labyrinth Canyon segments are popular for single and multi-day river trips and are within a 1-day drive of large metropolitan populations along the Wasatch Front and the Colorado Front Range. Crowding may be an issue on the Labyrinth Canyon segment under the current river permit system (the permit system helps minimize user impacts, particularly from overnight camping, but does not currently limit the number of users per day).

Conflicts between motorized and non-motorized users are a concern in the planning area. Motorized boats navigating upstream present safety concerns for non-motorized watercraft traveling downstream. Motorized users do not always slow down to appropriate speeds near non-motorized users and may not give non-motorized users enough space. Sometimes, non-motorized users paddle into the path of approaching motorized watercraft. Motorized boats also may diminish the non-motorized experience, disrupt canyon sounds, and contribute to bank erosion and pollution. The volume of watercraft, both motorized and non-motorized, has the potential to exacerbate safety issues and to disturb the experience for shore-based recreationists trying to avoid crowds. FFSL's ability to address this concern is limited because this activity occurs on the water and not on the bed or banks of the Green River; however, FFSL will consider the motorized/non-motorized conflicts when issuing authorizations for commercial river trips on the Labyrinth Canyon segment. In addition, FFSL is willing to work with those agencies and entities having jurisdiction over this matter to ensure public safety.

Nonnative tamarisk dominates the riparian vegetation on the riverbanks. Tamarisk has reduced the number of campsites in the river corridor and has blocked river access to some of the campsites that remain. The reduced number of campsites decreases visitor carrying capacity for overnight use. FFSL recognizes the importance of campsite accessibility at various river flows. In recent years, FFSL has conducted tamarisk and Russian olive clearing projects at several campsites in partnership with the BLM and county agencies.

An additional management concern on rivers is mitigation of navigational hazards. Data and public input indicate that there are very few human-made navigation obstacles in the planning area. Natural navigational hazards typical of most rivers are present, including rocky spots, shallow areas, overhanging tree branches, deadfall, and debris from flash flooding. Whether such hazards affect navigation usually depends on the water level. The lack of human-made navigation obstacles in the planning area minimizes the need for portages. Portages are areas where boaters must carry their watercraft around an obstacle in the river, such as a dam. A portage consists of two boater access points: an exit point to leave the river and an entry point to return to the river. The only known portage in the planning area is the portage around Tusher Diversion Dam.

Recreation Areas by River Segment

Figure 2.75 illustrates boater access points, campgrounds, WMAs, and other recreation areas along the river segments. In addition, the percentage of each river segment that has been designated through federal legislation to the National Wild and Scenic Rivers System as wild, scenic, or recreational is shown. The percentage of each river segment that is determined to be eligible for designation into the system or designated as suitable for recommendation into the system is also provided.

Further Reading

BLM Labyrinth Canyon River (BLM n.d. [2018])

BLM RMPs for the BLM Vernal, Moab, Monticello, Richfield, and Price Field Offices (BLM 2008a, 2008b, 2008c, 2008d, 2008e)

County RMPs for Grand, Emery, Uintah, and Wayne Counties (Rural Community Consultants 2017; Emery County 2016; Uintah County 2017; Wayne County 2017)

Desolation and Gray Canyons of the Green River Special Management Area Business Plan (BLM 2012)

DSPR Boating (DSPR 2018)

Integrating Recreational Boating Considerations Into Stream Channel Modification & Design Projects (Colburn 2012)

International Scale of River Difficulty (American Whitewater 2005)

National Wild and Scenic Rivers System (2018)

Recreational Use of Navigable Rivers (Utah Administrative Code R652-70-2400)

State Boating Act (Utah Code 73-18)

Utah Fishing Guidebook (DWR 2018b)

Utah hunting: Information on hunting in Utah (DWR 2018c)

GIS Data Layers

Boating Access, Campgrounds, DWR-Managed Access, Education Facilities, National Landscape Conservation System (Wilderness Areas, Wilderness Study Areas, Wild and Scenic Rivers), National Scenic and Historic Trails, Navigational Hazards, Recreation Facilities, Trails, Utah Scenic Byways, Wild Horse Herd Management Area

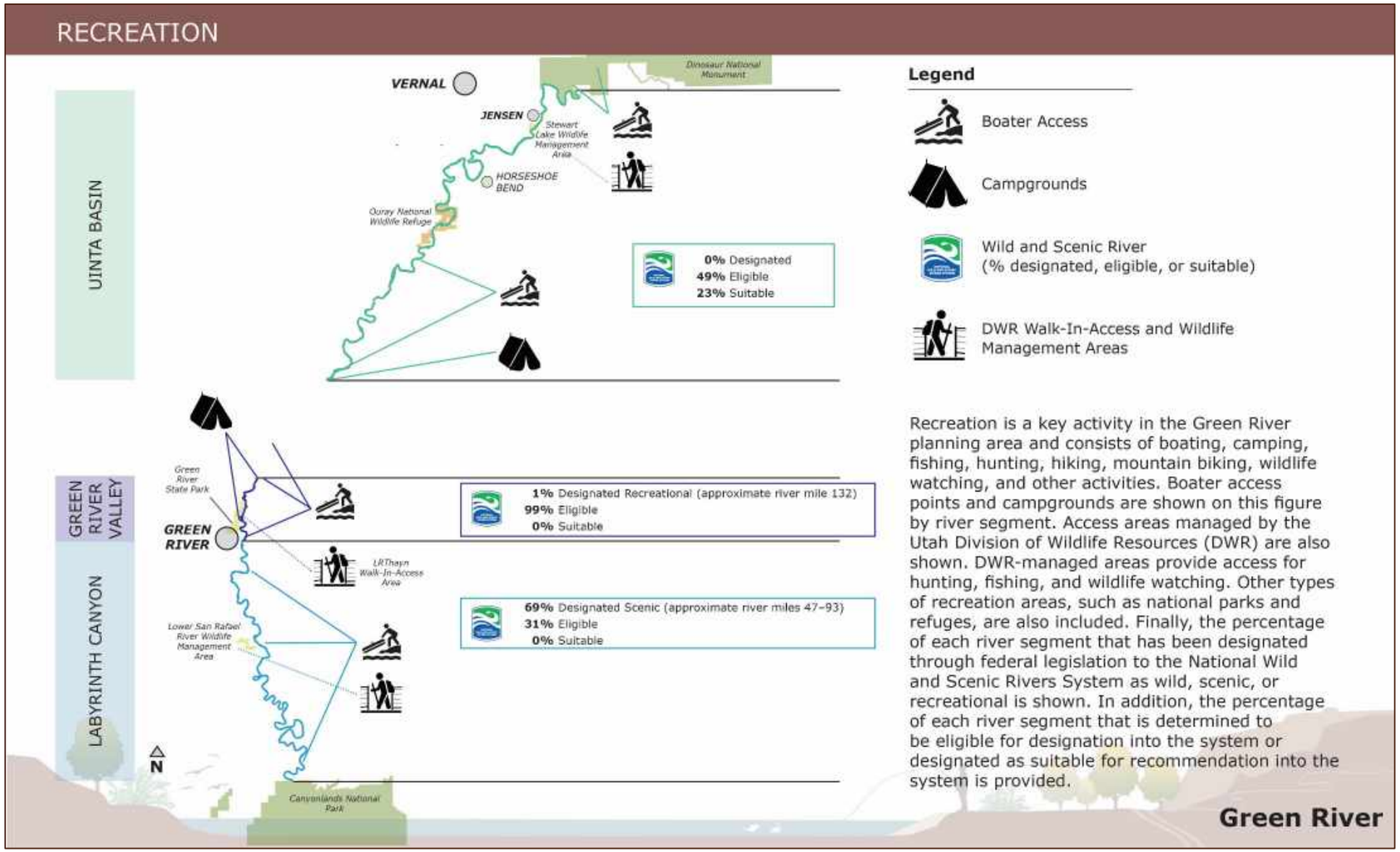

Figure 2.75. Boater access points, campgrounds, and WMAs along the Green River.

Access

Access is the ability to approach and use the Green River for recreation, development, education, research, or other purposes such as flood control. Because the State of Utah–owned bed and banks of the Green River are considered sovereign land and therefore public land, the public can generally access the Green River, riverbed, and banks as long as they do not trespass across private land.

Access to the planning area for the development of infrastructure or other projects requires an authorization such as an easement, general permit, or ROE from FFSL (see Section 1.7 in Chapter 1). Access to infrastructure such as utilities and outfall structures must be protected so that maintenance and repairs can be conducted. Access to infrastructure for recreation users in the planning area must also be protected so that activities such as boating, fishing, and hunting can occur. Boater access points for recreationists are shown on the GIS spatial data viewer. Infrastructure should be designed to be safe for the public, protect natural resources, consider river fluctuations, and be Americans with Disabilities Act–accessible as required by law.

Good public access fosters stewardship and support for the protection and enhancement of the river corridor. Access should take into account and tie into regional transportation networks (i.e., other trails and public transit) where possible. By doing so, it can provide an alternative transportation network for the region. Access must be balanced to protect the river. Too many access points can damage the river and associated infrastructure; too few access points can limit opportunities to experience the river, create crowding at access areas, and reduce the public support for and use of the river. For these reasons, spacing of access points is important. Careful planning would help preserve opportunities for access that have not yet been developed. Although there are no recommended distances between access points, FFSL will take into account safety, the number and type of existing access points, the presence of private land, roads, river use class, and other factors when deciding how close access points should be placed along the river.

Public Safety

Public safety refers to the welfare and protection of the general public. Public safety in the planning area primarily applies to recreational use of the Green River by watercraft and the associated boater access points, as well as by hunters and fishermen. Public safety could also apply to other recreation uses (e.g., wildlife watching, hiking, biking) on the banks of the river or on bridges in the planning area. Natural hazards, such as wildfire and floods, are also public safety issues.

Public use of facilities such as parking lots and restrooms is outside of FFSL jurisdiction because these structures are not located directly on sovereign lands, and safety at these locations is the responsibility of other entities. The safety of workers during the construction, operation, and maintenance of utility lines, bridges, roads, and other facilities in the planning area is protected through regulations administrated by the federal Occupational Safety and Health Administration.

Water quality is considered a public safety issue because the beneficial uses for the three segments of the Green River include domestic/drinking water and frequent primary contact recreation (such as swimming). The planning area is not listed as impaired for domestic/drinking water and frequent primary contact recreation (see the Water Quality section of Chapter 2).

Conflicts between motorized and non-motorized users are present in the planning area and may present safety issues, as identified in the Recreation Management Concerns section. FFSL is willing to work with those agencies and entities having jurisdiction over this matter to ensure public safety.

FFSL, the BLM, DWR, and DSPR all have responsibility for law enforcement on the Green River. Potential public safety hazards in the planning area are present in Figure 2.76.

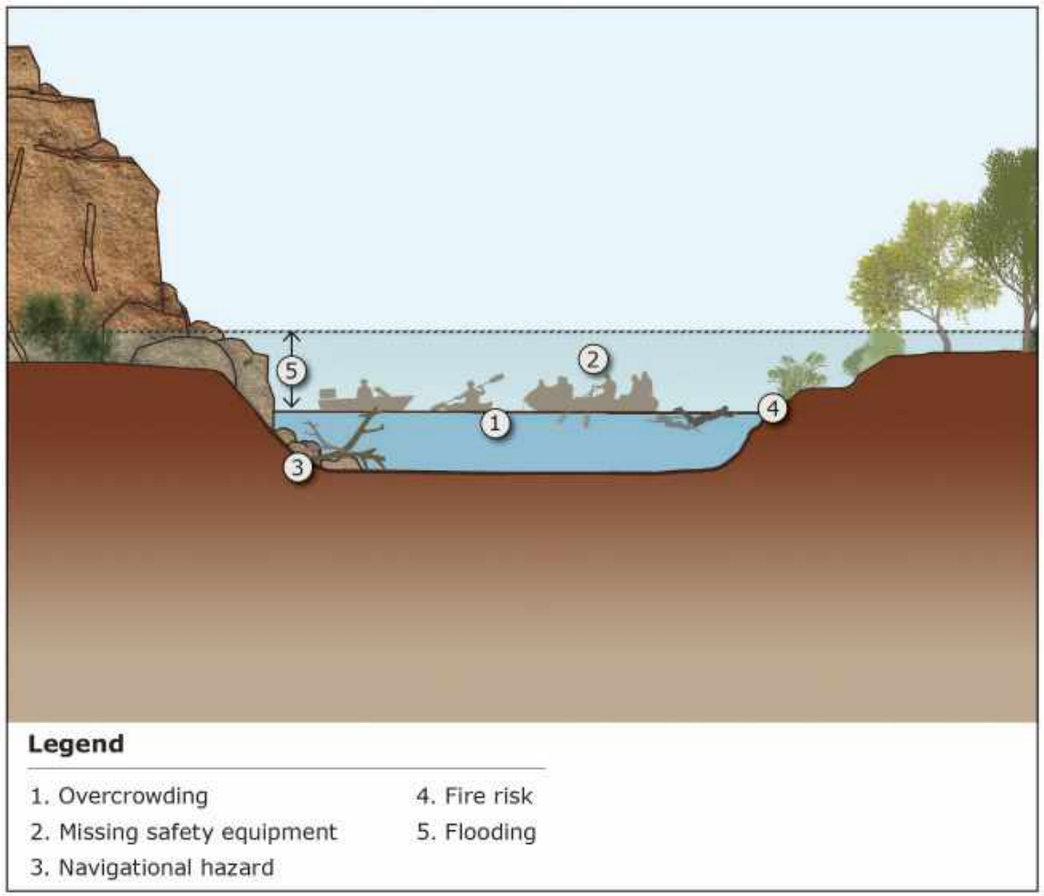

Figure 2.76. Cross section showing potential public safety hazards in the planning area.

In addition to flooding and fire, other natural hazards may be present in the planning area. A risk assessment in Emery County's HMP ranks drought, flood, wildland fire, and severe weather as the top four natural hazards for the county, respectively (Emery County 2018). Grand County's HMP risk assessment ranks severe weather, flooding, wildfire, and drought as the top four natural hazards, respectively (Grand County 2018). The HMP developed for the Uintah Basin Association of Governments lists five natural hazards of concern in Uintah County: dam failure, earthquakes, flooding, landslides, and wildlife (Uintah Basin Association of Governments 2012). The Six County Association of Governments lists earthquake, flood, drought, wildfire, and severe weather as being the hazards posing the most potential risk to the counties in its planning district (Six County Association of Governments 2015).

The EPA has developed a draft sub-area contingency plan for the Green River that provides response planning to guide initial actions to major oil discharges that threaten waters of the United States (EPA 2015). The EPA's general approach to a spill is to control the source of the spill as quickly as possible and then limit downstream impacts. The contingency plan discusses sensitive areas, specific hazards, worst-case discharges and projections, cultural resources, threatened and endangered species, response operations and roles, and coordination with other agencies and levels of government.

Education

Education is an important component of successfully managing the planning area because it provides direction to user groups for the appropriate use of the Green River, clarifies FFSL's jurisdiction and management authority on Green River sovereign lands, and fosters public appreciation of the river and understanding of its value and the need to protect it. In addition, educating Green River planners and managers through the dissemination of research data and analysis can improve their understanding of the ecosystem and enhance the management and stewardship of the resource.

User groups that benefit from educational efforts about the Green River are listed in Figure 2.77.

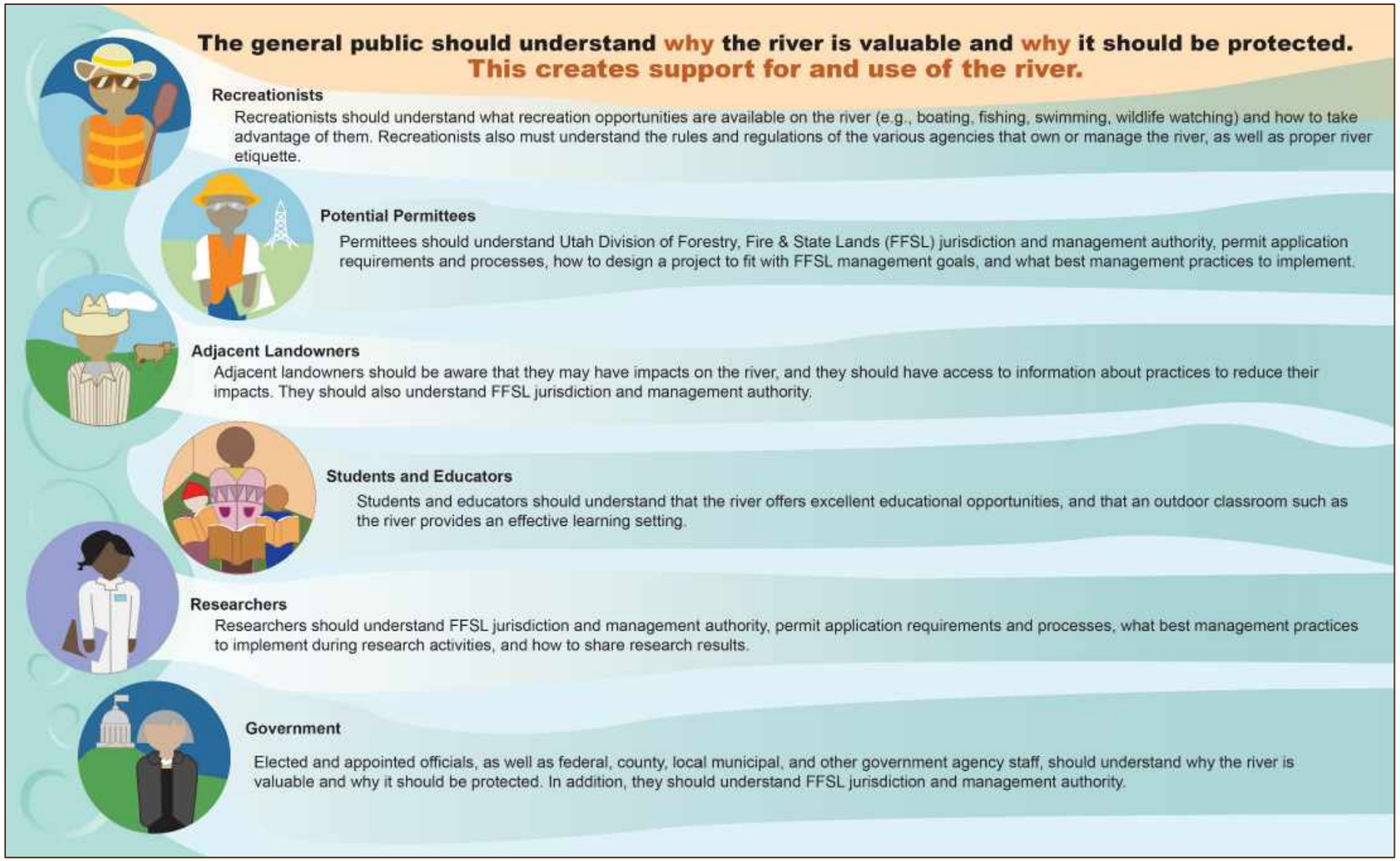

Figure 2.77. User groups in the planning area.

Educational Materials

A number of entities provide educational materials about the Green River in or near the planning area. These include Dinosaur National Monument; Ouray National Wildlife Refuge; the John Wesley Powell River History Museum; Green River State Park; Canyonlands National Park; the BLM's Vernal, Price, and Moab Field Offices; and DWR.

Comments from the public outreach process indicated a need to better educate recreationists using the river. Education is needed about respecting private property rights, handling trash, preventing graffiti, river manners, and other topics. Additional education could occur through new signage at popular boater access points, by working with commercial outfitters and non-profit groups like American Whitewater, and through the FFSL and BLM permitting processes. Section 3.4 contains FFSL's suggestions for stewardship and river etiquette.

The Green River in the planning area does not currently have a coordinated signage system. Interpretive and informational signing could help increase public awareness about the river, river etiquette, access, safety, and recreational opportunities. For these reasons, FFSL would support the implementation of a coordinated signage system on the three river segments in the planning area. Such a system would be especially useful to boaters.

In general, signs should be easy to spot, easy to maintain, and consistent. Interpretive signs could be distributed at key locations (such as boater access points) to provide educational information about river etiquette, the history of the Green River, wildlife and habitat restoration and protection efforts, unique ecological features, and local culture. All signs should fulfill a need, command attention, convey a clear and simple meaning, and command respect from river users. However, signs should be carefully placed and should not detract from the natural environment, viewsheds, or aesthetic beauty.

Research

Research on the Green River is often conducted in the planning area and may require FFSL authorization for access and equipment installation. Researchers may be associated with universities, other educational facilities, private or public entities, non-profit organizations, or government agencies. FFSL encourages research on the Green River and would support partnerships with organizations doing research, such as the Upper Colorado River Endangered Fish Recovery Program, Flaming Gorge Technical Working Group, and the Utah State University Department of Watershed Sciences.

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CHAPTER 3 – MANAGEMENT FRAMEWORK

3.1 Introduction

This chapter focuses on strategies that FFSL will implement to manage the Green River resources described in Chapter 2. Management strategies are organized by resource and consist of goals and objectives focusing on actions and decisions within FFSL's jurisdiction. Identified goals and objectives allow multiple opportunities for coordination with other Green River management entities. Collectively, strategies discussed in this chapter are designed to facilitate FFSL's management of Green River sovereign lands and resources in accordance with the Public Trust Doctrine and under multiple-use, sustained-yield principles, as stated in Utah Administrative Code R652-2-200 and Utah Code 65A-2-1. In cases where FFSL does not have direct management authority over a particular element of the river, FFSL will coordinate with the agencies and other partners that do have such authority. The term *partners* as used in this chapter is defined as landowners, 501(c) and nonprofit organizations, special interest groups, and other Green River stakeholder groups.

Managing for the Public Trust

As described in Chapter 1, in managing for the Public Trust, FFSL "recognizes and declares that the beds of navigable waters within the state are owned by the state and are among the basic resources of the state, and that there exists, and has existed since statehood, a public trust over and upon the beds of these waters. It is also recognized that the public health, interest, safety, and welfare require that all uses on, beneath or above the beds of navigable lakes and streams of the state be regulated, so that the protection of navigation, fish and wildlife habitat, aquatic beauty, public recreation, and water quality will be given due consideration and balanced against the navigational or economic necessity or justification for, or benefit to be derived from, any proposed use" (Utah Administrative Code R652-2-200). The following management strategies reflect FFSL's commitment to the Public Trust on sovereign lands when considering specific projects, decisions, and applications for authorizations or permits:

- Navigation: FFSL will strive to maintain or improve navigation on the Green River. Decisions concerning river management will consider mitigation and removal of existing navigational hazards as well as parameters for new projects to facilitate navigation.
- Fish and wildlife habitat: FFSL will strive to maintain, enhance, or restore aquatic, wetland, riparian, and terrestrial fish and wildlife habitat under its jurisdiction.
- Aquatic beauty: FFSL will strive to maintain or improve aesthetic conditions in and along the Green River, recognizing that aquatic beauty increases the value of the Green River as a community resource.
- Public recreation: FFSL will consider and support diverse recreation activities and facilities at sustainable levels.
- Water quality: FFSL will support the State of Utah's antidegradation policy.

When implementing management strategies, FFSL is obligated to follow applicable laws, including statutes, regulations, and legal doctrines.

Desired Future Condition

A *desired future condition* is a benchmark for what a resource should look like with the implementation of a management plan and associated goals and objectives. The GRCMP identifies desired future conditions for ecosystem resources; water resources; geology, paleontology, oil and gas, and other mineral resources; and community resources. The subsequent management goals and objectives provide a means to work toward the desired future conditions. Although the use of desired future conditions has limitations (as does any planning construct), these conditions allow for multiple-use management, can be modified

over time based on new data, and avoid the pitfalls of setting a "restored" ecological condition as a management target. For example, in managed systems like the Green River, setting restoration goals must account for normal conditions—e.g., invasive species and hydrologic modifications—that make restoration to some earlier condition unrealistic or in some cases unattainable.

River Use Classes

As described in Chapter 1, Utah Administrative Code R652-70-200 indicates that sovereign lands should be classified based on their current and planned uses and provides definitions for six classes. FFSL uses the classes to guide management and use of Green River sovereign lands with diverse current and desired future conditions. Table 3.1 lists and describes the river use classes.

Table 3.1. Classification of Sovereign Lands

River Use Class	Description
Class 1	Manage to protect existing resource development uses
Class 2	Manage to protect potential resource development options
Class 3	Manage as open for consideration of any use
Class 4	Manage for resource inventory and analysis
Class 5	Manage to protect potential resource preservation options
Class 6	Manage to protect existing resource preservation uses

Source: Utah Administrative Code R652-70-200

Note: Class 4 is not applied to the GRCMP planning area because adequate information about Green River sovereign lands exists to develop this planning document.

A map book of how these use classes are applied to Green River sovereign lands is found in Chapter 1, Figure 1.8. From a management perspective, FFSL recognizes that different activities have different impacts on sovereign lands. Table 3.2 lists common activities (proposed actions) requiring FFSL authorization and guidance for applicants seeking an easement, general permit, ROE, or other authorization. Proposed actions not listed in Table 3.2 will be reviewed on a case-by-case basis by FFSL to arrive at an appropriate use determination.

Use determinations for proposed actions consist of allowable (A), potentially allowable (P), and not allowable (N). An "A" use determination will likely require no site-specific analysis of resources within a project area, but the project will still be reviewed for adherence to BMPs. For "P" use determinations, a site-specific analysis may be completed to determine project feasibility and mitigation opportunities or requirements. The site-specific analysis will consider potential impacts (beneficial and adverse) of the proposed project to Green River resources. Certain BMPs must be incorporated into project design, as well as long-term maintenance to minimize adverse impacts to sovereign lands. For "N" use determinations, the proposed use will not be permitted unless the GRCMP is amended. The suitability of proposed easements, general permits, ROEs, and other authorizations will also be considered in the context of existing authorizations to avoid potential conflicts, e.g., boater access points and utilities in the same location. Finally, under certain jurisdictions such as Clean Water Act (CWA) permit conditions, FERC Management Areas, or FEMA-accredited levee operation and maintenance, some proposed actions may not be authorized regardless of FFSL river use class or use determination.

Table 3.2. Use Determinations for Proposed Actions by River Use Class

Proposed Action*	Class 1	Class 2	Class 3	Class 5	Class 6
Bed, Bank, and Vegetation Management					
Bank stabilization (bioengineering)	A	A	A	A	A
Bank stabilization (hardened)	A	A	P	P	P
Dredging†	P	P	P	P	P
Fire prevention treatments	A	A	A	P	P
Grade controls	P	P	P	P	P
Herbicide treatment (authorization required)	A	A	A	A	A
Vegetation planting and propagule harvesting (e.g., willow whips)	A	A	A	A	A
Vegetation removal	A	A	A	P	P
Education and Research					
Education and interpretation	A	A	A	A	A
Scientific research instruments	A	A	A	A	A
Survey and monitoring activities	A	A	A	A	A
Habitat Management					
Aquatic habitat structures	A	A	A	A	A
Wildlife habitat (e.g., nesting structures)	A	A	A	A	A
Fisheries Management					
Fisheries management actions	A	A	A	A	A
Infrastructure					
Above-ground water, oil and gas, sewer, and communication lines§	P	P	N	N	N
Below-ground or buried utilities†	A	A	A	A	P
Bridges (pedestrian)†	A	A	A	P	P
Bridges (vehicle)†	A	A	A	P	N
Dams	P	P	P	N	N
Intake canals	P	P	P	P	P
Irrigation pumps	A	A	A	A	A
Fences (to the water's edge only)	A	A	A	P	P
Outfall structures	A	A	A	P	P
Overhead power lines‡	P	P	P	P	P
Regulatory markers (e.g., buoys, signage)	A	A	A	A	P
Trash booms	A	A	A	P	P
Recreation					
Boat docks (permanent)†	N	N	N	N	N
Boat docks (seasonal/temporary)†	A	A	A	P	P
Boat ramps†	P	P	P	P	P
Navigational hazard removal	A	A	A	A	A
Other recreation structures (permanent)†	P	P	P	P	P
Other recreation structures (temporary/seasonal)†	A	A	A	P	P
Emergency Actions					
Emergency response and cleanup	A	A	A	A	A
Emergency response training	A	A	A	A	P
Oil and Gas¶					
Mineral Resources¶					

Notes: A = allowable; P = potentially allowable with certain conditions; N = not allowable.

* Actions generally pertain to public and commercial activities, but some carry over to private landowners (e.g., bank stabilization, emergency cleanup, fire prevention, herbicide treatment, vegetation planting, vegetation removal, and habitat or nesting structures).

† In the interest of supporting the Public Trust, utilities, bridges, boat docks, boat ramps, dredging, and other similar actions proposed by private landowners will generally not be permitted. Irrigation pumps and electrical utilities servicing pumps installed and maintained by private landowners are exempt from this condition. Above-ground utilities that cross the river require authorization because sovereign lands include the air space over the river.

‡ Height to be determined during site-specific planning and based on National Electrical Code power line clearance guidelines (National Electrical Code 2017).

§ Potentially allowable if attached to existing permitted structures.

¶ Refer to the *Green and Colorado Rivers Mineral Leasing Plan* (SWCA 2020) for specific guidance for oil, gas, and mineral leasing on sovereign lands.

Class 4 is not applied to the GRCMP planning area because adequate information about Green River sovereign lands exists to develop this planning document.

Resource Management Issues

The management strategies in this chapter are organized by resource and follow the same order as in Chapter 2 (Current Conditions). Each resource section includes a list of desired future conditions for that resource as well as a management strategy table with goals; subsequent objectives; and applicable management, permitting, and intersecting agencies. BMPs for the resources are also included.

Management issues for Green River resources have been identified by FFSL, the planning team, and through the public involvement process (i.e., at public open houses, stakeholder meetings, county commissioner meetings, during the public comment period, and on FFSL's project website). Where resource (or sub-resource) management issues overlap, management goals are included in the resource section most pertinent to the objectives for achieving the goal.

Management Goals and Objectives

The goals and objectives reflect the intention of FFSL to protect and sustain the Pubic Trust resources while providing for their use. Each goal is supported by objectives that can be used to achieve the goal. Goals and objectives equate to specific management prescriptions to be implemented by FFSL where it has jurisdiction (e.g., inventory and map noxious weed occurrences in and along the banks of Green River). Where FFSL does not have jurisdiction or has concurrent jurisdiction, objectives consist of coordination (e.g., coordinate with cities, counties, agencies, and partners to improve existing recreation infrastructure and to add recreation infrastructure where needed), cooperation, and general support (e.g., support state and local law enforcement efforts to minimize boater speeding and enforce wake rules). FFSL will work proactively and cooperatively with management agencies, permitting agencies, intersecting agencies, and interested partners to implement applicable management goals and objectives.

Interagency Coordination

Effective coordination and communication with government agencies regarding Green River resources are vital to ensuring the health and long-term stability of the ecosystem. Coordination and communication between FFSL and other agencies will vary in timing and intensity based on the resource issue. For the purposes of developing the CRCMP management strategies, the government agencies involved fall into one or more of the following three categories depending on their participation in each unique resource issue:

1. Management agency: A management agency is directly responsible for the management of a particular resource. As mandated through Utah Code, administrative rule, or agency objectives, a management agency is responsible for on-the-ground management and/or monitoring.
2. Permitting agency: A permitting agency is responsible for authorizing Green River resource-related permits. For example, FFSL, DWQ, and DWRi can each issue permits for projects in or adjacent to the Green River. Each permitting agency has the potential to impact the resource through permit authorizations, including mitigation. A permitting agency is responsible for monitoring permit compliance.
3. Intersecting agency: An intersecting agency is an agency that does not have direct responsibility for managing a particular resource or permitting activities on the Green River but is tangentially related. The decisions of an intersecting agency may directly or indirectly impact a particular resource. In addition to federal and state agencies, an intersecting agency can include a tribal government, county government, municipal government, and a regional planning organization. FFSL management decisions impact resources that may be managed, influenced, and/or researched by intersecting agencies. These agencies often have tools, data, and information that could be used by FFSL to make well-informed management decisions. Intersecting agencies may be responsible for research and/or monitoring at a broad scale.

It is important to note that although adjacent private landowners, businesses, special interest groups, land managers, local universities, and other stakeholders may not be listed as responsible parties in each goals and objectives table, FFSL is interested and available to discuss resource-specific matters with any concerned entity.

Best Management Practices

Implementation of BMPs for resources helps avoid or minimize impacts to Green River sovereign lands. BMPs may range from using approved plant lists and seed mixes for revegetation to design specifications for buried utility lines. Many BMPs pertain specifically to the bed and bank of the Green River. For BMPs relevant to land uses extending from the river and beyond, readers can review supplemental literature, e.g., *Riparian Buffer Design Guidelines for Water Quality and Wildlife Habitat Functions on Agricultural Landscapes in the Intermountain West* (Johnson and Buffler 2008) or consult other sources of technical information such as the local offices of the NRCS. Users of the GRCMP should review BMPs during their project planning process and demonstrate in the application documents which BMPs are incorporated, how they will be implemented, and/or why they are not practicable. BMPs are aspirational in nature and may change over time based on available information or technology. FFSL may deviate from BMPs as written in this CMP on a case-by-case basis.

3.2 Ecosystem Resources

Desired future conditions for ecosystem resources are as follows:

- A sustainable river system supporting human uses, diverse populations of native plant and animal species, and desirable introduced and native fish with limited constraints from invasive and nonnative species.
- A healthy river corridor preserving wildlife migration routes through contiguous habitats and between fragmented habitats.
- Recognition that natural disturbance can be beneficial, but that anthropogenic disturbance such as development and pollution should be avoided to the extent practicable.
- Preservation of areas providing ecosystem services (e.g., flood attenuation and wildlife habitat) and restoration of degraded ecosystems to enhance overall ecological condition.

As discussed in Chapter 1, Section 1.11, river use classes are applied to specific locations on Green River sovereign lands based on a variety of parameters. Table 3.3 describes what the river use classes mean for ecosystem management.

Table 3.3. River Use Classes and Ecosystem Management

River Use Class	What the Use Class Means for Ecosystem Management
Class 1	Higher potential for actual loss or degradation of wildlife habitat due to authorizations and uses. High potential for restoring wildlife habitat and improving vegetation communities because more bed, bank, and vegetation management is allowed.
Class 2	Potential future loss or degradation of wildlife habitat due to possible authorizations and uses. High potential for restoring wildlife habitat and improving vegetation communities because more bed, bank, and vegetation management is allowed.
Class 3	Moderate potential for actual loss or degradation of wildlife habitat due to authorizations and uses; more emphasis on mitigation than in Classes 1 or 2. Moderate potential for restoring wildlife habitat and improving vegetation communities because more bed, bank, and vegetation management is allowed than in Classes 5 and 6 (e.g., vegetation removal).
Class 5	Potential for future ecosystem services and wildlife habitat protection and conservation. Adjacent lands may resemble those eligible for conservation easement status. Likely no current regulatory restrictions on adjacent land use. Emphasis on streambank and instream wildlife habitat restoration, though not all bed, bank, and vegetation management activities may be allowed.
Class 6	Emphasis on protection and conservation of ecosystem services and wildlife habitat. Ongoing opportunities for adaptive management and habitat improvement projects. Current regulatory protection of adjacent land use. Emphasis on streambank and instream wildlife habitat restoration, though not all bed, bank, and vegetation management activities may be allowed.

Wildlife Habitat

Fish and wildlife habitat is one of the components of the Public Trust FFSL is mandated to protect. The management goals and objectives for wildlife habitat generally seek to protect, enhance, and restore healthy native wildlife habitats. Table 3.4 presents management goals and objectives common to all classes for wildlife habitat. Figure 3.1 provides a list of BMPs for wildlife habitat in the planning area.

Table 3.4. Wildlife Habitat Goals and Objectives Common to All Classes

Wildlife Habitat Goal 1: Protect and sustain healthy native habitats in and along the banks of the Green River.
Objective: Cooperate with agencies and partners to identify and maintain areas with high wildlife habitat value, including wetlands and IBAs.
Objective: As part of the authorization application process, consider the cumulative impacts of past, present, and future projects on instream and adjacent wildlife habitat through consultation with the management, permitting, and intersecting agencies listed below.
Objective: Minimize habitat fragmentation from authorizations and uses, especially in areas with high wildlife habitat value; cluster authorizations with habitat impacts whenever possible.
Objective: Focus habitat protection efforts on areas with healthy native plant communities.
Objective: Identify and protect areas providing healthy habitat for special-status plant species (e.g., clay reed-mustard, Uinta Basin hookless cactus, Ute ladies'-tresses).
Management Agencies: FFSL, DWQ, DWR, BLM, and USFWS
Permitting Agencies: FFSL, DWRi, DWQ, BLM, USACE, and USFWS
Intersecting Agencies: County, municipal, and tribal governments; FERC; and USBR
Wildlife Habitat Goal 2: Restore and enhance native habitats in and along the banks of the Green River.
Objective: Support restoration of the riparian zone, emphasizing connectivity along the river corridor.
Objective: Coordinate with agencies and partners to re-establish floodplains and other geomorphic features where appropriate (e.g., point bars, bank woody debris, side channels and secondary channels, and low emergent benches).
Objective: Support removal of structures degrading native habitats.
Objective: Work with agencies and partners to identify problem areas of bank erosion, determine the causes of the erosion, and encourage solutions to limit or prevent future bank erosion.
Management Agencies: FFSL, DWQ, DWR, BLM, and USFWS
Permitting Agencies: FFSL, DWRi, DWQ, BLM, USACE, and USFWS
Intersecting Agencies: County, municipal, and tribal governments; FERC; and USBR
Wildlife Habitat Goal 3: Support habitat restoration or enhancement on lands adjacent to the Green River.
Objective: Coordinate with agencies and partners on projects that are adjacent to and benefit habitat on sovereign lands.
Objective: Cooperate with agencies and partners to inventory adjacent lands where restoration or enhancement would benefit navigation, water quality, fish and wildlife habitat, recreation, or aquatic beauty.
Management Agencies: FFSL, DWR, BLM, NPS, and USFWS
Permitting Agencies: FFSL, BLM, USACE, and USFWS
Intersecting Agencies: County, municipal, and tribal governments
Wildlife Habitat Goal 4: Manage invasive and noxious weed species in and along the banks of the Green River.
Objective: Inventory and map noxious weed occurrences in and along the banks of the Green River.
Objective: Identify concentrations and dispersal vectors for noxious weeds within the river corridor.
Objective: Target and treat invasive weed species (especially tamarisk, Russian olive, Russian knapweed, and perennial pepperweed), and treat colonizing invasive species in the planning area.
Objective: Coordinate with adjacent landowners who are interested in treating invasive and noxious weed infestations on their property.
Management Agencies: FFSL, UDAF, and BLM
Permitting Agencies: FFSL, BLM
Intersecting Agencies: County, municipal, and tribal governments; NRCS; and NPS

Best Management Practices

Use native or desirable species from approved plant lists and seed mixes when revegetating disturbed areas or conducting restoration or enhancement activities (see Table 2.4 in Chapter 2).

Implement measures to reduce the introduction and spread of invasive and noxious weed species during project construction and maintenance, such as equipment washing and inspection.

For invasive and noxious weed species management, refer to guidance on the Southeastern Utah Riparian Partnership's website, including the *Field Guide for Managing Salt Cedar in the Southwest* (U.S. Forest Service 2014b) and *Tamarisk Best Management Practices in Colorado Watersheds* (Nissen et al. 2010).

Enhance the river vegetative buffer to minimize noise and light pollution. During project design and construction, use equipment with low levels of lighting and noise.

Protect undisturbed areas, maximize open space, and minimize surface disturbance in project designs.

Limit negative impacts to streambanks. Project designs should protect bank stability.

Implement erosion-control measures (e.g., silt fencing and straw wattles) during project construction to protect aquatic habitat.

Figure 3.1. Best management practices for wildlife habitat in the planning area.

Wildlife Species

The management goals and objectives for wildlife species seek to support healthy populations of native fishes, migratory birds, and terrestrial wildlife. Table 3.5 presents management goals and objectives for wildlife species that are common to all classes. Figure 3.2 provides a list of BMPs for wildlife species in the planning area.

Table 3.5. Wildlife Species Goals and Objectives Common to All Classes

Wildlife Species Goal 1: Recognize the importance and support the sustainability of viable populations of native and desirable nonnative fishes, along with migratory bird species and their habitats.
Objective: Coordinate with agencies and partners to encourage the creation, restoration, enhancement, and maintenance of a diversity of habitats and adequate cover, reproductive sites, and food supply for fish and migratory birds.
Objective: Support inventory, monitoring, and research of fisheries and migrating bird populations with agencies and partners, including non-governmental organizations and citizen science groups.
Objective: Support DWQ aquatic wildlife–related beneficial uses and help ensure compliance with numeric criteria for pollutants.
Objective: Emphasize the protection of sovereign land areas providing habitat for the special-status fish and migratory bird species in Table 2.7.
Objective: Coordinate with USFWS on new authorizations proposed in areas of designated critical habitat on sovereign lands (see Table 2.7).
Objective: Manage for consistency with current USFWS plans for threatened, endangered, and candidate species, and with any management plans for other special-status species (e.g., the range-wide conservation agreement and strategy for the roundtail chub, bluehead sucker, and flannelmouth sucker [DWR 2006]).
Objective: Consider individual bird species, federally listed bird species, Utah bird SPC, Utah Partners in Flight priority species, and *Utah Wildlife Action Plan* SGCN when trying to achieve habitat-related management goals (e.g., enhancement, restoration, preservation).
Objective: Support flows and releases that benefit special-status fishes and amphibians on sovereign lands (see Table 2.7).
Objective: Manage to preserve and protect critical habitats for spawning and rearing for listed and sensitive native fish species.
Management Agencies: FFSL, DWR, BLM, and USFWS
Permitting Agencies: FFSL, DWRi, DWQ, BLM, USACE, and USFWS
Intersecting Agencies: County, municipal, and tribal governments; Upper Green River Endangered Fish Recovery Program

Wildlife Species Goal 2: Recognize the importance of and support the sustainability of viable populations of native terrestrial wildlife species on lands adjacent to the Green River.

Objective: Coordinate with agencies and partners to encourage projects that are adjacent to sovereign lands and benefit terrestrial wildlife species.

Objective: Promote the creation, restoration, enhancement, and maintenance of a diversity of habitats and adequate cover, reproductive sites, and food supply for terrestrial wildlife on adjacent lands.

Objective: Support inventory, monitoring, and research of terrestrial wildlife populations on adjacent lands with agencies and partners, including non-governmental organizations and citizen science groups.

Objective: Emphasize the protection of sovereign land areas connected to special-status terrestrial wildlife habitat species (see Table 2.7) on adjacent lands.

Management Agencies: FFSL, DWR, USFWS, BLM, and NPS

Permitting Agencies: FFSL, BLM, USACE, and USFWS

Intersecting Agencies: County, municipal, and tribal governments

Wildlife Species Goal 3: Support the control or eradication of existing aquatic invasive species and terrestrial nonnative, invasive species; discourage the spread of existing aquatic invasive species and terrestrial, nonnative species; and discourage the introduction of new aquatic invasive species and terrestrial, nonnative species to the Green River.

Objective: Support control and eradication of aquatic and terrestrial nonnative, invasive pests presently in the river system through coordination with DWR and other agencies.

Objective: Coordinate with DWR on public awareness programs and other strategies for keeping nonnative, invasive pest species out of the Green River.

Objective: Support the creation of a CWMA for the city of Green River area (or other new CWMAs as appropriate) for weed management.

Management Agencies: FFSL, UDAF, and BLM

Permitting Agencies: FFSL, BLM

Intersecting Agencies: County, municipal, and tribal governments; NRCS

Best Management Practices

Adhere to all federal regulations for wildlife species (e.g., Endangered Species Act, Migratory Bird Treaty Act, and Bald and Golden Eagle Protection Act).

Apply seasonal bird nesting guidelines described in *Utah Field Office Guidelines for Raptor Protection from Human and Land Use Disturbances* (Romin and Muck 2002) during project implementation.

Refer to DWR key habitats and priority species when planning restoration projects in and along the river (Utah Wildlife Action Plan Joint Team 2015).

Refer to *Utah Partners in Flight Avian Conservation Strategy Version 2.0* (Parrish et al. 2002) for priority bird species and conservation actions.

Consider federally listed bird species, bird SPC, Utah Partners in Flight priority species, and SGCNs when working to achieve habitat-related goals such as enhancement or restoration.

Heron rookery along the Green River.

Follow herbicide and pesticide application protocol carefully, especially near aquatic resources, as follows:

- Applicators should be certified, licensed, or properly trained to work with pesticides and herbicides.
- Follow the manufacturer's label instructions.
- Follow all applicable federal, state, and local laws and regulations.
- Select compounds that are effective but are not likely to drift, do not leach into groundwater or wash into streams, are not toxic to people or other organisms, are easy to apply, and are not persistent in the environment.
- Use the minimum amount of compound needed to be effective.
- Select an appropriate application method for the local conditions.
- Ensure that no banned or unregistered pesticide or herbicide is applied.
- Do not apply herbicides or pesticides during storm events or windy weather.
- Do not apply herbicides or pesticides when water is running on or off-site or if the ground is saturated.
- During application, note and protect irrigation canals, open trenches, surface waters, wetlands, designated 303(d) waters, and groundwater sources.
- Understand appropriate safety procedures and emergency spill actions.

Follow applicable invasive species laws and regulations.

Refer to the *Utah Aquatic Invasive Species Management Plan* (DWR and Utah Invasive Species Task Force 2009) for aquatic invasive species management.

Figure 3.2. Best management practices for wildlife species in the planning area.

3.3 Water Resources

Desired future conditions for water resources are as follows:

- A sustainable river system with improvements, where possible, to naturalized flow, and floodplain connectivity.
- Maintenance of seasonal variation in discharge and instream flows that support sediment transport and enhance riparian plant communities where possible.
- A reduction in channel narrowing through a healthier flow regime where possible.
- Continued invasive species reduction to help improve sediment mobility and reduce channel narrowing.
- Improvements in water quality, especially reductions in selenium and salinity.
- Recognition that a warming climate is reducing runoff in the Green River watershed.
- Recognition of the importance of reducing consumptive use.

As discussed in Chapter 1, Section 1.11, river use classes are applied to specific locations on Green River sovereign lands based on a variety of parameters. Table 3.6 describes what the river use classes mean for water resources management.

Table 3.6. River Use Classes and Water Resources Management

River Use Class	What the Use Class Means for Water Resources Management
Class 1	Higher potential for monitoring, modifying, and replacing existing instream structures negatively affecting water resources. Higher potential for the installation of new instream structures or other authorizations and uses that could have a negative effect on water resources. Most uses are allowed in this class.
Class 2	Potential for installation of new instream structures or other authorizations or uses that could have a negative effect on water resources. Most uses are allowed in this class.
Class 3	Combination of existing authorizations and uses and protection of water resources; more emphasis on mitigation than in Classes 1 or 2. More authorizations and uses are allowed than in Classes 5 and 6 (e.g., bridges, vegetation removal). Potential degradation of local water resources is possible without successful implementation of BMPs and mitigation measures.
Class 5	Potential for future protection of water resources. Emphasis is on preserving existing healthy water resources and maintaining the opportunity to protect water resources. Certain authorizations and uses require more review than in Classes 1–3 (e.g., vehicle bridges, outfall structures).
Class 6	Protection of water resources. Current regulatory protection of adjacent land use lessens the likelihood of impacts to water resources. Fewer authorizations and uses are allowed, and some require more review than in Classes 1–5 (e.g., below-ground or buried utilities).

Hydrology

The hydrology goals and objectives seek to reduce negative impacts on hydrologic conditions in the Green River, while improving hydrologic conditions where possible. Table 3.7 presents management goals and objectives for hydrology that are common to all classes. Figure 3.3 provides a list of BMPs for hydrology management in the planning area.

Table 3.7. Hydrology Goals and Objectives Common to All Classes

Hydrology Goal 1: Support studies and research regarding instream structures and, where appropriate, support modification or removal.
Objective: Support comprehensive mapping and inventory of instream structures.
Objective: Assess condition of instream structures to determine impact on hydrology.
Objective: Consider removal or repair of those instream structures degrading hydrologic conditions.
Objective: Ensure that placement and design of new instream infrastructure will not degrade hydrology during the authorization application process (see BMPs following this table).
Management Agencies: FFSL
Permitting Agencies: FFSL, DWRi, DWQ, and USACE
Intersecting Agencies: FERC and USBR
Hydrology Goal 2: Support restoration efforts that integrate river processes.
Objective: Consider geomorphologic characteristics when managing river restoration efforts. For example, in river segments where the slope is steep, consider the likelihood of scour versus segments where slope is gentle. Also consider the likelihood of deposition.
Objective: Consider the needs of the larger river system when designing specific restoration efforts.
Management Agencies: FFSL, DWRi, and BLM
Permitting Agencies: FFSL, DWRi, BLM, and USACE
Intersecting Agencies: FERC and USBR
Hydrology Goal 3: Recognize that increasing demand for consumptive use of Green River water may alter the flow regime, decreasing total runoff and reducing peak annual flow magnitude and duration.
Objective: Encourage and support water conservation as opportunities arise.
Objective: Support agencies and partners using creative solutions to reduce water consumption.
Management Agencies: DWRi, DWRe, and BLM
Permitting Agencies: FFSL, DWRi, BLM, and USACE
Intersecting Agencies: FERC, USBR, and FEMA
Hydrology Goal 4: Recognize the importance of flows supporting healthy instream processes, as well as aquatic habitat and adjacent habitat.
Objective: Support research of flows and releases that would benefit the riverine ecosystem and fluvial processes.
Objective: Coordinate with agencies and partners to develop management strategies for projected declines to stream flows caused by warming temperatures.
Objective: Coordinate with DWR and other management agencies to study instream flows that support fisheries and associated aquatic and wildlife habitat.
Objective: Collaborate with and encourage management agencies and partners to promote healthy flow regimes, especially those supporting the life history requirements of native species.
Management Agencies: DWR, DWRe, and BLM
Permitting Agencies: FFSL, DWRi, BLM, and USACE
Intersecting Agencies: FERC, USBR, and FEMA
Hydrology Goal 5: Recognize the importance of flows supporting a variety of recreation uses.
Objective: Support research of preferential flows for all recreation types.
Objective: Coordinate with agencies and partners to discern how projected declines to stream flows might affect river recreation.
Objective: Collaborate with and encourage management agencies and partners to promote healthy flow regimes, including those beneficial to river recreation.
Management Agencies: DWRi, DWRe, and BLM
Permitting Agencies: FFSL, DWRi, BLM, and USACE
Intersecting Agencies: FERC, USBR, and FEMA

Best Management Practices

Use bioengineering techniques when possible.

Through engineering analyses, demonstrate no adverse impact on hydraulic, hydrologic, and scour/erosion conditions for new projects.

Replace and/or enhance bank vegetation disturbed by construction.

Ensure that steep channel bank slopes are 2.5:1.0 or flatter to support vegetative growth.

Ensure that structure measures are adequately toed down below the design scour depth or provide grade control to limit long-term scour.

Use *Integrating Recreational Boating Considerations Into Stream Channel Modification & Design Projects* (Colburn 2012) as an information source for integrating recreational needs into stream channel project design and implementation.

Figure 3.3. Best management practices for hydrology in the planning area.

Geomorphology and Sediment Supply and Transport

Table 3.8 presents management goals and objectives for geomorphology and sediment supply and transport that are common to all classes. Figure 3.4 provides a list of BMPs for geomorphology and sediment supply and transport in the planning area.

Table 3.8. Geomorphology and Sediment Supply and Transport Goals and Objectives Common to All Classes

Geomorphology and Sediment Supply and Transport Goal 1: Recognize the role of tamarisk as one of the primary drivers of channel narrowing in the Green River Basin.
Objective: Identify, target, and treat tamarisk in the planning area.
Management Agencies: FFSL, UDAF
Permitting Agencies: FFSL
Intersecting Agencies: DWR, NRCS
Geomorphology and Sediment Supply and Transport Goal 2: Improve connectivity between the river channel and floodplains where possible.
Objective: Work with agencies and partners to reduce nonnative vegetation on floodplains that may be altering floodplain sediment deposition.
Management Agencies: DWRe and DWRi
Permitting Agencies: FFSL, DWRi, and USACE
Intersecting Agencies: FERC, USBR, and FEMA
Geomorphology and Sediment Supply and Transport Goal 3: Work toward a healthier stream flow regime, improved sediment supply and transport, and reduced channel narrowing where possible.
Objective: Support and promote research identifying ways to improve the health of the Green River and resulting in more sustainable management.
Objective: Work with agencies and partners to better manage dams, diversions, and irrigation withdrawals with adverse effects on flow regime, sediment supply and transport, and geomorphology in the Green River (e.g., Flaming Gorge Dam).
Management Agencies: DWR and DWRe
Permitting Agencies: FFSL, DWRi, and USACE
Intersecting Agencies: FERC, USBR, and FEMA

Best Management Practices

Discourage activities in and adjacent to the channel that cause significant impact to sediment transport and the sediment balance in the river.

Through engineering analyses of projects, seek to minimize adverse impact on geomorphic processes such as scour, erosion, aggregation, or degradation of sediment features.

Discourage the diversion of flow or other reduction of flow during spring runoff when most sediment transport occurs.

Figure 3.4. Best management practices for geomorphology and sediment supply and transport in the planning area.

Water Quality

Water quality is one of the components of the Public Trust FFSL is mandated to protect. FFSL relies on DWQ's designated beneficial uses for water quality (not the river use class system). Table 3.9 presents management goals and objectives for water quality. Figure 3.5 provides a list of BMPs for water quality in the planning area.

Table 3.9. Water Quality Goals and Objectives Common to All Classes

Water Quality Goal 1: Promote the policy of antidegradation of Green River water quality.
Objective: Coordinate with DWQ to ensure compliance with Utah Water Quality Act regulations (Utah Administrative Code R317).
Objective: Require water quality certifications and provisions per Utah Administrative Code R317-15 and R652-20-3000. The purpose of certification is to ensure that the federally permitted or licensed activities will be conducted in a manner complying with applicable discharge and water quality requirements to maintain the chemical, physical, and biological integrity of waters of the U.S. within the state.
Objective: Promote maintenance and improvement of existing water quality to protect the beneficial uses designated for the Green River.
Objective: Consider water quality during the authorization application process.
Objective: Work with agencies and partners to educate adjacent agricultural landowners on the use of BMPs to protect water quality.
Management Agencies: FFSL and DWQ
Permitting Agencies: DWQ
Intersecting Agencies: County, municipal, and tribal governments; DWRe; and NRCS
Water Quality Goal 2: Recognize the importance of minimizing pollutant loads to the river, specifically those identified in the TMDL (e.g., selenium).
Objective: Coordinate with the DWQ to ensure compliance with the numeric criteria for parameters of concern (e.g., selenium).
Objective: Follow TMDL recommendations in all 303(d) listed reaches.
Objective: Coordinate with municipal stormwater management entities and other entities that discharge to reduce pollutant loads to the river.
Objective: Communicate new project proposals to DWQ to help ensure impacts do not affect compliance with existing water quality standards.
Objective: Support maintenance of existing and/or restore degraded wetland, riparian, and vegetated infiltration buffers adjacent to sovereign lands.
Objective: Implement BMPs and restoration projects to reduce salinity contributions to the Green River.
Management Agencies: FFSL, DWQ, and BLM
Permitting Agencies: DWRi, DWQ, BLM, and USACE
Intersecting Agencies: County, municipal, and tribal governments; UDAF; and NRCS

Best Management Practices

Implement sediment- and erosion-control measures (e.g., silt fencing and straw wattles) during project construction to protect water quality.

Where appropriate, use bioengineering practices for bank stabilization.

Encourage treatment of stormwater with constructed wetlands, bio-swales, and other features.

Revegetate the riparian corridor to provide filtration and thermal protection.

Rehabilitate riparian zones by establishing riparian buffers.

Stabilize streambanks through revegetation, snag removal and clearing, flow regulation structures, revetments, or deflectors.

Ensure areas designated as critical point sources meet UPDES requirements.

Implement water use efficiencies as common practice.

Minimize surface runoff whenever possible.

Figure 3.5. Best management practices for water quality in the planning area.

3.4 Geology, Paleontology, Oil and Gas, and other Mineral Resources

Desired future conditions for geology, paleontology, oil and gas, and other mineral resources are as follows:

- Improved awareness and understanding of geologic hazards and sensitive geological resources/formations in the planning area.
- Recognition of the value of paleontological resources in the planning area and protection of known paleontological resources.
- Effective management of oil and gas and other mineral resources in the planning area.

Mineral substances are classified in Utah Administrative Code R652-20-200 and include metalliferous minerals (e.g., copper, tin); coal; oil, gas, and hydrocarbon; oil shale; potash; gilsonite; building stone and limestone; phosphate; and gemstone and fossils (e.g., agate). In this section, oil and gas resources are discussed separately from the remaining mineral resources.

FFSL will use the *Green and Colorado Rivers Mineral Leasing Plan* (SWCA 2020) to determine where oil and gas and mineral leasing is allowed and to identify the required constraints, mitigations, and BMPs. The river use class system does not designate where oil and gas or mineral leasing is allowed and does not apply to surface occupancy or any geological, paleontological, oil and gas, or mineral resource extraction. Table 3.10 describes what the river use classes mean for geology, paleontology, oil and gas, and other mineral resources.

Table 3.10. River Use Classes and Geology, Paleontology, Oil and Gas, and other Mineral Resources

River Use Class	What the Use Class Means for Geology, Paleontology, Oil and Gas, and other Mineral Resources
Class 1	Higher potential for damage to infrastructure from geologic hazards because infrastructure is often clustered in Class 1 areas. Paleontological resources may have been disturbed or damaged by existing infrastructure. More appropriate class for authorizing the leasing of oil and gas and other mineral resources.
Class 2	Higher potential for disturbance or damage to paleontological resources from new authorizations and uses. More appropriate class for authorizing the leasing of oil and gas and other mineral resources.
Class 3	Moderate potential for disturbance and damage to paleontological resources from new authorizations and uses. Appropriate class for authorizing the leasing of oil and gas and other mineral resources, with more emphasis on mitigation than in Classes 1 and 2.
Class 5	Lower potential for damage to infrastructure from geologic hazards because there is less infrastructure in Class 5 areas. Lower potential for disturbance or damage to paleontological resources from new authorizations and uses. Less appropriate class for authorizing the leasing of oil and gas and other mineral resources; mitigation is heavily emphasized.
Class 6	Lower potential for damage to infrastructure from geologic hazards because fewer authorizations and uses are allowed. Lower potential for disturbance or damage to paleontological resources from new authorizations and uses. Least appropriate class for authorizing the leasing of oil and gas and other mineral resources; stringent mitigation would be required.

Geology

Table 3.11 presents management goals and objectives for geology that are common to all classes. Figure 3.6 provides a list of BMPs for geology management in the planning area.

Table 3.11. Geology Goals and Objectives Common to All Classes

Geology Goal 1: Improve awareness and understanding of geologic hazards in the planning area.
Objective: Identify and consider geologic hazards during the authorization application process.
Management Agencies: UGS
Permitting Agencies: FFSL, DWRi, DWQ, FERC, and USBR
Intersecting Agencies: County, municipal, and tribal governments; FEMA; and U.S. Department of Energy (DOE)
Geology Goal 2: Protect and preserve sensitive geological resources/formations in the planning area.
Objective: Identify and consider sensitive geological resources/formations during the authorization application process.
Management Agencies: FFSL and UGS
Permitting Agencies: FFSL, DWRi, DWQ, FERC, and USBR
Intersecting Agencies: County, municipal, and tribal governments; FEMA; and DOE

Best Management Practices

Coordinate with UGS to incorporate BMPs in new authorizations on a case-by-case basis (where there are geologic hazards or sensitive geological resources/formations).

Locate new infrastructure, development, and other uses in areas that minimize potential impacts to sensitive geological resources/formations.

Locate new infrastructure, development, and other uses in areas that minimize potential impacts from geologic hazards.

Figure 3.6. Best management practices for geology in the planning area.

Paleontology

Table 3.12 presents management goals and objectives for paleontology that are common to all classes. Figure 3.7 provides a list of BMPs for paleontology management in the planning area.

Table 3.12. Paleontology Goals and Objectives Common to All Classes

Paleontology Goal 1: Consider paleontological resources during the authorization application process.
Objective: Coordinate with management agencies such as UGS to determine whether paleontological resource record searches, pre-disturbance surveys, monitoring, mitigation, or avoidance is needed in areas with moderate to high potential to contain paleontological resources.
Management Agencies: FFSL and UGS
Permitting Agencies: FFSL and UGS
Intersecting Agencies: BLM
Paleontology Goal 2: Protect and preserve paleontological resources found on sovereign lands.
Objective: Coordinate with management agencies such as UGS to protect and preserve paleontological resources currently existing or newly discovered on sovereign lands.
Objective: Consider developing strategies to make individual paleontological resource sites available for public education and recreation purposes.
Objective: Develop and implement strategies to educate users about appropriate behaviors while observing and appreciating paleontological resources.
Management Agencies: FFSL and UGS
Permitting Agencies: FFSL and UGS
Intersecting Agencies: County, municipal, and tribal governments; NPS; and BLM

Best Management Practices

In the event of an unanticipated discovery of a paleontological resource during construction of an authorized project on sovereign lands, work should be immediately halted and FFSL should be notified of the discovery. FFSL will consult with the appropriate managing agency before work resumes.

Locate new infrastructure, development, and other uses in areas that minimize potential impacts to paleontological resources.

Figure 3.7. Best management practices for paleontology in the planning area.

Oil and Gas Resources

Table 3.13 presents management goals and objectives for oil and gas resources that are common to all classes. Figure 3.8 provides a list of BMPs for oil and gas resources in the planning area.

Table 3.13. Oil and Gas Resources Goals and Objectives Common to All Classes

Oil and Gas Resources Goal 1: Balance oil and gas resource development on sovereign lands while minimizing negative impacts, protecting Public Trust resources, and protecting the natural environment.
Objective: Foster coordination and cooperation in the management of all resources on the Green River with oil and gas applicants, and with local, state, federal, and tribal agencies with management authority adjacent to or on the Green River.
Objective: Enforce all applicable regulations, mitigation, and BMPs during oil and gas operations on sovereign lands and appropriate reclamation after developments cease.
Objective: Coordinate closely with DOGM for leases adjacent to Class 6 areas.
Management Agencies: FFSL, DOGM, BLM, and tribal governments
Permitting Agencies: FFSL, DOGM, BLM, and tribal governments
Intersecting Agencies: County, municipal, and tribal governments and UGS

Best Management Practices

Coordinate with DOGM and the BLM to incorporate BMPs in new leases in the planning area on a case-by-case basis.

Follow all applicable rules, regulations, and guidance, e.g., DOGM's *Onsite Pit Guidance Document* (Doebele 2017); DOGM's *Incident Reporting Guidance Document* (Cordova 2018), *The Practical Guide to Reclamation in Utah* (DOGM 2000), Utah Administrative Code Title R647, and *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development* (The Gold Book) (BLM 2007).

Prior to leasing, applicant must demonstrate that there will be compensation for any extraction of Public Trust resources on sovereign lands, and that there will be no negative impact on the surface of sovereign lands from drilling into underlying formations.

Consider mitigating or screening structures and operations in upland areas from view if visible from the river to minimize disruptions, sound, exhaust, fugitive dust, and visual impacts to aquatic beauty and recreation.

Figure 3.8. Best management practices for oil and gas resources in the planning area.

Mineral Resources

Table 3.14 presents management goals and objectives for mineral resources that are common to all classes. Figure 3.9 provides a list of BMPs for mineral resources in the planning area.

Table 3.14. Mineral Resources Goals and Objectives Common to All Classes

Mineral Resources Goal 1: Balance mineral resource development on sovereign lands while minimizing negative impacts, protecting Public Trust resources, and protecting the natural environment.
Objective: Foster coordination and cooperation in the management of all resources on the Green River with mineral applicants, and with local, state, federal, and tribal agencies with management authority adjacent to or on the Green River.
Objective: Enforce all applicable regulations, mitigation, and BMPs during mineral resource development and extraction operations and appropriate reclamation after projects cease.
Objective: Coordinate closely with permitting agencies for leases adjacent to Class 6 areas.
Management Agencies: FFSL, DOGM, BLM, and tribal governments
Permitting Agencies: FFSL, DOGM, BLM, and tribal governments
Intersecting Agencies: County, municipal, and tribal governments, and UGS

Best Management Practices

Coordinate with other management and permitting agencies to incorporate BMPs in new leases in the planning area on a case-by-case basis.

Follow all applicable rules, regulations, and guidance for the particular mineral resource being extracted.

Prior to leasing, applicant must demonstrate that there will be compensation for any extraction of Public Trust resources on sovereign lands, and that there will be no negative impact on the surface of sovereign lands from drilling into underlying formations.

Figure 3.9. Best management practices for mineral resources in the planning area.

3.5 Community Resources

Desired future conditions for community resources are as follows:

- A sustainable river system supporting multiple uses (e.g., recreation, irrigation) and providing navigability and safe access for diverse stakeholders.
- Preservation and enhancement of the aquatic beauty of the river ecosystem without impairment of multiple uses.
- Preservation of existing agricultural landscapes bordering sovereign lands.
- Preservation of cultural resources and recognition of prehistoric and historic landscapes.
- Improved education of river users to promote stewardship of the resource, reduce conflicts, and enhance public safety.
- Protect the recreation experience and the Public Trust values by creatively managing growing recreational use.

As discussed in Chapter 1, Section 1.11, river use classes are applied to specific locations along on Green River sovereign lands based on a variety of parameters. Table 3.15 describes what the river use classes mean for community resource management.

Table 3.15. River Use Classes and Community Resources

River Use Class	What the Use Class Means for Community Resources
Class 1	Clustering of community resources such as infrastructure and recreation facilities may exist or occur in this class with concern for safety, practicality, conflicting uses, and resource degradation. Cultural resources may have been disturbed or damaged by existing infrastructure. More infrastructure and recreation structures are allowed than in Classes 5 and 6.
Class 2	Clustering of community resources such as infrastructure and recreation facilities may occur in this class with concern for safety, practicality, conflicting uses, and resource degradation. Higher potential for disturbance or damage to cultural resources from new authorizations and uses. More infrastructure and recreation structures are allowed than in Classes 5 and 6.
Class 3	Appropriate class for clustering of community resources such as infrastructure and recreation facilities but with an emphasis on mitigation to avoid impacts to ecosystem, water, and cultural resources. Moderate potential for disturbance or damage to cultural resources from new authorizations and uses.
Class 5	Preference for authorizations and uses maintaining current agricultural activities and the potential for future resource preservation and restoration; mitigation is heavily emphasized. Lower potential for disturbance or damage to cultural resources from new authorizations and uses. Certain authorizations and uses require more review than in Classes 1–3 (e.g., pedestrian bridges, boat docks).
Class 6	Preference for authorizations and uses consistent with existing resource protections. Fewer infrastructure and recreation facility options than in other classes; some authorizations and uses require more review. Lower potential for disturbance or damage to cultural resources from new authorizations and uses. New authorizations and uses may have to adhere to mitigation standards and regulations associated with conditions of conservation easements, deed restrictions, and other state or federal laws.

Agriculture

Management goals and objectives generally seek to support the viability of agriculture as a desirable land use along the river, the use of sustainable agricultural practices, the enhancement of wildlife habitat on agricultural lands, and the mitigation or reduction of environmental impacts to water quality and other important environmental attributes of the river corridor. Table 3.16 presents management goals and objectives for agriculture that are common to all classes. Figure 3.10 provides a list of BMPs for agriculture in the planning area, including some from Utah State University Water Quality Extension (Utah State University 2018). FFSL is willing to discuss the permitting of specific agricultural equipment or unique agricultural situations as questions arise.

Table 3.16. Agriculture Goals and Objectives Common to All Classes

Agriculture Goal 1: Support programs to preserve agricultural lands along the river through agricultural conservation easements or other tools that help ensure the long-term viability of agriculture and recognize its importance as a vital open space and cultural resource in the region.
Objective: Support other management agencies and partners to identify opportunities for the preservation of agricultural lands along the river.
Management Agencies: FFSL, UDAF, and NRCS
Intersecting Agencies: County, municipal, and tribal governments
Agriculture Goal 2: Discourage the establishment and transport of noxious and invasive weed species threatening both adjacent agricultural lands and the riparian ecosystem.
Objective: Provide outreach and education targeted to adjacent agricultural landowners regarding noxious and invasive weed species threatening riparian ecosystems and spreading to and from agricultural lands through canal systems and other irrigation infrastructure.
Objective: Work with adjacent landowners and other management agencies and partners to identify, map, and treat infestations of noxious weeds along the river, within adjacent riparian areas, and along canals and ditches.
Management Agencies: FFSL, BLM, NPS, and UDAF
Permitting Agencies: FFSL
Intersecting Agencies: County, municipal, and tribal governments and NRCS
Agriculture Goal 3: Support instream irrigation infrastructure that enhances or does not substantially impair the Public Trust.
Objective: Provide outreach and educational materials describing BMPs for pumps, fences, and other instream structures.
Objective: Work with adjacent landowners and other partners to identify and upgrade instream structures or agricultural infrastructure currently impacting navigation, recreation, water quality, fisheries and wildlife habitat, or aquatic beauty.
Objective: Work with adjacent landowners and other partners to identify and upgrade instream structures or agricultural infrastructure that are not water efficient.
Objective: Require the use of water-efficient agricultural infrastructure in new authorizations.
Management Agencies: FFSL, UDAF, NRCS, and conservation districts
Permitting Agencies: FFSL and DWRi
Intersecting Agencies: County, municipal, and tribal governments; DWR; and DWQ
Agriculture Goal 4: Support projects on adjacent agricultural lands that apply BMPs and conservation practices to reduce streambank erosion, improve water quality, and preserve or enhance wildlife habitat.
Objective: Work with private landowners and other management agencies to maintain, improve, or establish vegetated buffers, including riparian vegetative corridors, vegetated swales, or constructed wetlands to trap sediment, filter nutrients, and provide wildlife habitat.
Objective: Encourage the construction of off-stream watering systems that reduce streambank erosion, nutrient loading, and bacterial contamination while also reducing herd injuries and reducing health risks such as foot disease and injury in livestock.
Objective: Support targeted grazing practices to improve plant species composition of riparian areas.
Objective: Support responsible grazing techniques (such as provision of shade or supplemental feed in areas away from the river) to disperse livestock and reduce concentrations of livestock on the streambank.
Objective: Work with private landowners to remove any fencing currently impacting navigation, recreation, water quality, fisheries and wildlife habitat, or aquatic beauty.
Management Agencies: FFSL, DWQ, UDAF, and NRCS
Permitting Agencies: FFSL and DWRi
Intersecting Agencies: DWR

Best Management Practices

Use vegetation strips as barriers to prevent potential pollutants from running off into surface waters (conservation buffers).

Manage irrigation to increase efficiency and reduce non-point source pollution to surface waters.

Employ practices to conserve and reduce the amount of sediment reaching surface waters (e.g., planting vegetation strips, crop rotation, applied tillage practices, mulching).

Use various integrated weed management methods (e.g., physical control, chemical control, biological control) to treat weeds while protecting soil, water, and air quality. See Figure 3.2 (BMPs for Wildlife Species) for herbicide and pesticide BMPs.

Manage grazing to lessen the water quality impacts from livestock (e.g., off-channel watering systems).

Fences may extend riverward only to the water's edge or reasonably beyond to restrain livestock so as not to create a navigational hazard.

Agriculture infrastructure such as pump units and intake lines should have fish screens.

Figure 3.10. Best management practices for agriculture in the planning area.

Source: USU (2018).

Infrastructure

Infrastructure management goals and objectives generally seek to 1) minimize the impacts of new and existing infrastructure and 2) protect elements of the river system such as the river channel and its banks. The appropriate placement of infrastructure, proper infrastructure design and installation, and ongoing maintenance are a priority for FFSL to protect bank stability, fish and wildlife habitat, geomorphic processes, cultural resources, and adjacent land uses. Table 3.17 presents management goals and objectives for infrastructure that are common to all classes.

Table 3.17. Infrastructure Goals and Objectives Common to All Classes

Infrastructure Goal 1: Minimize the impact of new infrastructure.
Objective: Avoid creating navigational hazards or negatively impacting other Public Trust resources with infrastructure development.
Objective: Promote the restoration of instream and adjacent habitat impacted during construction of new infrastructure.
Objective: Coordinate with DWQ to ensure compliance with Utah Water Quality Act regulations (Utah Administrative Code R317) and numeric criteria for pollutants of concern to protect beneficial uses.
Management Agencies: FFSL, BLM
Permitting Agencies: FFSL, DWRi, DWQ, BLM, and USACE
Intersecting Agencies: County, municipal, and tribal governments and DWR
Infrastructure Goal 2: Support efforts to minimize the impact of infrastructure removal.
Objective: Avoid impacts to adjacent habitats during infrastructure removal.
Objective: Restore habitat impacted during infrastructure removal, as per a revegetation or restoration plan.
Objective: Coordinate with DWQ to ensure compliance with Utah Water Quality Act regulations (Utah Administrative Code R317) and numeric criteria for pollutants of concern to protect beneficial uses.
Management Agencies: FFSL, DWQ, and BLM
Permitting Agencies: FFSL, DWRi, and BLM
Intersecting Agencies: County, municipal, and tribal governments
Infrastructure Goal 3: Support projects that apply bioengineering methods to address bank and channel stability as appropriate.
Objective: Replace impermeable and hardened surfaces where possible.
Objective: Use densely rooted, native plant material to protect banks and decrease excessive erosion or scour and incorporate appropriately placed and sized rocks to anchor bioengineering as needed.
Management Agencies: FFSL, BLM
Permitting Agencies: FFSL, DWRi, BLM, and USACE
Intersecting Agencies: NRCS

Infrastructure Goal 4: Support flood-control measures minimizing impacts to the bed and bank of the Green River and maintaining or enhancing floodplain connectivity.
Objective: Coordinate as necessary with local government and other management agencies during emergency or high flow events that require flood control.
Objective: Support restoration of habitat damaged during flood events with an emphasis on bank stabilization and re-vegetation with appropriate species.
Management Agencies: DSPR, DWRe, USACE, and FEMA
Permitting Agencies: FFSL, DWRi, USACE, and FEMA
Intersecting Agencies: County, municipal, and tribal governments and DWRe

Figure 3.11 illustrates the correct placement of infrastructure in and along the Green River. Figure 3.12 provides a list of BMPs for the permitting, construction, and removal of infrastructure in the planning area.

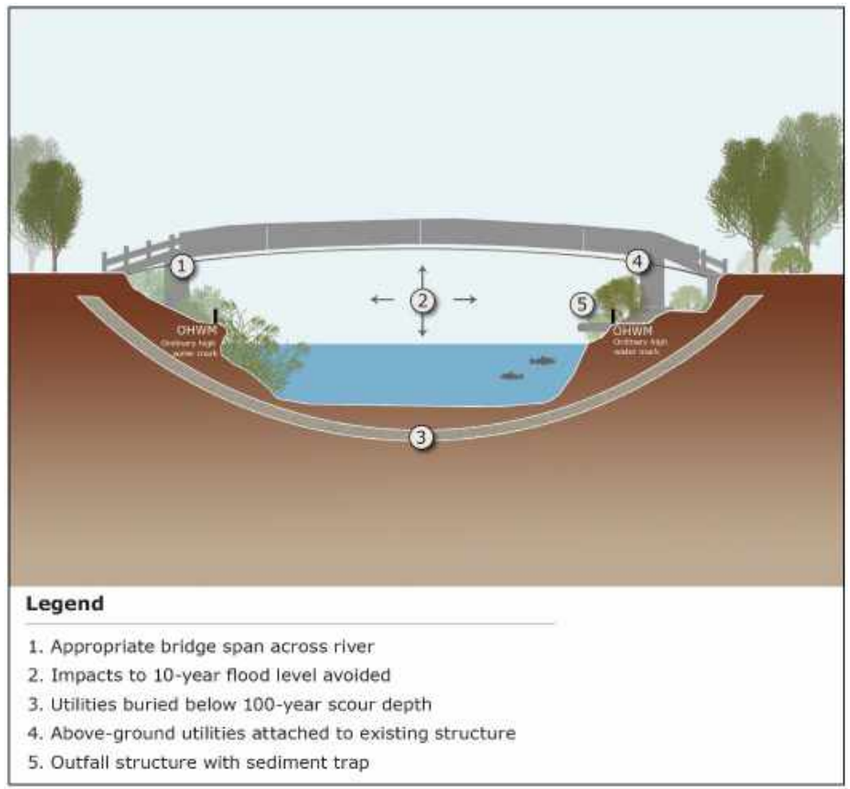

Figure 3.11. Correct placement of infrastructure in and along the Green River.

Best Management Practices

General

When removing existing bridges, above-grade utility crossings, outfall structures, and diversion dams, adhere to applicable CWA, stream alteration, and flood-control permits. These permits will require removal of the infrastructure without significantly or adversely affecting water quality and bank stability. Below-grade utility crossings should generally be abandoned in place after ensuring that pipes are plugged.

Habitat impacted during infrastructure removal should be restored during the same growing season as project implementation and seasonal conditions allow.

As unpermitted infrastructure is discovered on FFSL sovereign lands in the Green River corridor, owners should come into compliance through the permitting process or remove the infrastructure.

Although no minimum spacing of infrastructure is stipulated, the proximity of one facility to another should be considered as part of the permitting process. In general, pedestrian bridges should not be authorized within 500 feet of one another unless there are safety concerns, e.g., a busy road. Proposals for new vehicle bridges should be accompanied by a transportation analysis demonstrating its need. Utilities can be clustered to minimize disturbance. New utilities crossing the river, including powerlines, where voltages permit, should be buried according to the below-grade utility BMPs discussed below. If above-ground utilities must be installed, they should be attached to existing infrastructure (as appropriate based on infrastructure owner and where voltages permit) and not placed on the bed of the channel.

New infrastructure should be located in areas to minimize impacts to fluvial or geomorphic processes.

Existing infrastructure impacting Public Trust resources should be considered for removal or moved to another area, where practicable.

Infrastructure should be designed or modified with BMPs to minimize fish entrapment.

Design and construction of new bridges

The clear span of bridges should cross the main channel without piers or other obstructions in the channel.

Bridges should not impact the 10-year (10% annual chance) flood flow depth, velocity, water surface elevation, and channel section.

Bridges should be located (if possible) on a straight channel segment and oriented perpendicular to the flow.

Bridges should provide enough freeboard above the 10-year flood flow event to allow for clear navigation.

Bridge underpasses should accommodate pedestrian travel, bicycle traffic, and wildlife passage where appropriate.

Locate bridges frequently enough to provide adequate access but not so frequently to affect riparian habitat and boater use.

Design and construction of new below-grade utilities

Below-grade utility crossings should be buried below the 100-year (1% annual chance) local scour depth plus the long-term scour (local and general scour), and below the typical dredge depth.

The depth should be maintained across the floodplain or beyond a public structure, which will protect the utility from exposure by bank erosion.

Design and construction of new outfall structures to the Green River:

- New outfall structures should provide for dissipation of excess energy prior to discharge to the river.
- New outfall structures should have means for removal of settleable solids (e.g., sediment traps) prior to discharge.
- New outfall structures should not impede navigation.

Design and construction of new proposed diversion dams and intake canals

New diversion dams and canals should not impede navigation or passage of desirable fish species.

Proposed new dams should include a FEMA Conditional Letter of Map Revision, including mitigation of all adverse flooding impacts.

New diversion dams should contain structures to exclude fish and provide for dissipation of excess energy prior to flows entering the downstream river channel.

New diversion dams should have stable dam designs meeting all state dam safety requirements.

CWA and stream alteration permits should be obtained for new diversion dams.

Intake canals should be designed and installed to dissipate excess energy and erosion where water is diverted from the river.

Intake canal banks should be stable (preferably using bioengineering methods), thereby reducing contribution of sediment to the river.

Road construction or reconstruction below the OHWM on sovereign lands

Implement erosion- and sediment-control practices during project construction to protect water quality, such as silt fencing and straw wattles.

Implement dust control measures as needed.

Restore any vegetation or habitat damaged below the OHWM.

Figure 3.12. Best management practices for the permitting, construction, and removal of infrastructure in the planning area.

Cultural Resources

There is a higher likelihood of encountering intact historic and prehistoric cultural resources in river use classes with less development and fewer alterations. However, natural river meandering and other ongoing erosional processes can expose resources in almost any location or use class. Table 3.18 presents management goals and objectives for cultural resources that are common to all classes. Figure 3.13 provides a list of BMPs for cultural resources in the planning area.

Table 3.18. Cultural Resources Goals and Objectives Common to All Classes

Cultural Resources Goal 1: Recognize the importance of cultural resource protection on sovereign lands.
Objective: Collaborate with SHPO on the management of known cultural resources on Green River sovereign lands.
Objective: Consider how future projects using state funds would affect historic properties, according to Utah Code 9-8-404.
Objective: Adhere to Utah Code 9-9-401 through 9-9-406 regarding the discovery of human remains on sovereign lands.
Objective: Consider highlighting and developing protection strategies for cultural resources for public education and recreation purposes.
Objective: Develop and implement strategies to educate users about appropriate behaviors while observing and appreciating cultural resources.
Management Agencies: SHPO, tribal governments
Permitting Agencies: Not applicable
Intersecting Agencies: FFSL

Best Management Practices

For archaeological surveys, SHPO recommends resurveying areas if the previous survey is 10 or more years old, because the older survey may not use current inventory methods and requirements. For archaeological documentation, a full re-record is recommended when a previously documented site has significantly changed, when previous site forms have insufficient information, or if the current recorder or responsible agency feels a new record is necessary. When a previously documented site has associated records that are still acceptable, but minor changes or the fact that it has been recently visited/evaluated needs to be noted, an update is recommended as sufficient. New segments of linear features (e.g., canals, transmission lines, roads) that already have a Smithsonian Trinomial (a unique identifier assigned to an archaeological site) should be recorded under this category, but not in an abbreviated manner (Interagency Heritage Resources Work Group 2018).

Under Utah Code 9-8-307, "any person who discovers any archaeological resources on lands owned or controlled by the state or its subdivisions shall promptly report the discovery to the division." In addition, "any person who discovers any archaeological resources on privately owned lands shall promptly report the discovery to the division [Utah Division of State History]."

Before issuing any permits for projects adjacent to, over, or in the Green River, FFSL should notify SHPO before a project starts and before a permit is issued. Project notification will also allow FFSL to informally consult with SHPO on how to best complete FFSL's legal responsibilities regarding cultural resources. Treatment of unanticipated discoveries (i.e., cultural resources unexpectedly found during a project) in and along the Green River should be discussed during initial consultations to create a plan if these occur. For any Native American consultations, FFSL should follow the Utah Department of Natural Resources consultation plan created per the executive order issued by Governor Herbert on July 30, 2014.

It is illegal to damage, remove, or deface cultural resources.

Figure 3.13. Best management practices for cultural resources in the planning area.

Recreation

Public recreation is one of the components of the Public Trust FFSL is mandated to protect. The management goals and objectives for recreation seek to enhance and provide safe recreation experiences. The GRCMP does not intend to limit recreation but in some cases does support limited use in areas of high user conflict or certain areas of high wildlife habitat value. Table 3.19 presents management goals and objectives for recreation that are common to all classes. Figure 3.14 provides a list of BMPs for recreation in the planning area.

Table 3.19. Recreation Goals and Objectives Common to All Classes

Recreation Goal 1: Balance recreation needs, development, and protection of the natural environment.
Objective: Support the identification and development of areas where recreation infrastructure is most needed and is also appropriate, while reducing impacts to the natural environment and wildlife habitats.
Objective: Minimize the impacts of recreation infrastructure on the river environment and on existing and potential development (e.g., utility corridors) through authorization conditions.
Objective: Limit recreation, if needed, to protect sensitive areas or wildlife.
Objective: Ensure new development does not inhibit or negatively affect existing recreation or prevent future recreation infrastructure and access during the authorization process.
Objective: Coordinate with agencies, boating groups, and partners to make river stewardship materials available to recreation users (perhaps as part of river etiquette materials) (see Figure 3.18).
Management Agencies: FFSL, DSPR, and BLM
Permitting Agencies: FFSL, DSPR, DWRi, USACE, USFWS, and BLM
Intersecting Agencies: County, municipal, and tribal governments; DWR; DWRe; and NPS
Recreation Goal 2: Reduce recreation conflicts caused by growing recreational use or different types of recreation users (e.g., motorized and non-motorized users).
Objective: Support state and local law enforcement efforts to minimize boater speeding and enforce wake rules.
Objective: Coordinate with agencies, boating groups, and partners to widely disseminate river etiquette materials (see Figure 3.18).
Objective: Consider limiting or prohibiting new recreation authorizations in areas of high recreation conflict.
Objective: Consider adding new restrictions to existing recreation authorizations to reduce user conflicts.
Objective: Collaborate with other management and permitting agencies to creatively address growing numbers of recreation users, while protecting the recreation experience and Public Trust Values.
Objective: Coordinate with the BLM to ensure consistency in recreation permitting.
Management Agencies: FFSL, DSPR, and BLM
Permitting Agencies: FFSL, DSPR, and BLM
Intersecting Agencies: County, municipal, and tribal governments; state and local law enforcement; and NPS
Recreation Goal 3: Encourage recreational opportunities in and along the Green River where appropriate and allow for a variety of recreation interests.
Objective: Coordinate with cities, counties, agencies, and partners to improve existing recreation infrastructure and to add recreation infrastructure where needed (e.g., boater access points, fishing platforms).
Objective: Coordinate with management partners to develop, disseminate, and update recreation information (e.g., brochures, website, and signage) when changes occur or as needed.
Management Agencies: FFSL, DSPR, and BLM
Permitting Agencies: FFSL and BLM
Intersecting Agencies: County, municipal, and tribal governments
Recreation Goal 4: Support development and maintenance of recreation infrastructure.
Objective: Support the improvement or removal of recreation infrastructure that is dysfunctional, obsolete, or incompatible with other uses or river classes as opportunities allow.
Objective: Limit new bridges and dams to protect aesthetic beauty, minimize navigational hazards, and promote a positive experience for recreationists on the river.
Management Agencies: FFSL and DSPR
Permitting Agencies: FFSL, BLM, and USFWS
Intersecting Agencies: County, municipal, and tribal governments and DWR
Recreation Goal 5: Integrate recreation and restoration opportunities in and along the river as appropriate.
Objective: Consider recreational navigation of the river when designing restoration projects.
Objective: Evaluate recreation authorization applications to determine if there are opportunities for restoration.
Management Agencies: FFSL and BLM
Permitting Agencies: FFSL, DWRi, and USACE
Intersecting Agencies: County, municipal, and tribal governments; DWR; DSPR; DWRe; and USFWS

Best Management Practices

Develop boater access points and portages with safe, flexible, and functional designs to meet user needs at different flow levels of the river and to accommodate boating parties of varying sizes and skill levels.

Use a sloping riverbank boat access design for boater access points, which allows for variable stream flows and stream levels, is easy to maintain, is inexpensive, and does not trap river debris. Concrete sloping ramps are preferred.

Locate bridges and boater access points in areas that already have human impacts and are easily visible from both the river and shore.

Consider the proximity of one facility to another as part of the authorization process, even though no minimum spacing is stipulated for recreation infrastructure such as boater access points.

Modify as needed structural water-conveyance devices with alternatives that allow for recreation improvements.

Ensure recreation infrastructure protects as much native and sensitive habitat as feasible; enhance developed areas as needed with additional planting of native vegetation.

Avoid sensitive environments and encourage new recreation infrastructure construction in previously disturbed areas.

Choose recreation infrastructure that maintains river function and wildlife habitat, and that is sustainable and has a low environmental impact.

Ensure recreation infrastructure accounts for flooding.

Install trash and recycling receptacles near recreation infrastructure and at other places where users approach the river.

Swasey's Landing concrete boat ramp.

Consider installing restrooms near high-use recreation infrastructure.

Avoid creating barriers to wildlife movement with new recreation infrastructure.

Use NPS's design guide for canoe and kayak launches (NPS 2004), NPS's guidelines for designing and building access sites for carry-in watercraft (NPS and River Management Society 2018), or other relevant guidance as an information source for boat launch specifications and signage. Decision-making should account for local conditions.

Consider the preferred concept for boater access points, which includes associated parking with room for boat trailers, safe access to a concrete ramp such as wood stairs or gentle slopes, retention of structures along the ramp to protect banks, appropriate ramp slopes for boat launching and/or take-out, planting of vegetation to protect banks and provide aesthetic beauty, a nearby area for restrooms and waste bins, and convenient access to trail systems.

Refer to Figure 3.18 for suggested stewardship and river etiquette in the planning area.

Figure 3.14. Best management practices for recreation in the planning area.

Access

Management goals and objectives generally seek to facilitate safe access while protecting private landowners' rights adjacent to the river. Ensuring proper spacing of access points and minimizing impacts resulting from limited access (e.g., highly concentrated use, user conflicts, and habitat degradation) are a priority for FFSL. In support of public safety, private landowner access in the form of trails, boat docks, boat ramps, etc. are generally not permitted. Table 3.20 presents management goals and objectives for access that are common to all classes. Figure 3.15 provides a list of BMPs for access in the planning area.

Table 3.20. Access Goals and Objectives Common to All Classes

Access Goal 1: Balance needs for access with river protection.
Objective: Evaluate access points in an area before approving new access as part of an authorization application process.
Objective: Support development of new access points and associated amenities such as trash and recycling receptacles where appropriate through coordination with cities, counties, agencies, and partners.
Objective: Minimize the impacts of new access points on the river environment and Public Trust resources through appropriate design and siting during the authorization application process.
Objective: Work with cities, counties, and communities to identify the most appropriate locations for new access facilities and encourage the sharing of access points to minimize new infrastructure (e.g., bridges).
Management Agencies: FFSL, DSPR, DWR, DWQ, and BLM
Permitting Agencies: FFSL, DWRi, BLM, and USACE
Intersecting Agencies: County, municipal, and tribal governments

Access Goal 2: Ensure that new development does not unnecessarily impede access through the authorization process.
Objective: Evaluate authorization applications to confirm that projects do not limit, conflict with, or prevent current or future access (e.g., a low-clearance bridge may stop boaters, and construction of an outfall structure could prevent access for flood control).
Objective: Support siting new river access points in areas connecting to trails, campgrounds, and other recreation opportunities.
Management Agencies: FFSL, BLM
Permitting Agencies: FFSL, DWRi, BLM, and USACE
Intersecting Agencies: County, municipal, and tribal governments
Access Goal 3: Where possible, remove obstacles limiting or preventing access.
Objective: Improve navigation on the river through removal of navigational hazards.
Objective: Work to mitigate nonnative species that may impede river access (e.g., Russian olive, Russian knapweed, tamarisk).
Objective: Support the decommissioning of bridges and boater access points located in low-value areas or that are poorly designed.
Management Agencies: FFSL, DSPR, and DWR
Permitting Agencies: FFSL
Intersecting Agencies: County, municipal, and tribal governments

Best Management Practices

Develop boater access points and portages with safe, flexible, and functional designs to meet user needs at different flow levels of the river and to accommodate boating parties of varying sizes and skill levels.

Use a sloping riverbank boat access design for boater access points, which allows for variable streamflows and stream levels, is easy to maintain, is inexpensive, and does not trap river debris. Concrete sloping ramps are preferred.

Locate bridges and boater access points in areas that already have human impacts and are easily visible from both the river and shore.

Consider the proximity of one facility to another as part of the authorization application process, even though no minimum spacing is stipulated for recreation infrastructure such as boater access points.

Maintain or improve aesthetic beauty when designing new recreation facilities.

Support adherence to Americans with Disability Act accessibility guidelines in project designs.

Modify as needed structural water-conveyance devices with alternatives that allow for recreation improvements.

Manage invasive and nuisance species through the authorization process where possible.

Within permits, require restoration of vertical riverbanks to a gentle relief using laying back dredge berms or levees where possible to reduce erosion and improve public access and safety.

To allow passage of boats, ensure that the clear span of new bridges crosses the main channel without piers or other obstructions in the channel.

Use NPS's design guide for canoe and kayak launches (NPS 2004), NPS's guidelines for designing and building access sites for carry-in watercraft (NPS and River Management Society 2018), or other relevant guidance as an information source for boat launch specifications and signage. Decision-making should account for local conditions.

Consider conflicting access uses when developing access points (e.g., boater access should consider nearby recreational fishing).

Work with local general plans, planning organizations, and stakeholders in the site selection of new utility facilities; avoid siting utilities in areas with flood.

Share rights-of-way with other utilities such as roads, canals, and railroads; use land adjacent to other infrastructure to minimize access points.

Refer to Figure 3.18 for suggested stewardship and river etiquette in the planning area.

Figure 3.15. Best management practices for access in the planning area.

Public Safety

Table 3.21 presents management goals and objectives for public safety that are common to all classes. Figure 3.16 provides a list of BMPs for public safety in the planning area.

Table 3.21. Public Safety Goals and Objectives Common to All Classes

Public Safety Goal 1: Improve boater safety by addressing navigational hazards.
Objective: Support removal of temporary navigational hazards such as garbage or large woody debris (if a significant hazard).
Objective: Mitigate permanent navigational hazards when possible or incorporate into restoration activities that allow for avoidance.
Objective: Support removal of abandoned fencing material and agricultural equipment from the river.
Management Agencies: FFSL, DSPR, and DWR
Permitting Agencies: FFSL and DWRi
Intersecting Agencies: County, municipal, and tribal governments
Public Safety Goal 2: Evaluate new authorization applications with public safety in mind and require any needed public safety measures (e.g., for navigation, fire prevention, or traffic control).
Objective: Review new infrastructure design to reduce the potential for navigational hazards (e.g., water flow can expose buried pipes, bridge height can affect boater clearance) or other public safety concerns.
Objective: Include specific public safety measures in authorizations where appropriate.
Management Agencies: FFSL and DSPR
Permitting Agencies: FFSL
Intersecting Agencies: County, municipal, and tribal governments and state and local law enforcement
Public Safety Goal 3: Address safety issues in the planning area.
Objective: Support state and local law enforcement efforts to minimize boater speeding and enforce wake rules.
Objective: Improve boater and recreation user safety by promoting safe boating practices, including appropriate safety equipment, in conjunction with DSPR.
Objective: Identify ways to reduce overcrowding when it occurs in small sections of the river or at boater access points (e.g., promote the use of other river areas, encourage use on days with lower levels of recreation, encourage use at less popular times of day).
Objective: Partner with federal, state, and local agencies (e.g., DSPR, BLM, law enforcement) to address safety issues such as boat speed, fire, and flood. Consider jointly funding additional safety and enforcement personnel with other management agencies.
Objective: Support crime prevention and enforcement/patrolling by coordinating with other entities providing such services.
Objective: To ensure safe water quality, coordinate with DWQ to ensure compliance with Utah Water Quality Act regulations (Utah Administrative Code R317).
Management Agencies: FFSL, DSPR, and BLM
Permitting Agencies: FFSL, BLM, and DWQ
Intersection Agencies: County, municipal, and tribal governments and state and local law enforcement

Best Management Practices

Signage directing boaters to avoid a navigational hazard through use of a portage.

Educate river users on safe boating practices (e.g., Utah Boating Act regulations, BLM requirements for boaters).

Carefully consider new infrastructure design to maintain enough clearance for boaters, and ensure maximum space for natural river movement (e.g., bridges can be constriction points and may cause flood control issues).

Within permit conditions, require restoration of vertical riverbanks to a gentler relief using laying back dredge berms or levees where possible. These measures will help reduce erosion and improve public access and safety. Refer to Riparian Buffer Design Guidelines for Water Quality and Wildlife Habitat Functions on Agricultural Landscapes in the Intermountain West (Johnson and Buffler 2008).

Locate boater access points in river eddies of sufficient size to accommodate several boats to protect the boaters and ramps from the river current and reduce erosion. Avoid steep slopes.

Use NPS's design guide for canoe and kayak launches (NPS 2004), NPS's guidelines for designing and building access sites for carry-in watercraft (NPS and River Management Society 2018), other agency design standards, and other relevant planning documents as guidance for safe boater access points and consider appropriate signage. Decision-making should account for local conditions.

Design surface trail infrastructure (e.g., bridges) in the planning area with appropriate passing widths. Limit or eliminate blind corners.

Educate adjacent landowners on defensible space measures to protect against fire.

Incorporate bioengineering methods to stabilize shorelines (and protect vegetation) for sheltering boater access points.

Contact the local health department to report flooding and other public health concerns. Direct other public safety concerns to local police departments.

Refer to Figure 3.18 for suggested stewardship and river etiquette in the planning area.

Figure 3.16. Best management practices for public safety in the planning area.

Education

Goals and objectives generally seek to support and expand educational programs and information about FFSL's role and jurisdiction and the value of the Green River. During the public involvement process, commenters also identified a need to educate river users about proper river etiquette, private property, and boating regulations. Table 3.22 presents management goals and objectives for education. Figure 3.17 provides a list of BMPs for education in the planning area.

Table 3.22. Education Goals and Objectives Common to All Classes

Education Goal 1: Support education about the importance of the Green River and the need to conserve it as a healthy, functioning ecosystem.
Objective: Support development of information and public awareness programs for adjacent landowners and authorization applicants on the importance of a healthy river ecosystem and how to reduce impacts to the river.
Objective: Support partnerships, research programs, and school education programs in the planning area; integrate research results into management and planning.
Management Agencies: FFSL, DSPR, BLM, NPS, and DWR
Permitting Agencies: FFSL and BLM
Intersecting Agencies: County, municipal, and tribal governments; UDAF; and NRCS
Education Goal 2: Expand informational material regarding FFSL's role in management, jurisdiction, and application of multiple-use management strategies of the Green River.
Objective: Provide potential applicants with a clear authorization application process through the FFSL website and other media.
Objective: Provide potential applicants with a clear understanding of FFSL's role in the management and jurisdiction of the Green River through the FFSL website and other media.
Management Agencies: FFSL
Permitting Agencies: FFSL
Intersecting Agencies: County, municipal, and tribal governments; DSPR; DWRi; DWQ; and BLM

Education Goal 3: Provide information to river users on proper stewardship and river etiquette.
Objective: Coordinate with agencies, boating groups, and partners to widely disseminate stewardship and river etiquette materials (see Figure 3.18).
Objective: Coordinate with agencies responsible for prevention and enforcement to ensure their familiarity with the materials and to assist with education efforts.
Management Agencies: FFSL, DSPR, BLM, and DWR
Permitting Agencies: FFSL and BLM
Intersecting Agencies: County, municipal, and tribal governments; UDAF; NRCS; and SHPO
Education Goal 4: Be informed about ongoing research efforts on the Green River.
Objective: Incorporate data and conclusions from ongoing research into management decisions.
Management Agencies: DWRe, DWR, UGS, UDAF, BLM, NPS, USFWS, USBR, other state and federal agencies, and private and collaborative groups
Permitting Agencies: FFSL
Intersecting Agencies: County, municipal, and tribal governments; Flaming Gorge Technical Working Group; and Upper Colorado River Endangered Fish Recovery Program

Best Management Practices

Coordinate with other agencies, universities, and conservation organizations to establish partnerships to meet education and research goals and objectives.

Regularly identify any research needs that could result in better management of the planning area.

Refer to Figure 3.18 for suggested stewardship and river etiquette in the planning area.

Figure 3.17. Best management practices for education in the planning area.

Figure 3.18 provides suggested stewardship and river etiquette in the planning area. These guidelines are suggestions only to help ensure a positive and safe river experience and to help protect the river ecosystem; they are not enforceable rules or requirements. They are compiled primarily from BLM guidelines for Idaho rivers (BLM 2014), USFS guidelines for the Snake River (USFS 2019), and *Highlights from Utah's Boating Laws & Rules* (DSPR 2015).

SUGGESTED STEWARDSHIP AND RIVER ETIQUETTE

Your actions directly affect the experience of others on the river. The following guidelines can help ensure a positive and safe river experience for everyone, while helping to protect the river ecosystem.

General protocol

Read the river guidebooks, permit guidelines (if one is required), and appropriate agency publications before you go.

Always respect the privacy and rights of private landowners. Do *not* assume you can get out anywhere along the river; know the boundaries of the public lands. Some land above the OHWM is private property and should be avoided unless you have permission from the landowners.

Pack out all trash and dispose of it or recycle it in appropriate receptacles. Do not dump it into the water or on adjacent land.

Do not feed, disturb, or harass wildlife. Do not trample vegetation or biological soil crusts. Do not pollute the water.

Be friendly, helpful, and considerate. Avoid confrontational behavior.

Be respectful of those around you. Keep voices, music, and other noise at low levels.

If you bring a dog, keep it under control and respect others. Clean up all dog waste and pack it out.

Respect paleontological, cultural, and archaeological sites. Do not disturb these sites. It is illegal to damage, remove, or deface such sites. Do not touch petroglyphs or pictographs.

Graffiti is absolutely prohibited (this includes graffiti on adjacent private property; carving on rocks, rock walls, or trees; and graffiti on pictographs and petroglyphs).

Don't touch agricultural equipment (e.g., pumps) in the river or on the banks of the river. Give it a wide berth.

Know your limits. Be aware of dangerous situations and avoid taking excessive risks.

Boat ramp manners

If the ramp is busy, be patient and wait your turn.

Use the ramp *only* for loading and unloading from boats from a vehicle or trailer. Complete your launch quickly.

Pack or unpack your boat to the side of the launch area. After your trip, clean your boat to the side of the launch area.

Allow others to go first if they have a loaded boat in the water and are ready to take off.

Once your boat is in the water, move it out of the way so others can launch behind you.

Do not block a ramp with an unattended boat or vehicle.

River encounters

Communication and common sense are the key to successful interaction with other river users.

Give other boaters a lot of space, especially in rapids.

As a general rule, boats moving downstream have the right-of-way. However, they may not intentionally block navigation. Boats moving upstream through rapids should eddy out when possible and let the downstream craft pass. In addition, Utah's State Boating Act indicates that boaters in less maneuverable craft generally have the right-of-way (motorized boats are considered the most maneuverable). However, a motorized boat powering through a rapid may not be able to stop. An exception to these rules is when a boat has either committed to or entered a rapid from upstream or downstream. In this situation, all other craft should wait until the motorized boat is clear before proceeding.

Non-motorized boats should be aware that motorized boats can only travel in narrow channels in some sections of the river. When you see a motorized boat coming, pull to one side of the channel if possible and let it by.

Jet boats draw less water at higher speeds when the boat is on plane; they can't always slow down due to shallow water. Non-motorized boats should give the jet boat the deep channel if you have the choice.

Motorized boats should slow to no wake as they pass other boats and at boater access points.

Yield on the river where appropriate. If other parties are going faster, allow them to pass. If you are going faster than another party, group your boats together before passing.

Avoid making heavy waves or wakes. Utah's State Boating Act requires wakeless speed within 150 feet of another boat, a swimmer, water skiers, a shore fisherman, a designated swimming area, and boat launches and docks. Boaters who improperly create a wake may be cited with a Class C misdemeanor.

Use caution when navigating narrow river channels to prevent collision with other boaters and wading anglers.

If you encounter anglers, give them plenty of space. They have a need for space and quiet.

Watch for swimmers and give them plenty of room.

Be cautious if anchoring. Drop anchor only in eddies and slower water. Keep a knife handy and be ready to sacrifice your anchor if necessary.

Camping

Small groups should leave large camps for bigger groups.

Sending a boat ahead to secure a camp is discouraged.

Follow applicable regulations for group size, disposal of human waste, the use of fire and firewood, and dishwashing.

Tread lightly: use low-impact camping and hiking practices. Stay on main trails and disturbed areas. Avoid fragile soils such as biological soil crusts.

Follow all permit conditions.

Figure 3.18. Suggested stewardship and river etiquette in the planning area.

3.6 Coordination Framework

Multiple cities, counties, and state and federal agencies are involved in management and permitting in the planning area. Although FFSL has management jurisdiction from top of bank to top of bank, we are responsible for considering the protection of navigation, fish and wildlife habitat, aquatic beauty, public recreation, and water quality in keeping with the Public Trust. Because of this, FFSL has an interest in improving coordination with other agencies and Green River partners with respect to management, permitting, and research. Permitting new activities can have important implications on the management of the Green River. Research can inform and improve Green River management objectives and actions. Currently there is a need for more frequent coordination between and within these spheres. Table 3.23 lists the primary roles of state, federal, and other regulatory and coordinating bodies in permitting, management, and research on the Green River.

Table 3.23. Primary Roles of State, Federal, and other Regulatory and Coordinating Bodies in Permitting, Management, and Research on the Green River

Agency		Permitting and Compliance	Management	Research
Utah Department of Natural Resources	FFSL	X	X	X
	DOGM	X	X	
	DSPR	X	X	
	DWR	X	X	X
	DWRe		X	X
	DWRi	X		
	UGS	X		X
Other state agencies	DWQ	X	X	X
	SHPO	X	X	X
	SITLA	X	X	
	UDAF		X	X
	UDOT		X	
Federal agencies	BLM	X	X	X
	EPA		X	
	FEMA		X	X
	FERC	X	X	X
	NPS	X	X	X
	NRCS		X	X
	USACE	X		
	USBR	X	X	X
	USFWS	X	X	X
Tribal	Ute Indian Tribe		X	
Local government	Emery County		X	
	Grand County		X	X
	Uintah County		X	
	Wayne County		X	
	Municipalities		X	
Collaborative management groups	Flaming Gorge Technical Working Group		X	X
	Upper Colorado River Endangered Fish Recovery Program		X	X

Broader geographic coordination is also required in management and permitting for the planning area. As described in Chapter 1, in addition to the Green River, FFSL has jurisdiction over the Colorado River. In some cases, management activities, e.g., weed management, should be implemented at a scale that extends beyond the Green River, and that includes coordination and support for activities on tributaries and adjacent lands.

Permitting

As illustrated in Chapter 1, Figure 1.2, multiple entities have jurisdiction over the Green River and its immediate environs. Each entity currently requires a different permit, in part because each focuses on a different aspect of river management, e.g., DWRi (water rights) and USACE (placement of fill below the OHWM).

Research and Management Implementation

The Utah State University Center for Colorado River Studies focuses on management of the Colorado River and other major rivers of the American Southwest, including the Green River. It undertakes critical studies to inform how different parts of the Colorado River and its tributaries can be effectively managed. Their website lists recently published research, news, educational materials, links to partners, and provides educational materials. The collaborative management groups listed in Table 3.23 and organizations such as the Southeast Utah Riparian Partnership also have websites, with access to research and management strategies for the Colorado River and its tributaries. Ongoing coordination of Green River research and its management implications is necessary for the success of projects such as noxious and invasive weeds management, restoration, and bank stabilization.

Recent research on the Green River ranges from topics such as channel narrowing to climate change to proposed changes to Flaming Gorge Dam operations and is implemented by academic researchers, state agencies, local governments, and stakeholder groups. Much of this research has practical application and may inform future management to improve water quality and fish and wildlife habitat conditions, among other aspects of the Public Trust. For large projects, partnerships are needed, with different actors taking on roles as champion, planner, funder, and implementer. Although the GRCMP does not prioritize specific projects, FFSL supports projects that produce information and data that can help manage and improve the conditions of the Public Trust resources: navigation, fish and wildlife habitat, aquatic beauty, public recreation, and water quality.

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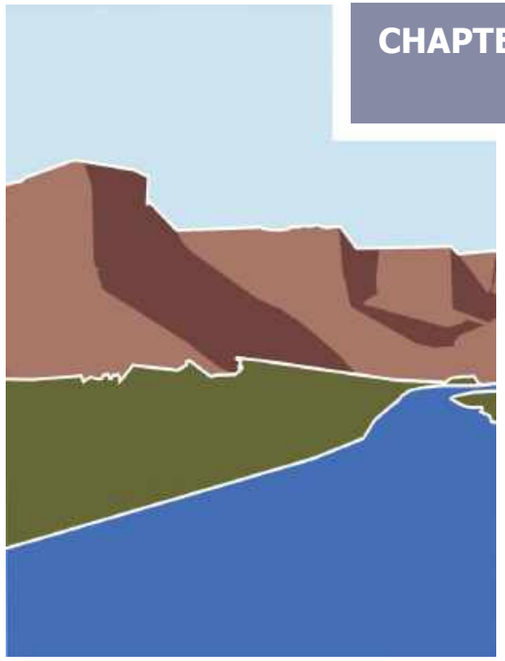
CHAPTER 4 – LITERATURE CITED



Alexander, J.S. 2007. The timing and magnitude of channel adjustments in the upper Green River below Flaming Gorge Dam in Browns Park and Lodore Canyon, Colorado: An analysis of the pre-and post-dam river using high-resolution dendrogeomorphology and repeat topographic surveys: Utah State University. Available at: https://pqdtopen.proquest.com/pubnum/1454881.html. Accessed March 2019.

Allred, T.M., and J.C. Schmidt. 1999. Channel narrowing by vertical accretion along the Green River near Green River, Utah. *Geological Society of America Bulletin* 111:1757–1772. DOI: 10.1130/0016-7606(1999)111<1757:CNBVAA>2.3.CO;2.

American Rivers. 2017. Upper basin of the Colorado River. Available at: https://www.americanrivers.org/river/upper-basin-colorado-river/. Accessed October 24, 2018.

American Whitewater. 2005. International Scale of River Difficulty. Available at: https://www.americanwhitewater.org/content/Wiki/safety:start#vi._international_scale_of_river_difficulty. Accessed October 11, 2018.

———. 2017. Green River, Utah. Ouray to Green River Town. Available at: https://www.americanwhitewater.org/content/River/detail/id/1854/. Accessed October 18, 2018.

Andrews, E.D. 1986. Downstream effects of Flaming Gorge Reservoir on the Green River, Colorado and Utah. *Geological Society of America Bulletin* 97:1012–1023. DOI: 10.1130/0016-7606(1986)97<1012.

Auerbach, D.A., D.M. Merritt, and P.B. Shafroth. 2013. Tamarix, Hydrology, and Fluvial Geomorphology. In *Tamarix: a Case Study of Ecological Change in the American West*, A.A. Sher and M.F. Quigley, eds., pp. 99–122. Oxford University Press.

Bauer, B.O., M.S. Lorang, and D.J. Sherman. 2002. Estimating Boat-Wake-Induced Levee Erosion using Sediment Suspension Measurements. *Journal of Waterway, Port, Coastal, and Ocean Engineering* 128(4):152–162. DOI: 10.1061/(ASCE)0733-950X(2002)128:4(152). Available at: https://www.researchgate.net/publication/245292815_Estimating_Boat-Wake-Induced_Levee_Erosion_using_Sediment_Suspension_Measurements. Accessed October 11, 2017.

Bentrup, G. 2008. *Conservation Buffers: Design Guidelines for Buffers, Corridors, and Greenways*. Available at: https://www.srs.fs.usda.gov/pubs/gtr/gtr_srs109.pdf. Accessed November 8, 2018.

Bestgen, K.R. 2015. *Aspects of the Yampa River Flow Regime Essential for Maintenance of Native Fishes*. Natural Resource Report NPS/NRSS/WRD/NRR—2015/962. Fort Collins, Colorado: Larval Fish Laboratory, Department of Fish, Wildlife, and Conservation Biology, Colorado State University.

Bestgen, K.R., and A.A. Hill. 2016. *River Regulation Affects Reproduction, Early Growth, and Suppression Strategies for Invasive Smallmouth Bass in the Upper Colorado River Basin*. Final report submitted to the Upper Colorado River Endangered Fish Recovery Program. Denver, Colorado: Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins. Larval Fish Laboratory Contribution 187.

Bestgen, K.R., C.D. Walford, G.C. White, J.A. Hawkins, M.T. Jones, P.A. Webber, M. Breen, J.A. Skorupski, Jr., J. Howard, K. Creighton, J. Logan, K. Battige, and F.B. Wright. 2018. *Population Status and Trends of Colorado Pikeminnow in the Green River Sub-Basin, Utah and Colorado, 2000–2013*. Final report of the Larval Fish Laboratory, Colorado State University to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Bestgen, K.R., G.B. Haines, and A.A. Hill. 2011. *Synthesis of Flood Plain Wetland Information: Timing of Razorback Sucker Reproduction in the Green River, Utah, Related to Stream Flow, Water Temperature, and Flood Plain Wetland Availability*. Final report. Prepared for the Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado. Larval Fish Laboratory Contribution 163.

Bestgen, K.R., R.C. Schelly, R.R. Staffeldt, M.J. Breen, D.E. Snyder, and M.T. Jones. 2017. First reproduction by stocked bonytail in the Upper Colorado River Basin. *North American Journal of Fisheries Management* 37(2)445–455. DOI: 10.1080/02755947.2017.1280571.

Bezzerides, N., and K. Bestgen. 2002. *Status Review of Roundtail Chub* Gila robusta*, Flannelmouth Sucker* Catostomus latipinnis *and Bluehead sucker* Catostomus discobolus *in the Colorado River Basin.* Final report. Prepared for the U.S. Department of Interior, Bureau of Reclamation, Division of Planning. Denver, Colorado.

Birken, A.S., and D.J. Cooper. 2006. Processes of Tamarix invasion and floodplain development along the lower Green River, Utah. *Ecological Applications* 16:1103–1120. DOI: 10.1890/1051-0761(2006)016[1103:POTIAF]2.0.CO;2.

Blackstock, A. 2005. *A Green River Reader*. Salt Lake City: University of Utah Press.

Bon, R.L., and S. Heuscher. 2008. Small Mines in Utah 2008. Salt Lake City, Utah: Utah Geological Survey, Utah Department of Natural Resources. Available at: https://geology.utah.gov/map-pub/maps/geologic-resource-maps/. Accessed August 31, 2018.

Borland, W.M., and C.R. Miller. 1960. Sediment Problems of the Lower Colorado River. *Journal of the Hydraulics Division* 86:61–87.

Bureau of Land Management (BLM). 2007. *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (The Gold Book)*. Available at: https://www.blm.gov/sites/blm.gov/files/Table%20of%20Contents.pdf. Accessed February 5, 2019.

———. 2008a. *Vernal Field Office Proposed Resource Management Plan and Final Environmental Impact Statement*. Available at: https://eplanning.blm.gov/epl-front-office/eplanning/planAndProjectSite.do?methodName=dispatchToPatternPage&currentPageId=98982. Accessed September 5, 2018.

———. 2008b. *Moab Field Office Proposed Resource Management Plan and Final Environmental Impact Statement*. Available at: https://eplanning.blm.gov/epl-front-office/eplanning/planAndProjectSite.do?methodName=dispatchToPatternPage&currentPageId=94940. Accessed September 5, 2018.

———. 2008c. *Monticello Field Office Record of Decision and Approved RMP*. Available at: https://eplanning.blm.gov/epl-front-office/eplanning/planAndProjectSite.do?methodName=dispatchToPatternPage&currentPageId=98873. Accessed October 25, 2018.

———. 2008d. *Richfield Field Office Record of Decision and Approved Resource Management Plan*. Available at: https://eplanning.blm.gov/epl-front-office/eplanning/planAndProjectSite.do?methodName=dispatchToPatternPage&currentPageId=99311. Accessed October 25, 2018.

———. 2008e. *Price Field Office Record of Decision and Approved Resource Management Plan*. Available at: https://eplanning.blm.gov/epl-front-office/eplanning/planAndProjectSite. do? methodName=dispatchToPatternPage&currentPageId=96976. Accessed October 25, 2018.

———. 2012. *Desolation and Gray Canyons of the Green River Special Management Area Business Plan*. U.S. Department of the Interior, Bureau of Land Management, Price Field Office. Available at: https://www.blm.gov/sites/blm.gov/files/documents/files/UT_Business_Plan_Price_DesolationGrayCanyons.pdf. Accessed October 18, 2018.

———. 2014. River Etiquette. Available in-house at SWCA Environmental Consultants, Salt Lake City, Utah.

———. 2016. Potential Fossil Yield Classification (PFYC) System for Paleontological Resources on Public Lands. IM 2016-124. Available at: https://www.blm.gov/policy/im-2016-124. Accessed September 28, 2018.

———. n.d. [2018]. Labyrinth Canyon River. Available at: https://www.blm.gov/visit/labyrinth-canyon. Accessed October 25, 2018.

———. n.d. [2019]. BLM National. What We Manage. Available at: https://www.blm.gov/about/what-we-manage/national. Accessed August 20, 2018.

Clover, E.U., and L. Jotter, L. 1944. Floristic studies in the canyon of the Colorado and tributaries. *American Midland Naturalist* 32:591–642.

Colburn, K. 2012. *Integrating Recreational Boating Considerations Into Stream Channel Modification & Design Projects*. Available at: https://www.americanwhitewater.org/content/Document/view/documentid/1006/. Accessed August 19, 2019.

Colorado State University. 2000. *Creating an Integrated Weed Management Plan: A Handbook for Owners and Managers of Lands with Natural Values*. Caring for the Land Series, Vol. IV. Colorado Department of Agriculture, Colorado State University Division of Plant Industry. Available at: https://training.fws.gov/resources/course-resources/pesticides/IPM/IWMhandbooktext.pdf. Accessed December 11, 2018.

Cordova, L. 2018. *Incident Reporting Guidance Document (re: Utah Oil & Gas Conservation General Rules R649-3-32 Incident Reporting).* Utah Division of Oil, Gas and Mining. Available at: https://oilgas.ogm.utah.gov/pub/Publications/Handbooks/IncidentReporting.pdf. Accessed February 5, 2019.

Corenblit, D., N.S. Davies, J. Steiger, M.R. Gibling, and G. Bornette. 2015. Considering river structure and stability in the light of evolution: Feedbacks between riparian vegetation and hydrogeomorphology. *Earth Surface Processes and Landforms* 40:189–207. DOI: 10.1002/esp.3643.

Coombs, E.M., J.K. Clark, and G.L. Piper. 2004. *Biological Control of Invasive Plants in the United States*. Corvallis, Oregon: Oregon State University Press.

Cosco, J.M. 1995. *Echo Park: Struggle for Preservation*. Boulder, Colorado: Johnson Books.

Crone, A.J., and R.L. Wheeler. 2000. *Data for Quaternary faults, liquefaction features, and possible tectonic features in the Central and Eastern United States, east of the Rocky Mountain front*. U.S. Geological Survey Open-File Report 00-260. Available at: https://pubs.usgs.gov/of/2000/ofr-00-0260/ofr-00-0260.pdf. Accessed January 15, 2019.

Cosco, J.M. 1995. *Eco Park: Struggle For Preservation*. Johnson Books.

Diehl, R.M., A.C. Wilcox, J.C. Stella, L. Kui, L.S. Sklar, and A. Lightbody. 2017 Fluvial sediment supply and pioneer woody seedlings as a control on bar-surface topography. *Earth Surface Processes and Landforms* 42:724–734. DOI: 10.1002/esp.4017.

Doebele, A. 2017. *Onsite Pit Guidance Document (re: Utah Oil & Gas Conservation General Rules R649-3-16 Reserve Pits and Other On-site Pits).* Utah Division of Oil, Gas and Mining. Available at: https://oilgas.ogm.utah.gov/pub/Publications/Handbooks/OnsitePitGuidance.pdf. Accessed February 5, 2019.

Doelling, H.H., and E.W. Tooker. 1983. Utah mining district areas and principal metal occurrences. Available at: https://geology.utah.gov/map-pub/maps/geologic-resource-maps/. Accessed August 31, 2018.

Don Hatch River Expeditions. n.d. [2018]. The Don Hatch Legacy. Available at: http://www.donhatchrivertrips.com/hatch-legacy.php. Accessed October 24, 2018.

eBird. 2017. Explore Hotspots. Available at: https://ebird.org/hotspots. Accessed September 14, 2018.

———. 2018. Explore Hotspots. Available at: https://ebird.org/hotspots. Accessed September 14, 2018.

Emery County. 2016. Revised 2016. *Emery County General Plan (and RMP).* Available at: http://www.emerycounty.com/publiclands/GeneralPlan.htm. Accessed October 25, 2018.

———. 2018. *Emery County Pre-Disaster Hazard Mitigation Plan 2018*. Available at: http://www.emerycounty.com/emerycountypdm.pdf. Accessed October 18, 2018.

Envision Utah. n.d. [2018]. Background: Agriculture in Utah. Available at: https://yourutahyourfuture.org/topics/agriculture/item/27-background-agriculture-in-utah. Accessed September 20, 2018.

Fassnacht, S.R. 2006. Upper versus lower Colorado River sub-basin streamflow: Characteristics, runoff estimation and model simulation. *Hydrological Processes* 20(10):2187–2205.

Federal Interagency Stream Restoration Working Group. 2001. *Stream Corridor Restoration: Principles, Processes, and Practices*. Available at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044574.pdf. Accessed November 8, 2018.

FitzGerald, D., Z. Hughes, and P. Rosen. 2011. Boat wake impacts and their role in shore erosion process, Boston Harbor Islands National Recreation Area. Natural Resource Report NPS/NERO/NRR—2011/403. Fort Collins, Colorado: National Park Service.

Ford, R. 2018. Personal communication between Randy Ford, Green River State Park, and John Gangemi, River Science Institute. September 25, 2018.

Fortney, S.T. 2015. *A Century of Geomorphic Change of the San Rafael River and Implications for River Rehabilitation: Utah State University*. Available at: http://digitalcommons.usu.edu/etd/4363. Accessed March 2019.

Francis, T.A. and K.R. Bestgen. 2016. *Population Status of Humpback Chub,* Gila cypha*, and Catch Indices and Population Structure of Sympatric Roundtail Chub,* Gila robusta*, in Black Rocks, Colorado River, Colorado, 1998–2012*. Larval Fish Laboratory Contribution 199. Final report to the Upper Colorado River Endangered Fish Recovery Program Project Number 131. Grand Junction, Colorado.

Friedman, J.M., G.T. Auble, P.B. Shafroth, M.L. Scott, M.F. Merigliano, M.D. Freehling, and E.R. Griffin. 2005. Dominance of non-native riparian trees in western USA. *Biological Invasions* 7:747–751. DOI: 10.1007/s10530-004-5849-z.

Gaeuman, D.A., J.C. Schmidt, and P.R. Wilcock. 2003. Evaluation of in-channel gravel storage with morphology-based gravel budgets developed from planimetric data. *Journal of Geophysical Research* 108:1–16. DOI: 10.1029/2002JF000002.

———. 2005. Complex channel responses to changes in stream flow and sediment supply on the lower Duchesne River, Utah. *Geomorphology* 64:185–206. DOI: 10.1016/j.geomorph.2004.06.007.

Gardner, P.A., R. Stevens, and F.P. Howe. 1999. *A Handbook of Riparian Restoration and Revegetation for the Conservation of Land Birds in Utah With Emphasis on Habitat Types in Middle and Lower Elevations*. Utah Division of Wildlife Resources Publication Number 99-38. Available at: https://wildlife.utah.gov/pdf/riparian.pdf. Accessed November 9, 2018.

Gessler, D., and E. Moser. 2001. Two Dimensional Computer Modeling of Green River at Dinosaur National Monument and Canyonlands National Park. Colorado State University, National Park Service.

Gloyn, R.W., R.L. Bon, S. Wakefield, and K. Krahulec. 2005. Uranium and vanadium map of Utah. Available at: https://geology.utah.gov/map-pub/maps/geologic-resource-maps/. Accessed August 31, 2018.

Graf, J.B., R.H. Webb, and R. Hereford. 1991. Relation of sediment load and flood-plain formation to climatic variability, Paria River drainage basin, Utah and Arizona., *Geological Society of America Bulletin* 103:1405. DOI: 10.1130/0016-7606(1991)103<1405:ROSLAF>2.3.CO;2.

Graf, W.L. 1978. Fluvial adjustments to the spread of tamarisk in the Colorado Plateau region. *Geological Society of America Bulletin* 89:1491–1501. DOI: 10.1130/0016-7606(1978)89<1491:FATTSO>2.0.CO;2.

Grams, P.E., and J. Schmidt. 2002. Streamflow regulation and multi-level flood plain formation: Channel narrowing on the aggrading Green River in the eastern Uinta Mountains, Colorado and Utah. *Geomorphology* 44:337–360. Available at: http://www.sciencedirect.com/science/article/pii/S0169555X01001829. Accessed March 2019.

———. 2005. Equilibrium or indeterminate? Where sediment budgets fail: Sediment mass balance and adjustment of channel form, Green River downstream from Flaming Gorge Dam, Utah and Colorado. *Geomorphology* 71:156–181. DOI: 10.1016/j.geomorph.2004.10.012.

Grand Canyon Monitoring and Research Center (GCMRC). 2018. Sediment data. Available at: https://www.gcmrc.gov/discharge_qw_sediment/stations/DINO. Accessed October 1, 2018.

Grand County. 2018. *Grand County Pre-Disaster Hazard Mitigation Plan 2018*. Available at: https://www.grandcountyutah.net/174/Emergency-Management. Accessed October 10, 2018.

Grippo, M., K.E. LaGory, D. Waterman, J.W. Hayse, L.J. Walston, C.C. Weber, A.K. Magnusson, and X.H. Jiang. 2017. *Relationships Between Flow and the Physical Characteristics of Colorado Pikeminnow Backwater Nursery Habitats in the Middle Green River, Utah*.

Gurgel, K.D., B.R. Jones, and D.E. Powers. 1983. Energy Resources Map of Utah. Salt Lake City: University of Utah, Department of Natural Resources and Energy, Utah Geological and Mineral Survey. Available at: https://ugspub.nr.utah.gov/publications/maps/m-68.pdf. Accessed August 31, 2018.

Hardesty, D.L., and B.J. Little. 2000. *Assessing Site Significance: A Guide for Archaeologists and Historians*. Walnut Creek, California: AltaMira Press.

Hatch River Expeditions. n.d. [2018]. Our History. Available at: http://hatchriver expeditions.com/about-us/our-history. Accessed October 24, 2018.

Heitmeyer, M.E., and L.H. Fredrickson. 2005. *An Evaluation of Ecosystem Restoration and Management Options for the Ouray National Wildlife Refuge, Utah*. Available at: https://ecos.fws.gov/ServCat/DownloadFile/6762. Accessed November 9, 2018.

Hereford, R. 1984. Climate and ephemeral-stream processes: twentieth century geomorphology and alluvial stratigraphy of the Little Colorado River, Arizona. *Geological Society of America Bulletin* 95:654–668. DOI: 10.1130/0016-7606(1984)95<654:CAEPTG>2.0.CO;2.

———. 1986. Modern alluvial history of the Paria River drainage basin, southern Utah. *Quaternary Research* 25:293–311. DOI: 10.1016/0033-5894(86)90003-7.

Herron, W.H. 1917. Profile surveys in the Colorado River basin in Wyoming, Utah, Colorado, and New Mexico. Available at: http://pubs.er.usgs.gov/publication/wsp396.

Howard, J., and J. Caldwell. 2018. *Population Estimates for Humpback Chub (*Gila cypha*) in Desolation and Gray Canyons, Green River, Utah 2001–2015*. Final report of Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program. Denver, Colorado.

Hylland, M.D., and W.E. Mulvey. 2003. *Geologic Hazards of Moab-Spanish Valley, Grand County, Utah*. Available at: ugspub.nr.utah.gov/publications/special_studies/ss-107.pdf. Accessed January 15, 2019.

Ikeda, H. 1989. Sedimentary controls on channel migration and origin of point bars in sand-bedded meandering rivers. In *River Meandering, American Geophysical Union Water Resources Monograph, S.* Ikeda and G. Parker, eds, vol. 12, pp. 51–68. DOI: 10.1029/WM 012p0051.

Interagency Heritage Resources Work Group (IHRWG). 2018. Utah Archaeology Site Form Manual, May 2018 version. Interagency Heritage Resources Work Group, Salt Lake City.

Iorns, W.V, C.H. Hembree, and G.L. Oakland. 1965. *Water Resources of the Upper Colorado River Basin*. Technical Report: US Geological Survey Professional Paper 441. Available at: https://pubs.er.usgs.gov/publication/pp441.

Jahrsdoerfer, S. 2018. Wetland Management at Ouray National Wildlife Refuge. In *39th Annual Researchers Meeting, Upper Colorado River Endangered Fish Recovery Program and San Juan Basin Recovery Implementation Program*. Vernal, Utah. Available at: http://www.coloradoriver recovery.org/committees/biology-committee/researchers/39th Annual Researchers Meeting Program.pdf.

Johnson, C.W., and S. Buffler. 2008. *Riparian Buffer Design Guidelines for Water Quality and Wildlife Habitat Functions on Agricultural Landscapes in the Intermountain West*. General Technical Report RMRS-GTR-203. Fort Collins, Colorado: U.S. Forest Service, Rocky Mountain Research Station.

Johnson, R.R., L.T. Haight, and J.M. Simpson. 1985. Endangered species vs. endangered habitats: A management challenge. *Western Birds* 18:89–96.

Karp, C.A., and H.M. Tyus. 1990. Humpback chub (*Gila sypha*) in the Yampa and Green rivers, Dinosaur National Monument, with observations on roundtail chub (*G. robusta*) and other sympatric fishes. *Great Basin Naturalist* 50(3):article 7.

Kennedy, T.A., J.D. Muehlbauer, C.B. Yackulic, D.A. Lytle, S.W. Miller, K.L. Dibble, E.W. Kortenhoeven, A.N. Metcalfe, and C.V. Baxter. 2016. Flow management for hydropower extirpates aquatic insects, undermining river food webs. *BioScience* 66: 561–575. DOI: 10.1093/biosci/biw059.

King, T.F. 2002. *Thinking about Cultural Resource Management: Essays from the Edge*. Walnut Creek, California: AltaMira Press.

Krueper, D.J., J.L. Bart, and T.D. Rich. 2003. Response of breeding birds to the removal of cattle on the San Pedro River, Arizona. *Conservation Biology* 17(2):607–615.

Laderoute, L., and B. Bauer. 2013. *River Bank Erosion and Boat Wakes Along the Lower Shuswap River, British Columbia*. Final project report. Available at: http://www.rdno.ca/docs/River_Bank_Erosion_Lower_Shu_River_Final_Project_Report.pdf. Accessed October 11, 2017.

LaGory, K.E., J.W. Hayse, and D. Tomasko. 2003. Recommended Priorities for Geomorphology Research in Endangered Fish Habitats of the Upper Colorado River Basin. Final report by Argonne National Laboratory. Upper Colorado River Endangered Fish Recovery Program, Project Number 134. Denver, Colorado.

LaGory, K.E., L.J. Walston, A. Orr, and C.C. Weber. 2017. 2016 *Reassessment of Floodplain Wetland Connections in the Middle Green River, Utah*. Argonne National Laboratory Report.

Lane, E.W. 1955. The importance of fluvial morphology in hydraulic engineering. *Proceedings of the American Society of Civil Engineers* 81:1–17.

LaRue, E.C., and N.C. Grover. 1916. *Colorado River and its Utilization*. Water-Supply Paper 395. U.S. Geological Survey. DOI: 10.3133/wsp395.

Leech, M. 2018. From Utah Division of Forestry, Fire, and State Lands (FFSL). Email from Margo Leech, secretary for FFSL's Southeastern Area, to Gretchen Semerad, SWCA Environmental Consultants. October 3, 2018.

Lichvar, R.W., D.L. Banks, W.N. Kirchner, and N.C. Melvin. 2016. *The National Wetland Plant List: 2016 wetland ratings. State of Utah 2016 Wetland Plant List*. Phytoneuron 2016-30: 1–17. Published April 28, 2016. ISSN 2153 733X. Available at: https://www.fws.gov/wetlands/documents/National-Wetland-Plant-List-2016-Wetland-Ratings.pdf. Accessed September 5, 2018.

Lipe, W.D. 2009. Archaeological values and resource management. In *Archaeology and Cultural Resource Management*, edited by L. Sebastian and W.D. Lipe, pp. 41–63., Santa Fe, New Mexico: School for Advanced Research Press.

Lowry, B.J., C.V. Ransom, R.E. Whitesides, and H. Olsen. 2017. *Noxious Weed Field Guide for Utah*. 4th ed. Logan, Utah: Utah State University Extension. Available at: https://extension.usu.edu/fieldguides/ou-files/Noxious-Weed-Field-Guide-for-Utah.pdf. Accessed December 11, 2018.

Lyons, J.K., M.J. Pucherelli, and R.C. Clark. 1992. Sediment transport and channel characteristics of a sand-bed portion of the green river below flaming gorge dam, Utah, USA. *Regulated Rivers: Research & Management* 7:219–232. DOI: 10.1002/rrr.3450070302.

Mack, R.N., D. Simberloff, W.M. Lonsdale, H. Evans, M. Clout, and F.A. Bazzaz. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. *Ecological Applications* 10:689–710.

Mahoney, J.M., and S.B. Rood. 1998. Streamflow requirements for cottonwood seedling recruitment—An integrative model. *Wetlands* 18:634–645. DOI: 10.1007/BF03161678.

Manners, R.B., J.C. Schmidt, and M.L. Scott. 2014. Mechanisms of vegetation-induced channel narrowing of an unregulated canyon river: Results from a natural field-scale experiment. *Geomorphology* 211: 100–115. DOI: 10.1016/j.geomorph.2013.12.033.

Martin, T., and D. Whitis. 2016. *Guide to the Colorado & Green Rivers in the Canyonlands of Utah & Colorado*. Vishnu Temple Press and RiverMaps, LLC.

Mayers, J., and J. Schmidt. n.d. [1995]. Unpublished notes and draft master's thesis. Department of Geology, Utah State University.

McCabe, G.J., D.M. Wolock, G.T. Pederson, C.A. Woodhouse, and S. McAfee. 2017. Evidence that recent warming is reducing upper Colorado river flows. *Earth Interactions* 21. DOI: 10.1175/EI-D-17-0007.1.

McGinty, E.I. Leydsman, and C.M. McGinty. 2009. Section 3–Physiography of Utah. In *Rangeland Resources of Utah*, compiled by E.I. Leydsman McGinty, pp. 24–28. Available at: https://extension.usu.edu/rangelands/ou-files/RRU_Final.pdf. Accessed September 5, 2018.

McMillen, LLC. 2014. *Final Environmental Impact Statement. Green River Diversion Rehabilitation Project. Emery and Grand Counties, Utah*. Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ut/programs/?cid=nrcs141p2_034037. Accessed October 18, 2018.

Meade, R.H., T.R. Yuzyk, and T.J. Day. 1990. Movement and storage of sediment in rivers of the United States and Canada. In *Surface Water Hydrology, U.S.A, Geological Society of America*, M.G. Wolman and H.C. Riggs, eds, pp. 255–280. DOI: 10.1130/DNAG-GNA-O1.255.

Merritt, D.M., and D.J. Cooper. 2000. Riparian vegetation and channel change in response to river regulation: A comparative study of regulated and unregulated streams in the Green River Basin, USA. *Regulated Rivers-Research &Management* 564:543–564. DOI: 10.1002/1099-1646(200011/12)16:6<543::AID-RRR590>3.0.CO;2-N.

Miller, P.S. 2014. *A Population Viability Analysis for the Colorado Pikeminnow (*Ptychocheilus lucius*) in the San Juan River. Apple Valley, Minnesota: Conservation Breeding Specialist Group (IUCN/SSC).*

————. 2018. *A Population Viability Analysis for the Colorado Pikeminnow (*Ptychocheilus lucius*) in the Upper Colorado River Basin*. Apple Valley, Minnesota: Conservation Breeding Specialist Group (IUCN/SSC).

Mulvey, W.E. 1992. *Geologic Hazards of Castle Valley, Grand County, Utah*. Available at: https://ugspub.nr.utah.gov/publications/open_file_reports/OFR-238.pdf. Accessed January 15, 2019.

Muth, R.T., L.W. Crist, K.E. LaGory, J.W. Hayse, K.R. Bestgen, T.P. Ryan, J.K. Lyons, and R.A Valdez. 2000. *Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam*. Final report. Upper Colorado River Endangered Fish Recovery Program Project FG-53. Available at: http://www.coloradoriverrecovery.org/documents-publications/technical-reports/isf/flaminggorgeflowrecs.pdf. Accessed April 5, 2019.

National Fire Protection Association (NFPA). 2017. NFPA 70 Electrical Code (NEC). Available at: https://www.nfpa.org/NEC/About-the-NEC/Explore-the-2017-NEC. Accessed January 22, 2019.

National Park Service (NPS) and River Management Society. 2018. Prepare to Launch! Guidelines for Assessing, Designing and Building Access Sites for Carry-In Watercraft. Available at: https://www.river-management.org/prepare-to-launch-. Accessed March 6, 2019.

National Park Service (NPS). 2004. *Logical Lasting Launches. Design Guidance for Canoe and Kayak Launches*. Available at https://www.americantrails.org/files/pdf/water-trail-launch-guide-nps.pdf. Accessed January 30, 2019.

National Wild and Scenic Rivers System. 2018. Online information. Available at rivers.org. Accessed October 23, 2018.

Natural Resources Conservation Service (NRCS). 1998. *The Practical Streambank Bioengineering Guide. User's Guide for Natural Streambank Stabilization Techniques in the Arid and Semi-Arid Great Basin and Intermountain West*. Aberdeen, Idaho: NRCS Plant Materials Center. Available at: https://efotg.sc.egov.usda.gov/references/public/NM/BIO-48_The_Practical_Streambank_Bioengineering_Guide.pdf. Accessed November 8, 2018.

————. 2015a. SSURGO. Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627. Accessed October 15, 2018.

————. 2015b. Record of Decision. Green River Diversion Rehabilitation. Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ut/programs/?cid=nrcs141p2_034037. Accessed October 18, 2018.

———. 2016. Irrigation Pumping Plants. In *Irrigation National Engineering Handbook*, Pt. 623, pp. 8-i–8G-6. Available at: https://www.wcc.nrcs.usda.gov/ftpref/wntsc/waterMgt/irrigation/NEH15/ch8.pdf. Accessed October 2018.

———. 2018. Stream Restoration. Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/water/manage/restoration/?cid=stelprdb1043243. Accessed April 4, 2019.

Nissen, S., A. Norton, A. Sher, and D. Bean. 2010. *Tamarisk Best Management Practices in Colorado Watersheds*. Colorado State University. Available at: https://riversedgewest.org/sites/default/files/resource-center-documents/CSUtamariskBMP_lowres.pdf. Accessed February 6, 2019.

Northern Colorado Water Conservancy District. 2018. Municipal Subdistrict: Windy Gap Firming Project, Project Info. Available at: https://www.northernwater.org/sf/wgfp/project-info/project-overview. Accessed on October 9, 2018.

Occupational Safety and Health Administration. n.d. [2018]. Confined Spaces. Overview. Available at: https://www.osha.gov/SLTC/confinedspaces/index.html. Accessed October 10, 2018.

Orchard, K.L., and J.C. Schmidt, J.C. 1998. *A Geomorphic Assessment of the Availability of Potential Humpback Chub Habitat in the Green River in Desolation and Gray Canyons, Utah*. Final report to Utah Division of Wildlife Resources.

Parrish, J.R., F.P. Howe, and R.E. Norvell. 2002. *Utah Partners in Flight Avian Conservation Strategy Version 2.0*. Utah Partners in Flight Program, Utah Division of Wildlife Resources. UDWR Publication Number 02-27. Salt Lake City, Utah. Available at: https://wildlife.utah.gov/publications/pdf/utah_partners_in_flight.pdf. Accessed October 12, 2018.

Pederson, J., N. Burnside, Z. Shipton, and T. Rittenour. 2013. Rapid river incision across an inactive fault—Implications for patterns of erosion and deformation in the central Colorado Plateau. *Lithosphere* 5;513–520. DOI: 10.1130/L282.1.

Pettitt, A.N. 1979. A Non-Parametric Approach to the Change-Point Problem. *Applied Statistics* 28:126. DOI: 10.2307/2346729.

Powell, J.W. 1961. *The Exploration of the Colorado River and Its Canyons*. New York: Dover Publications, Inc.

Reid, C.R., K.H. Christensen, and R.W. Hill. 2008. Water Rights in Utah. Utah State University Cooperative Extension. Available at: https://digitalcommons.usu.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=2256&context=extension_curall. Accessed September 25, 2018.

RiversEdge West. 2016. *Why Are My Trees Brown? Tamarisk and the Tamarisk Beetle*. Available at: https://riversedgewest.org/sites/default/files/resource-center-documents/2016_TLB_Pamphlet.pdf. Accessed October 2, 2018.

Romin, L.A., and J.A. Muck. 2002. *Utah Field Office Guidelines for Raptor Protection from Human and Land Use Disturbances*. Salt Lake City, Utah: U.S. Fish and Wildlife Service, Utah Field Office. Available at: https://www.fws.gov/utahfieldoffice/species_migratory.php. Accessed November 9, 2018.

Rowland, R.C., D.W. Stephens, B. Waddell, D. Naftz. 2003. *Selenium Contamination and Remediation at Stewart Lake Waterfowl Management Area and Ashley Creek, Middle Green River Basin, Utah*. Fact Sheet 031-03. U.S. Geological Survey, U.S. Department of the Interior. Available at: https://pubs.usgs.gov/fs/fs-031-03/.

Rural Community Consultants. 2017. *Grand County Resource Management Plan, 2017*. Available in-house at SWCA Environmental Consultants.

Schmidt, J.C. 2010. A watershed perspective of changes in streamflow, sediment supply, and geomorphology of the Colorado River. In *Proceedings of the Colorado River Basin Science and Resource Management Symposium, November 18–20, 2008, Scottsdale, Arizona*, edited by T.S. Melis, J.F. Hamill, G.E. Bennett, L.G. Coggins, Jr., P.E. Grams, T.A. Kennedy, D.M. Kubly, and B.E. Ralson, pp. 51–76. Scientific Investigations Report 2010-5135. U.S. Department of the Interior and U.S. Geological Survey. U.S. Geological Survey, Reston, Virginia.

Schmidt, J.C., and J. Brim Box. 2004. Application of a Dynamic Model to Assess Controls on Age-0 Colorado Pikeminnow Distribution in the Middle Green River, Colorado and Utah. *Annals of the Association of American Geographers* 94:458–476. DOI: 10.1111/j.1467-8306.2004.00408.x.

Schmidt, J.C., and P.R. Wilcock. 2008. Metrics for assessing the downstream effects of dams. *Water Resources Research* 44:1–19. DOI: 10.1029/2006WR005092.

Schumm, S.A., and R.W. Lichty. 1965. Time, space, and causality in geomorphology. *American Journal of Science* 263:110–119. DOI: 10.2475/ajs.263.2.110.

Scott, M.L., S.K. Skagen, and M.F. Mergliano. 2003. Relating geomorphic change and grazing to avian communities in riparian forests. *Conservation Biology* 17:284–296.

Sher, A.A., K. Lair, M. DePrenger-Levin, and K. Dohrenwend. 2010. *Best Management Practices for Revegetation After Tamarisk Removal: In the Upper Colorado River Basin*. Available at: https://riversedgewest.org/sites/default/files/resource-center-documents/BMP_for_reveg_after_tamarisk_removal.pdf. Accessed November 9, 2018.

Simms, S.R. 2008. *Ancient Peoples of the Great Basin and Colorado Plateau*. New York: Routledge Books.

Six County Association of Governments Planning and Community Development. 2015. *Pre-Disaster Mitigation 5-Year Plan. Sections 1 and 7*. Available at: http://sixcounty.com/wp-content/uploads/2016/01/Section-1-Introduction.pdf and http://sixcounty.com/wp-content/uploads/2016/01/Section-7-Wayne-County.pdf. Accessed October 18, 2018.

Skagen, S.K., R. Hazlewood, and M.L. Scott. 2005. *The Importance and Future Condition of Western Riparian Ecosystems as Migratory Bird Habitat*. USDA Forest Service Gen. Tech. Rep. PSWGTR- 191. Available at: https://www.fs.fed.us/psw/publications/documents/psw_gtr191/psw_gtr191_0525-0527_skagen.pdf. Accessed September 14, 2018.

Slade, D.C., R.K. Kehoe, and J.K. Stahl. 1997. *Putting the Public Trust Doctrine to Work. The Application of the Public Trust Doctrine to the Management of Lands, Waters and Living Resources of the Coastal States*. 2nd ed. Coastal States Organization, Inc. Available at: http://greatlakesresilience.org/library/general-reference/putting-public-trust-doctrine-work-application-public-trust-doctrine. Accessed August 16, 2018.

Spangler, J.D. 2007. Site 42UN513, site form accessible via Utah SHPO.

———. 2013. *Nine Mile Canyon: The Archaeological History of an American Treasure*. Salt Lake City: University of Utah Press.

Sperry, L.J., J. Belnap, and R.D. Evans. 2006. Bromus tectorum invasion alters nitrogen dynamics in an undisturbed arid grassland ecosystem. *Ecology* 87(3):603–615.

SWCA Environmental Consultants (SWCA). 2020. *Green and Colorado Rivers Mineral Leasing Plan*.

SWCA Environmental Consultants (SWCA), CRSA Architecture, River Science Institute, Inc., J. Schmidt, and A. Walker. 2020. *Colorado River Comprehensive Management Plan.* Salt Lake City, Utah: SWCA Environmental Consultants.

Syvitski, J.P., C.J. Vörösmarty, A.J. Kettner, and P. Green. 2005. Impact of humans on the flux of terrestrial sediment to the global coastal ocean. *Science* 308(5720):376–380.

Tamarisk Coalition. 2016. *Why Are My Trees Brown? Tamarisk and the Tamarisk Beetle*. Available at: https://riversedgewest.org/sites/default/files/resource-center-documents/2016_TLB_Pamphlet.pdf. Accessed November 9, 2018.

———. 2017. 2007–2017 Distribution of Tamarisk Beetle (*Diorhabda* spp.). Available at: https://riversedgewest.org/sites/default/files/files/2017_Beetle_Map_12_28.pdf. Accessed October 24, 2018.

Topping, D.J., and S.A. Wright. 2016. *Long-Term Continuous Acoustical Suspended-Sediment Measurements in Rivers—Theory, Application, Bias, and Error*. DOI: 10.3133/pp1823.

Topping, D.J., E.R. Mueller, J.C. Schmidt, R.E. Griffiths, D.J. Dean, and P.E. Grams. 2018. Long-Term Evolution of Sand Transport Through a River Network: Relative Influences of a Dam Versus Natural Changes in Grain Size From Sand Waves. *Journal of Geophysical Research: Earth Surface* 1879–1909. DOI: 10.1029/2017JF004534.

Tu, M. 2003. *Element Stewardship Abstract for* Elaeagnus angustifolia *L. Russian olive, oleaster. Arlington, Virginia: The Nature Conservancy*. Available at: http://www.invasive.org/weedcd/pdfs/tncweeds/elaeang.pdf. Accessed December 11, 2018.

Tyus, H.M., and C.A. Karp. 1990. Spawning and movements of razorback sucker, *Xyrauchen texanus*, in the Green River basin of Colorado and Utah. *Southwest Naturalist* 35(4):427–433.

Udall, B., and J. Overpeck. 2017. The twenty-first century Colorado River hot drought and implications for the future. *Water Resources Research*. DOI: 10.1002/2016WR019638.

Uintah Basin Association of Governments. 2012. *Uintah Basin Regional Pre-Disaster Mitigation Plan 2012*. Available at: http://ubaog.org/images/DisasterMitigationPlan.pdf. Accessed October 18, 2018.

Uintah County. 2017. *Uintah County Resource Management Plan 2017*. Available at: http://co.uintah.ut.us/document_center/CommunityDevelopment/Uintah_Resource_Management_Plan___FINAL__Web_File.pdf. Accessed October 25, 2018.

Upper Colorado River Endangered Fish Recovery Program (UCRRP). 2012. *Study Plan to Examine the Effects of Using Larval Razorback Sucker Occurrence in the Green River as a Trigger for Flaming Gorge Dam Peak Releases*. Prepared by the Larval Trigger Study Plan Ad Hoc Committee and Coordinated by the Upper Colorado River Endangered Fish Recovery Program. Denver, Colorado.

U.S. Department of Agriculture (USDA). 2012a. *Census of Agriculture. 2012 Census Publications. State and County Profiles. Utah. Emery County*. Available at: https://www.nass.usda.gov/Publications/AgCensus/2012/Online_Resources/County_Profiles/Utah/cp49015.pdf. Accessed October 16, 2018.

———. 2012b. *Census of Agriculture. 2012 Census Publications. State and County Profiles. Utah. Grand County*. Available at: https://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Utah/cp49019.pdf. Accessed September 24, 2018.

———. 2012c. *Census of Agriculture. 2012 Census Publications. State and County Profiles. Utah. Uintah County*. Available at: https://www.nass.usda.gov/Publications/AgCensus/2012/Online_Resources/County_Profiles/Utah/cp49047.pdf. Accessed October 16, 2018.

———. 2012d. *Census of Agriculture. 2012 Census Publications. State and County Profiles. Utah. Wayne County*. Available at: https://www.nass.usda.gov/Publications/AgCensus/2012/Online_Resources/County_Profiles/Utah/cp49055.pdf. Accessed October 16, 2018.

U.S. Bureau of Reclamation (USBR). 2012. *Colorado River Basin Water Supply and Demand Study*. Available at: http://www.usbr.gov/lc/region/programs/crbstudy/finalreport/studyrpt.html. Accessed March 2019.

———. 2017a. Colorado River Basin Natural Flow and Salt Data. U.S. Department of the Interior. Available at: https://www.usbr.gov/lc/region/g4000/NaturalFlow/index.html. Accessed June 15, 2018.

———. 2017b. *Quality of Water Colorado River Basin, Progress Report No. 25*. U.S. Department of the Interior, Upper Colorado Region. Available at: https://www.usbr.gov/uc/progact/salinity/pdfs/PR25final.pdf. Accessed September 18, 2018.

———. 2018. About Us – Fact Sheet. Available at: https://www.usbr.gov/main/about/fact.html. Accessed August 20, 2018.

U.S. Environmental Protection Agency (EPA). 1998. *Report on the Peer Consultation Workshop on Selenium Aquatic Toxicity and Bioaccumulation*. Environmental Protection Agency Office of Water.

———. 2015. *Draft Green River Sub-Area Contingency Plan*. Available at: https://www.nrt.org/sites/32/files/Draft%20Green%20River%20ACP%201%2025%202016.pdf. Accessed October 24, 2018.

U.S. Fish and Wildlife Service (USFWS). 1990a. Bonytail Chub Recovery Plan. Denver, Colorado: U.S. Fish and Wildlife Service. Available at: https://www.fws.gov/southwest/es/Documents/R2ES/BonytailChub.pdf. Accessed October 16, 2018.

———. 1990b. *Humpback Chub Recovery Plan*. Revised. Prepared by Colorado River Fishes Recovery Team for the U.S. Fish and Wildlife Service, Region 6. Denver, Colorado.

———. 1991. *Colorado Squawfish Recovery Plan*. Denver, Colorado: U.S. Fish and Wildlife Service, Region 6.

———. 1998. *Razorback Sucker Recovery Plan*. Denver, Colorado: U.S. Fish and Wildlife Service, Region 6.

———. 2002a. *Bonytail (*Gila elegans*) Recovery Goals: Amendment and Supplement to the Colorado Squawfish Recovery Plan*. Denver, Colorado: U.S. Fish and Wildlife Service, Mountain-Prairie Region (6).

———. 2002b. *Colorado pikeminnow (*Ptychocheilus lucius*) Recovery Goals: Amendment and Supplement to the Colorado Squawfish Recovery Plan*. Denver, Colorado: U.S. Fish and Wildlife Service, Mountain-Prairie Region (6).

———. 2002c. *Humpback chub (*Gila cypha*) Recovery Goals: Amendment and Supplement to the Colorado Squawfish Recovery Plan*. Denver, Colorado: U.S. Fish and Wildlife Service, Mountain-Prairie Region (6).

———. 2002d. *Razorback sucker (*Xyrauchen texanus*) Recovery Goals: Amendment and Supplement to the Colorado Squawfish Recovery Plan*. Denver, Colorado: U.S. Fish and Wildlife Service, Mountain-Prairie Region (6).

———. 2013. *ESA Basics: 40 Years of Conserving Endangered Species*. Available at: https://www.fws.gov/endangered/esa-library/pdf/ESA_basics.pdf. Accessed October 16, 2018.

———. 2018a. National Wetland Inventory. Version 2.0. Classification of Wetlands and Deepwater Habitats of the United States. FWS/OBS-79/31. Washington, D.C.: U.S. Department of the Interior, U.S. Fish and Wildlife Service.

———. 2018b. Information for Planning and Consultation (IPaC). IPaC resource list for Uintah County, Utah. Available at: https://ecos.fws.gov/ipac/. Accessed September 6, 2018.

———. 2018c. Information for Planning and Consultation (IPaC). IPaC resource list for Emery County, Utah. Available at: https://ecos.fws.gov/ipac/. Accessed September 6, 2018.

———. 2018d. Information for Planning and Consultation (IPaC). IPaC resource list for Grand County, Utah. Available at: https://ecos.fws.gov/ipac/. Accessed September 6, 2018.

———. 2018e. Information for Planning and Consultation (IPaC). IPaC resource list for Wayne County, Utah. Available at: https://ecos.fws.gov/ipac/. Accessed October 3, 2018.

———. 2018f. *Humpback Chub (*Gila cypha*) Five-Year Review: Summary and Evaluation*. Denver, Colorado: U.S. Fish and Wildlife Service, Mountain-Prairie Region (6).

U.S. Forest Service (USFS). 2014a. *Field Guide for Managing Russian Olive in the Southwest*. Available at: https://riversedgewest.org/sites/default/files/resource-center-documents/Field_Guide_for_Managing_RO_SW.pdf. Accessed November 9, 2018.

———. 2014b. *Field Guide for Managing Saltcedar in the Southwest*. Available at: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5410127.pdf. Accessed November 9, 2018.

———. 2018. What Are Native Plant Materials? Available at: https://www.fs.fed.us/wildflowers/Native_Plant_Materials/whatare.shtml. Accessed September 4, 2018.

———. 2019. Wild and Scenic Snake River – River Use and Etiquette. Available at: https://www.fs.usda.gov/detail/wallowa-whitman/specialplaces/?cid=stelprdb5227289. Accessed May 24, 2019.

U.S. Geological Survey (USGS). 2005. Southwestern Regional GAP Analysis Project-Land Cover Descriptions. National GAP Analysis Program. Logan, Utah: RS/GIS Laboratory, College of Natural Resources, Utah State University. Available at: http://swregap.org/docs/. Accessed September 6, 2018.

———. 2013. USGS Southwest Repeat Photography Collection 1863–2013, Green River stake locations. Flagstaff, Arizona: Southwest Biological Science Center.

———. 2014. Earthquake Hazards Program, Information by Region - Utah, 2014 Seismic Hazard Map. Available at: https://earthquake.usgs.gov/earthquakes/byregion/utah-haz.php. Accessed January 15, 2019.

———. 2016. Green River near Jensen, UT 09261000. Grand Canyon Monitoring and Research Center. U.S. Department of the Interior. Available at: https://www.gcmrc.gov/discharge_qw_sediment/station/DINO/09261000. Accessed September 19, 2018.

———. 2017a. Geologic Provinces of the United States: Colorado Plateau Province. Available at: https://geomaps.wr.usgs.gov/parks/province/coloplat.html. Accessed September 28, 2018.

———. 2017b. Sites 09234500, 09260050, 09251000, 09315000. Time series: Daily Statistics. Available at: https://nwis.waterdata.usgs.gov/ut/nwis/. Accessed December 14, 2017.

———. 2018a. USGS 09261000 Green River Near Jensen, UT, Time-series: Monthly Statistics. U.S. Department of the Interior. Available at: https://waterdata.usgs.gov/nwis/monthly/?referred_module=sw&site_no=09261000&por_09261000_142806=448352,00060,142806,1946-10,2018-06&format=html_table&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=parameter_selection_list. Accessed October 1, 2018.

———. 2018b. USGS 09315000 Green River at Green River, UT. U.S. Department of the Interior. Available at: https://waterdata.usgs.gov/ut/nwis/inventory/?site_no=09315000&agency_cd=USGS, accessed on September 18, 2018.

———. 2018c. Green River near Jensen, UT GCMRC-GR1. Grand Canyon Monitoring and Research Center. U.S. Department of the Interior. Available at: https://www.gcmrc.gov/discharge_qw_sediment/station/DINO/GCMRC-GR1. Accessed September 19, 2018.

———. 2018d. Green River at Mineral Bottom nr Cynlnds Ntl Park 09328920. Grand Canyon Monitoring and Research Center. U.S. Department of the Interior. Available at: https://www.gcmrc.gov/discharge_qw_sediment/station/CL/09328920. Accessed September 19, 2018.

———. 2018e. USGS Southwest Repeat Photography Collection, Green River stake locations. Flagstaff, Arizona: Southwest Biological Science Center.

Utah Department of Agriculture and Food (UDAF). 2018. State of Utah noxious weed list. Available at: http://ag.utah.gov/plants-pests/noxious-weeds/37-plants-and-pests/599-noxious-weed-list.html. Accessed December 11, 2018.

Utah Department of Natural Resources (UDNR). 2018. Oil, Gas and Mining. Available at: https://naturalresources.utah.gov/oil-gas-and-mining. Accessed August 14, 2018.

Utah Division of Oil, Gas and Mining (DOGM). 2000. *The Practical Guide to Reclamation in Utah*, edited by Mary Ann Wright. Available at: https://fs.ogm.utah.gov/PUB/MINES/Coal_Related/RecMan/Reclamation_Manual.pdf. Accessed February 5, 2019.

———. 2018a. Utah oil production by field (past 5 years). Available at: https://oilgas.ogm.utah.gov/oilgasweb/statistics/oil-prod-by-fld.xhtml. Accessed August 31, 2018.

———. 2018b. Utah natural gas production by field (past 5 years). Available at: https://oilgas.ogm.utah.gov/oilgasweb/statistics/gas-prod-by-fld.xhtml. Accessed August 31, 2018.

Utah Division of State Parks and Recreation (DSPR). 2015. *Highlights From Utah's Boating Laws & Rules*. Available at: https://site.utah.gov/stateparks/wp-content/uploads/sites/13/2015/09/DNR-Boating-Highlights-15-Artx.pdf.

———. 2018. Boating. Available at: https://stateparks.utah.gov/activities/boating/. Accessed October 23, 2018.

Utah Division of Water Quality (DWQ). 2010. Standards of Quality for Waters of the State. Utah Administrative Code R317-2. Salt Lake City, Utah. July 1.

———. 2014. *TMDL for Selenium in the Colorado River Watershed.* Utah Department of Environmental Quality. Available at: https://deq.utah.gov/legacy/destinations/c/colorado-river/docs/2013/10Oct/ColoradoRiver_draft.pdf. Accessed September 13, 2018.

———. 2016. *2016 Final Integrated Report*. Utah Department of Environmental Quality.

Utah Division of Water Resources (DWRe). 1999. *Utah State Water Plan. Uintah Basin*. Available at: https://water.utah.gov/Planning/PlanningPage2.html. Accessed October 16, 2018.

———. 2000a. *Utah State Water Plan. Southeast Colorado River Basin*. Available at: https://water.utah.gov/Planning/PlanningPage2.html. Accessed September 24, 2018.

———. 2000b. *Utah State Water Plan. West Colorado River Basin*. Available at: https://water.utah.gov/Planning/PlanningPage2.html. Accessed September 24, 2018.

———. 2016. *Utah State Water Plan. Uintah Basin*. Available at: https://water.utah.gov/Planning/PlanningPage2.html. Accessed October 16, 2018.

———. 2018. Water Budget data provided to SWCA Environmental Consultants by Scott McGettigan, water resources engineer.

Utah Division of Water Rights (DWRi). 2011. Water Right Information. Available at: https://www.waterrights.utah.gov/wrinfo/default.asp. Accessed September 25, 2018.

———. n.d. [2018]. Map of Utah canals. Inspected dams and non-inspected dams layer. Available at: https://www.waterrights.utah.gov/canalinfo/default.asp. Accessed October 10, 2010.

Utah Division of Wildlife Resources (DWR). 2006. *Conservation and Management Plan for Three Fish Species in Utah: Addressing Needs for Roundtail Chub (*Gila robusta*), Bluehead Sucker (*Catostomus discobolus*), and Flannelmouth Sucker (*Catostomus latipinnis*).* Publication Number 06-17. Salt Lake City: Utah Division of Wildlife Resources.

———. 2009. *Conservation and Management Plan for Three Fish Species in Utah: Addressing needs for Roundtail Chub (*Gila robusta*), Bluehead Sucker (Catostomus discobolus), and Flannelmouth Sucker (*Catostomus latipinnis). Publication Number 06-17. Salt Lake City: Utah Division of Wildlife Resources.

———. 2017. *Utah Conservation Data Center. Utah's State Listed Species By County*. Available at: https://dwrcdc.nr.utah.gov/ucdc/viewreports/sscounty.pdf. Accessed September 10, 2018.

———. 2018a. Utah Conservation Data Center. Available at: https://dwrcdc.nr.utah.gov/ucdc/default.asp. Accessed September 7, 2018.

———. 2018b. *2018 Utah Fishing Guidebook*. Available at: https://wildlife.utah.gov/utah-fishing-guidebook.html. Accessed October 12, 2018.

———. 2018c. Utah hunting: Information on hunting in Utah. Available at: https://wildlife.utah.gov/hunting-in-utah.html. Accessed October 12, 2018.

———. n.d. [2018]. Walk-in access. Find a walk-in access property. Available at: http://wildlife.utah.gov/walkinaccess/. Accessed October 22, 2018.

Utah Division of Wildlife Resources (DWR) and Utah Invasive Species Task Force. 2009. *Utah Aquatic Invasive Species Management Plan*. Prepared in coordination with Utah Aquatic Invasive Species Task Force. Publication No. 08-34. Available at: https://wildlife.utah.gov/pdf/AIS_plans_2010/AIS_mgt_plan_full.pdf. Accessed March 2019.

Utah Geological Survey (UGS). 2000. Geologic map of Utah. UGS 1:500,000 geologic dataset. Available at: https://geology.utah.gov/map-pub/maps/gis/#tab-id-3. Accessed September 28, 2018.

———. 2018a. Physiographic Provinces. Available at: https://geology.utah.gov/popular/general-geology/utah-landforms/physiographic-provinces/. Accessed September 5, 2018.

———. 2018b. Utah Quaternary Fault and Fold Map. Available at: https://geology.utah.gov/apps/qfaults/index.html. Accessed September 5, 2018.

———. 2018c. Utah Mineral Occurrence System. Available at: https://geology.utah.gov/resources/data-databases/utah-mineral-occurrence-system/. Accessed September 4, 2018.

———. 2019a. GIS Data: 30′×60′ Geologic Maps (Huntington, La Sal, Moab, Seep Ridge, San Rafael, Vernal, Smoky Mountains, and Westwater), Other Geologic Maps (White Canyon Area and Lower Escalante River Area), and Geologic Map of Utah. Available at: https://geology.utah.gov/map-pub/maps/gis/#tab-id-1. Accessed March 2019.

———. 2019. Landslides: Events and Information. Available at: https://geology.utah.gov/hazards/landslides-rockfalls/. Accessed January 22, 2019.

Utah Rare Plants. 2018. *Utah Rare Plant Guide*. Available at: https://www.utahrareplants.org/rpg_species.html. Accessed September 10, 2018.

Utah State Historical Society. 1988. Beehive History 14. Utah's Counties. Available at: https://issuu.com/utah10/docs/beehivehistory14/2. Accessed September 20, 2018.

Utah State University. 2018. Water Quality. Best Management Practices. Available at: https://extension.usu.edu/waterquality/protectyourwater/howtoprotectwaterquality/bmps/index. Accessed January 28, 2019.

Utah Wildlife Action Plan Joint Team. 2015. *Utah Wildlife Action Plan: A Plan for Managing Native Wildlife Species and Their Habitats to Help Prevent Listing under the Endangered Species Act*. Publication No. 15-14. Salt Lake City, Utah: Utah Division of Wildlife Resources.

Ute Indian Tribe. 2013. About the Utes, Short History, and Governing Body. Available at: http://www.utetribe.com/. Accessed September 19, 2018.

Valdez, R. 2018. Approximate relative abundance of fish species in the planning area by segment. Data from various surveys. Data provided to SWCA Environmental Consultants as part of the Wildlife Species section of the comprehensive management plan.

Valdez, R.A., and P. Nelson. 2004. *Green River Subbasin Floodplain Management Plan*. Project Number C-6. Denver, Colorado: Upper Colorado River Endangered Fish Recovery Program.

Valdez, R.A., and P. Nelson. 2006. *Upper Colorado River Subbasin Floodplain Management Plan*. Project Number C-6. Denver, Colorado: Upper Colorado Endangered Fish Recovery Program.

Valdez, R.A., and A.M. Widner. 2011. *Research Framework for the Upper Colorado River Basin. Upper Colorado River Endangered Fish Recovery Program.* Final report. April 28, 2011. Available at: http://www.coloradoriverrecovery.org/documents-publications/technical-reports/rsch/ResearchFramework.pdf. Accessed March 2019.

Valdez, R.A., D.A. House, M.A. McLeod, and S.W. Carothers. 2012. *Review and Summary of Razorback Sucker Habitat in the Colorado River System*. Report Number 1. Final report for the U.S. Bureau of Reclamation, Upper Colorado Region. SWCA Environmental Consultants, Salt Lake City, Utah.

Vanden Berg, M.D. 2008. Basin-Wide Evaluation of the Uppermost Green River Formation's Oil-Shale Resource, Uinta Basin, Utah and Colorado. Available at: https://geology.utah.gov/map-pub/publications/. Accessed January 17, 2019.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences* 37:130–137.

Villarini, G., F. Serinaldi, J.A. Smith, and W.F. Krajewski. 2009. On the stationarity of annual flood peaks in the continental United States during the 20th century. *Water Resources Research* 45:1–17. DOI: 10.1029/2008WR007645.

Wait, J. 2004. Interior Secretary Norton in Moab to sign river mining withdrawal; groups on hand to protest policies. The *Times-Independent*.

Walker, A.E. 2017. *Twentieth Century Channel Change of the Green River in Canyonlands National Park, Utah*. Utah State University. Available at https://digitalcommons.usu.edu/etd/6884/. Accessed March 2019.

Ward, J. V., and J.A. Stanford. 1995. The serial discontinuity concept: Extending the model to floodplain rivers. *Regulated Rivers: Research & Management* 10:159–168. DOI: 10.1002/rrr.3450100211.

Wayne County. 2017. *Wayne County Public Lands Resource Management Plan*. Available in-house at SWCA Environmental Consultants.

Webb, R. 1994. The Green River. Utah History Encyclopedia. Available at: https://www.uen.org/utah_history_encyclopedia/g/GREEN_RIVER_THE.shtml. Accessed October 24, 2018.

———. 2008. *Riverman: The Story of Bus Hatch*. 3rd ed. Flagstaff, Arizona: Fretwater Press.

Webb, R.H., J. Belnap, and J. Weisheit. 2004. *Cataract Canyon: A Human and Environmental History of the Rivers in Canyonlands*. Salt Lake City: University of Utah Press.

Webb, R.H., S.A. Leake, and R.M. Turner. 2007. *The Ribbon of Green: Change in Riparian Vegetation in the Southwestern United States*. Tucson: University of Arizona Press.

Wells, J.F., D.K. Niven, and J. Cecil. 2005. *The Important Bird Areas Program in the United States: Building a Network of Sites for Conservation, State by State*. USDA Forest Service General Technical Report PSW-GTR-191. Available at: https://www.nrc.gov/docs/ML1426/ML14265A511.pdf. Accessed September 5, 2018.

Williams, G.P., and M.G.G. Wolman. 1984. *Downstream Effects of Dams on Alluvial Rivers*. U.S. Geological Survey. DOI: 10.1126/science.277.5322.9j.

Willis, G. 2019. Personal communication between Grant Willis (Utah Geological Survey) and Laura Vernon (FFSL) on January 8, 2019.

Woinarski, J.C.Z., C. Brock, M. Armstrong, C. Hempel, D. Cheal, and K. Brennan. 2000. Bird distribution in riparian vegetation in the extensive natural landscape of Australia's tropical savannas: A broad-scale survey and analysis of a distributional database. *Journal of Biogeography* 27:843–868.

Wood, R.E., and Chidsey, T.C., Jr. 2015. Oil and Gas Fields Map of Utah: Utah Geological Survey Circular 119, scale 1:700,000. Available at: https://geology.utah.gov/map-pub/maps/geologic-resource-maps/. Accessed August 31, 2018.

Woodhouse, C., J. Lukas, K. Morino, D. Meko, and K. Hirschboeck. 2016. Using the Past to Plan for the Future—The Value of Paleoclimate Reconstructions for Water Resource Planning. In *Water Policy and Planning in a Variable and Changing Climate*, pp. 161–182. DOI: 10.1201/b19534-12.

Woodhouse, C.A., D.M. Meko, G.M. MacDonald, D.W. Stahle, and E.R. Cook. 2010. A 1,200-year perspective of 21st century drought in southwestern North America. *Proceedings of the National Academy of Sciences* 107:21283–21288. DOI: 10.1073/pnas.0911197107.

Woodhouse, C.A., S.T. Gray, and D.M. Meko. 2006. Updated streamflow reconstructions for the upper Colorado River basin. *Water Resources Research* 42:1–16. DOI: 10.1029/2005WR004455.

Xiao, M., B. Udall, and D.P. Lettenmaier. 2018. On the causes of declining Colorado River streamflows. *Water Resources Research*. DOI: 10.1029/2018WR023153.

Yampa/White/Green Basin Roundtable. 2015. *Yampa/White/Green Basin Implementation Plan*. Available at: https://www.colorado.gov/pacific/sites/default/files/Yampa-WhiteBIP_Full.pdf. Accessed April 2016.

Young, S. 2018. River ranger at Canyonlands National Park. Email to John Gangemi, River Science Institute. September 26, 2018.

Zelasko, K.A., K.R. Bestgen, and G.C. White. 2010. Survival rates and movement of hatchery-reared razorback suckers in the upper Colorado River basin, Utah and Colorado. *Transactions of the American Fisheries Society* 139:1478–1499.

Zelasko, K.A., K.R. Bestgen, and G.C. White. 2018. *Abundance and Survival Rates of Razorback Suckers* Xyrauchen texanus *in the Green River, Utah, 2011–2013*. Final report. Prepared for Upper Colorado Endangered Fish Recovery Program. Denver, Colorado. Larval Fish Laboratory, Colorado State University.

Zouhar, K. 2005. Elaeagnus angustifolia. In *Fire Effects Information System*. U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available at: http://www.fs.fed.us/database/feis/plants/tree/elaang/all.html#180. Accessed December 11, 2018.

Zouhar, K.L. 2001. Acroptilon repens. In: *Fire Effects Information System*. U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available at: https://www.fs.fed.us/database/feis/plants/forb/acrrep/all.html. Accessed December 11, 2018.

APPENDIX A – PUBLIC INVOLVEMENT AND PUBLIC COMMENT

A.1 Public Involvement

The public outreach process for the 2020 *Green River Comprehensive Management Plan* (GRCMP) was structured to capture input and comments from five groups: 1) counties, 2) the general public, 3) federal agencies, 4) tribes, and 5) specific stakeholder groups. A summary of the outreach process for each group and comment themes and issues is presented below.

Public involvement for the GRCMP was combined with that of the *Colorado River Comprehensive Management Plan* (SWCA et al. 2020), which was developed concurrently. This summary focuses on those elements most applicable to the GRCMP.

Public Outreach Process

Counties

Because county governments often manage property up to the boundary of sovereign lands or apply zoning to these properties, the Utah Division of Forestry, Fire & State Lands (FFSL) made direct contact with county-elected officials and planning staff by email and telephone to present the rationale for the GRCMP and answer any questions about the process. Commissioners were invited to the public open houses described below. In addition, a meeting was scheduled with the county commissioners in each county. These meetings occurred in Vernal (Uintah County), Loa (Wayne County), Castle Dale (Emery County), and Moab (Grand County) on the same day as each public open house meeting (with the exception of the Castle Dale meeting, which was held 2 days prior to the Green River open house).

General Public

Adjacent landowners, current lessees, the general public, key stakeholders, special interest groups, 501(c) and nonprofit organizations, counties, municipalities, and other interested government agencies all had the opportunity to attend public open houses during the kickoff and information-gathering phase of public involvement (public open house series #1) and after the publication of the draft GRCMP (public open house series #2).

PUBLIC OPEN HOUSE SERIES #1: KICKOFF AND INFORMATION-GATHERING

The first general public outreach event comprised open house meetings held during the information-gathering phase of the plan. The purposes of the open houses were to describe and explain the GRCMP process, identify any available local information on river resources, and collect input on Green River issues and concerns. Feedback from the public open houses was used to frame the GRCMP's discussion of current conditions, identify issues requiring better management, and develop management goals and objectives. Five individual public open houses were held, one in each of the counties through which the river flows and one in Salt Lake City.

PUBLIC OPEN HOUSE: UINTAH COUNTY

Date and Time: Tuesday, March 27, 2018; 6:00 p.m. to 8:00 p.m.
Location: Uintah County Library in Vernal
Attendance: 13 individuals signed in to this meeting.

PUBLIC OPEN HOUSE: WAYNE COUNTY

Date and Time: Thursday, April 12, 2018; 6:00 p.m. to 8:00 p.m.
Location: Hanksville EMS Building in Hanksville
Attendance: No individuals signed in or attended this meeting.

Public Open House: Grand County

Date and Time: Wednesday, April 18, 2018; 6:00 p.m. to 8:00 p.m.
Location: Grand County High School in Moab
Attendance: 18 individuals signed in to this meeting.

Public Open House: Emery County

Date and Time: Thursday, April 19, 2018; 6:00 p.m. to 8:00 p.m.
Location: John Wesley Powell River History Museum in Green River
Attendance: 10 individuals signed in to this meeting

Public Open House: Salt Lake City

Date and Time: Tuesday, May 22, 2018; 5:00 p.m. to 7:00 p.m.
Location: Department of Natural Resources Library in Salt Lake City
Attendance: four individuals signed in to this meeting.

An open house format was used for each meeting, with participants allowed to attend anytime during the meeting. A welcome table was set up to greet visitors, help them understand the purpose of the open house, and provide a mailing and/or email list for future notifications. During each open house, FFSL presented a slideshow that provided an overview of the planning process and outcome.

Materials at each open house included explanatory brochures, business cards with the GRCMP project website, large-format project overview boards on easels with key information, and large-format aerial maps showing the planning area. Participants were asked to provide written comments and input on a comment form, on the aerial maps, on some of the project overview boards, by letter, or by email. In addition, participants were given the option of leaving site-specific comments on an online comment map accessed through the project website (http://bit.ly/gcrcmp). The comment map allowed participants to drop a colored pin (green for ecosystem resources, blue for water resources, and orange for community resources) at a particular river location with an attached comment. Verbal comments from discussions at the pubic open houses were also noted.

PUBLIC OPEN HOUSE SERIES #2: DRAFT PLAN REVIEW

The second general public outreach event comprised open house meetings held after the publication of the draft GRCMP. The purposes of the meetings were to present the draft GRCMP and to provide information on how to comment. Four individual public open houses were held, one in each of the counties through which the river flows.

Public Open House: Uintah County

Date and Time: Monday, June 10, 2019; 5:00 p.m. to 7:00 p.m.
Location: Uintah County Library in Vernal
Attendance: 16 individuals signed in to this meeting.

Public Open House: Wayne County

Date and Time: Monday, June 10, 2019; 5:00 p.m. to 7:00 p.m.
Location: Hanksville EMS Building in Hanksville
Attendance: 4 individuals signed in or attended this meeting.

Public Open House: Grand County

Date and Time: Tuesday, June 25, 2019; 5:00 p.m. to 7:00 p.m.
Location: Grand Center in Moab
Attendance: 26 individuals signed in to this meeting.

Public Open House: Emery County

Date and Time: Wednesday, June 26, 2019; 5:00 p.m. to 7:00 p.m.
Location: John Wesley Powell River History Museum in Green River
Attendance: 12 individuals signed in to this meeting

The same open house format was used for public open house series #2. During each open house, FFSL presented a slideshow that provided an overview of the draft GRCMP and information about how to submit comments.

Materials at each open house included explanatory brochures, business cards with the GRCMP project website, and large-format project overview boards on easels with key information. Participants were asked to provide written comments and input on the draft GRCMP on a comment form, by letter, or by email. In addition, participants were given the option of leaving site-specific or plan-specific comments on the online comment map accessed through the project website. The comment map allowed participants to drop colored pins at a particular river location with an attached comment. It also provided a form to submit a plan-specific comment. Verbal comments from discussions at the public open houses were also noted.

Federal Agencies

Federal agencies manage property adjacent to the boundary of sovereign lands and may have overlapping jurisdiction with FFSL. FFSL made direct contact with federal agencies such as the U.S. Bureau of Land Management, U.S. National Park Service, Natural Resources Conservation Service, U.S. Fish and Wildlife Service, and the Office of Sen. Mike Lee through email to present an overview of the GRCMP process and invite staff to all of the public open houses. In addition, a working meeting was scheduled with federal agencies to allow for one-on-one discussions of agency-specific issues and concerns. The working meeting occurred in Vernal (Uintah County) on June 13, 2018, from 1:00 to 3:00 p.m.; there were no attendees at the meeting. A second meeting was scheduled after the publication of the draft GRCMP to collect feedback on the plan. This meeting occurred in Vernal on June 10, 2019, from 3:00 to 4:00 p.m.; 1 individual signed in to the meeting.

Tribes

Because the Ute Indian Tribe of the Uintah and Ouray Indian Reservation is considered an adjacent landowner and stakeholder in the GRCMP process, FFSL reached out to tribal officials through email and by phone to explain the GRCMP process and invite tribal members to attend any of the public open houses. In addition, FFSL presented a slideshow that provided an overview of the GRCMP planning process and outcome on August 10, 2018, at the Utah Tribal Leaders meeting in Salt Lake City. After publication of the draft GRCMP, FFSL presented an overview of the draft plan and information on how to submit comments at a Utah Tribal Leaders meeting in Cedar City, Utah, on June 6, 2019.

Stakeholder Groups

All stakeholders interested in the Green River were invited to attend the public open house in each county. In addition, two stakeholder workshops were scheduled to obtain more detailed information on management concerns and goals from the following stakeholder groups: recreation, agriculture/irrigation, environmental, and mineral/energy. Directed questions were prepared to use in small groups for guided discussion during the workshops; however, attendees preferred a more free-flowing conversation. The stakeholder workshops were held on June 13, 2018, from 5:00 to 7:00 p.m. in Vernal (15 attendees signed into the workshop with two people representing recreation, eight people representing agriculture/irrigation, and five persons not affiliated with a specific stakeholder group or representing multiple stakeholder groups) and on June 28, 2018, from 11:00 a.m. to 1:00 p.m. in Green River (eight attendees signed into the workshop with one person representing recreation, three people representing agriculture/irrigation, one person representing environmental, and three people not affiliated with a specific stakeholder group or representing multiple stakeholder groups). An additional stakeholder meeting was held after the publication of the draft GRCMP on June 10, 2019, in Vernal from 7:00 to 8:00 p.m.; 2 individuals signed in to this meeting.

Public Outreach Process Comment Themes and Issues

Several letters and emails, multiple verbal comments, and multiple online comment map comments were received during the public outreach process (this does not include comments submitted during the formal public comment period and second public open house series on the draft GRCMP, which are discussed below in Section A.2.). This input from all public outreach groups is summarized below by resource category.

Ecosystem Resources:

- Concerns about noxious weeds (e.g., tamarisk, knapweed, Russian olive), and questions about how to get assistance for weed treatment
- Concerns about bank erosion
- Need streambank restoration and bank stabilization in some areas; questions about how to coordinate these activities on private land adjacent to the river
- Need to ensure sufficient water flows for fish species
- Need to consider the presence of designated critical habitat for federally listed species when making management decisions

Water Resources:

- High water flows implemented for federally listed fish have created flooding for landowners
- Prioritize the protection of water quality
- Concerns about decreasing river flows and the protection of natural river flows
- Specific location information on such events as spills and slackwater deposits (provided on the comment map)

Geology, Paleontology, Oil and Gas, and Other Mineral Resources

- Prohibit oil and gas leasing under the river
- Concerns about any changes to (removal of) FFSL's no surface occupancy classification
- How do leasing activities impact downstream resources?

Community Resources:

- Improve existing boater access points
- Create new boater access points
- Need for improved management in Labyrinth Canyon due to heavy recreational use
- Allow for continued multiple use of the river (motorized and non-motorized boats)
- Concerns with the impact motorized boats have on the non-motorized experience
- Prohibit jet skis
- Encourage recreational access and use of the river corridor and advocate for sustained access and maintenance of trails
- What is the permitting process for agriculture and irrigation stakeholders? What are the fees? Concerns about fee escalation over time.
- How does permitting work for agricultural and irrigation uses in different scenarios (e.g., multiple pumps in different areas on one property)?
- What are the limitations on fencing in the river? How do changing water levels affect fencing?
- Need clear definitions for agricultural equipment such as pumps, booms, and hoses
- What are the requirements for livestock river access?
- Concerns with frequent off-highway vehicle use on exposed sandbars
- Concerns about trespassing, graffiti, and littering on private lands adjacent to the river
- Educate river users on proper river etiquette (e.g., trespassing, boating regulations)
- Preserve the recreation experience by protecting canyons and viewsheds from development

A.2 Public Comment Period

A 50-day formal public comment period for the draft GRCMP began on May 31, 2019, and ended on July 19, 2019. Comments could be submitted at the second open house series, at federal or stakeholder meetings, online at the FFSL GRCMP website, by email, or by mail. FFSL received five written submissions commenting on the draft GRCMP. Verbal comments were also noted at the open house series and at federal and stakeholder meetings. Comments pertained to carrying capacity, terminology, education, wild and scenic river designation, motorized use, wildlife, FFSL jurisdiction, and GRCMP goals and objectives, to name a few. From the submissions, 30 individual comments were extracted for review of acceptance or non-acceptance. Individual comments are numbered per letter number (1–5). These individual comments are part of the project record and are included below in Table A-1, along with comment responses as required by rule and statute Utah Administrative Code R652-90-600 (1)(b-d) and Utah Code 65-A-2-4. Verbal comments were generally consistent with those provided in the comment submissions.

Table A-1. Green River Comprehensive Management Plan Public Comments

Submission Number	Comment Location	Commenter	Topic	Comment Number	Comment	Disposition/Response to Comment
1	Email, paragraph 3	River Runners for Wilderness	Carrying capacity	1.1	As such, we wholly support the management of all the river sections covered by these comprehensive plans for the preservation of aquatic and terrestrial wildlife. We must do everything we can to safeguard these precious resources from damaging activities, be they mineral extraction, agricultural development, bottomland "protection" by the creation of levies, or excessive visitation. Missing from these draft plans is any discussion of recreational carrying capacities. As such, these plans must address the need to create and identify carrying capacities for all the river sections covered in both the Green River and Colorado River comprehensive management plans.	As stated in Chapter 1, FFSL recognizes that protection of navigation, fish and wildlife habitat, aquatic beauty, public recreation, and water quality must be given due consideration and balanced against the need for, justification of, or benefit from any proposed use (Utah Administrative Code R652-2-200). By statute, FFSL is required to manage for these five Public Trust values. Recreational carrying capacity is currently not a significant issue on the Green River, and identification of a recreational carrying capacity is not needed at this time.
1	Email, paragraph 4	River Runners for Wilderness	Education	1.2	We wholeheartedly support continued educational efforts on the part of the Utah Department of Natural Resources to educate river runners about best camp practices with regards to packing out human waste and ash from fires. Educational goals as spelled out on page 213-14 of the GRCMP and ps 201-02 of the CRCMP are a good step in that direction.	Thank you for your comment.

Submission Number	Comment Location	Commenter	Topic	Comment Number	Comment	Disposition/Response to Comment
1	Email, paragraph 5	River Runners for Wilderness	Terminology	1.3	Both the CRCMP and GRCMP use the terms "private boaters" and "commercial operators." These terms are misleading. "Commercial operators" are private businesses conducting guided river tours. "Private boaters" are do-it-yourself river runners, public boaters or self-guided river runners. The terminology in these management plans should reflect actual practice. For example, the section "The Moab Daily" on page 160 of the CRCMP states "Commercial outfitters offered 51,355 non-motorized river trips to visitors on The Moab Daily segment in 2011. The BLM estimates daily private use on this section is 50% of the commercial use numbers, which would be 25,677 private non-motorized boaters in 2011 (BLM 2012)." In fact, private businesses conducting guided non-motorized river tours manage 51,355 clients on non-motorized trips, while 25,677 do-it-yourself river runners traveled the same section on non-motorized watercraft. The GRCMP defines "General Permits" on page 18 are for general public use or for private use such as private property. The same concepts apply for the general public who recreates on their own verses private business conducting for-profit and non-profit guided services.	Definitions for the terms *private boater* and *commercial outfitter* or *commercial operator* have been added to the Recreation section in Chapter 2 of the GRCMP.
1	Email, paragraphs 6, 7, 16	River Runners for Wilderness	River history	1.4	On pages 45 and 46 of the CRCMP and page 58 of the GRCMP, the history of river running is briefly covered in a combined total of three short paragraphs. Those paragraphs are dedicated to John Wesley Powell and Norm Nevills in the CRCMP, and Bus Hatch in the GRCMP. A simple search of the word "boat" shows that this word (including boat, boats, boater, boaters, and boating) is used 245 times in the GRCMC and 283 times in the CRCMP. The incredibly brief historic reviews of river running is most curious, given that river running is the largest recreational activity occurring in the areas of these management plans. The sections on river history must include additional historical content, based on recent publications recounting the history of river running. Any review of river history must include recreational river trips conducted by river runners free of commercially guided services. The history of do-it-yourself (DIY) river running is entirely missing in the river history paragraphs on page 44-45 of the CRCMP and page 58 of the GRCMP. The CRCMP jumps from the Powell Expedition of 1869 to the few Nevills conducted trips in the 1940's on the Green and Colorado River, missing the 1938 Clover Expedition on which Norm Nevills played a part. The GRCMP focusses solely on Bus Hatch. In the GRCMP, there is no mention of A.K. Reynolds, who was conducting commercial river trips in Lodore Canyon through Dinosaur National Monument in 1950, before Bus Hatch received a concessions permit to do so in Dinosaur National Monument (Big Water Little Boats; Moulty Fulmer and the First Grand Canyon Dory on the Wild Colorado River, Tom Martin, Vishnu Temple Press, Flagstaff, AZ, 2012, p 79). On both the Colorado and Green rivers covered by these comprehensive management plans, there were many hundreds of earlier river trips than the Nevills and Hatch river trips, yet none of them are mentioned or even hinted at. You should also be aware that both Norm Nevills and Bus Hatch actively worked to keep do-it-yourself river runners off the rivers they operated their private businesses on. As such, they are far from the best examples of river runners for these management plans. the Green and Colorado Rivers covered by these two plans has a robust and dynamic river running history completely apart from John Wesley Powell, Norn Nevills and Bus Hatch. Please correct this oversite that left out the very significant history of river running in these management plans.	Thank you for your comment. The GRCMP provides a very brief overview of river running history only and is not meant to provide an in-depth look at the history of river running. Other resources are available for those who are interested in learning more about this topic.

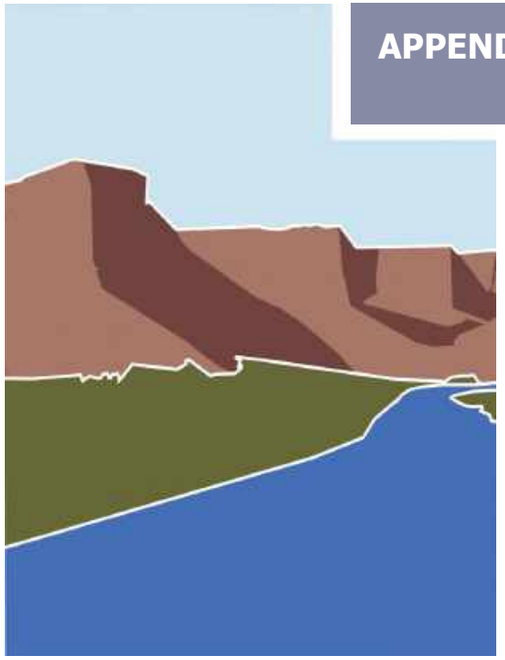
Submission Number	Comment Location	Commenter	Topic	Comment Number	Comment	Disposition/Response to Comment
2	Email, paragraphs 1, 2, 5	Joshua Wilmarth	Wild and scenic river designation	2.1	My name is Joshua Wilmarth. I am a resident of Green River, Utah and I am against any new river designation from the federal government. I do not believe that any of our state-owned lands should be cared for by people who don't live here or who have never been here. I do not like being locked out of public lands. I agree that some sort of river management plan is required, but that river management plan should be planned and implemented by the State of Utah. It is my understanding that the DNR is already addressing this issue. The federal government has been closing lands all over the country. In my opinion this is forcing a more focused and finite amount of land that we the people can recreate on, especially when we try to divide up the lands for special use. The detrimental impact on the smaller, government-approved land is much greater. It is very hard to teach people how to be good stewards of the land and rivers when it feels like we are being locked out at every turn. I believe public education - not public exclusion - is the best way to preserve our lands.	The designation of portions of the Green River as wild, scenic, or recreational was first proposed by local officials (and supported at the local level) in the Emery County Public Land Management Act of 2018. This act was incorporated into the federal law that made the designation official. Wild and scenic designation does not lock the public out of public lands, and recreation can still occur on these rivers. More information on wild and scenic rivers can be found here: https://www.rivers.gov/. The GRCMP is being developed for the management of state-owned sovereign land sections of the Green River by a state agency—FFSL.
2	Email, paragraphs 3 and 4	Joshua Wilmarth	Motorized use	2.2	I am a long-time user of the Green River, from the town of Green River to the town of Moab. I use a power boat to recreate, help clean out trash and debris that finds its way to the river, and occasionally help canoers and rafters who find themselves in need of assistance. But mostly, I use the Green River to gain quality time with my son. It is a very rare opportunity to find a digital-free zone to really get good quality time with a ten-year-old. The Green River has a long history of motoring that began before Lake Powell was created by the Glen Canyon Dam in 1966. I firmly believe that having motorized boats on the Green River results in far more good than harm. Without these boats safety also becomes an issue, as it can be very difficult to do a helicopter rescue in some places along the Green River, or any type of search and rescue.	The GRCMP does not change the current use of motorized watercraft in sovereign land sections of the river.
3	Email, paragraph 5	American Whitewater	Wild and scenic river designation	3.1	The management of those segments of the Green River - less than 0.5 river miles of the Green River north of Swasey's Landing boater access point and the 46 mile segment from Bull Bottom south to the county line (the Labyrinth Canyon segment from approximately RM 47 to RM 93) – designated as recreational and scenic, respectively, under the National Wild and Scenic Rivers Act should be managed in accordance with that legislation and as to protect the outstandingly remarkable values (ORVs) of those river segments.	Page 9 of the GRCMP discusses the management implications of these designations for FFSL.
3	Email, paragraph 6	American Whitewater	Wild and scenic river designation	3.2	The addition of these Wild and Scenic river sections to the Esri Story Map would be useful in understanding the management implications of the Plans.	The new designations will be included in the Esri Story Map if the appropriate data can be obtained.
3	Email, paragraph 7	American Whitewater	Wild and scenic river designation	3.3	When considering specific projects, decisions, and applications for authorizations or permits, FFSL should analyze impacts to ORVs on designated, eligible, and suitable wild and scenic segments of the Green River whether identified as sovereign lands or not. The continuity of the Green River between Wild and Scenic segments allows for impacts that could negatively affect ORVs.	Page 9 of the GRCMP discusses the management implications of the wild and scenic river designations for FFSL.
3	Email, paragraph 8	American Whitewater	Desired future conditions for water resources	3.4	Section 3.3 Water Resources: American Whitewater strongly supports all desired future conditions for water resources. Naturalized and seasonally variable flow and floodplain connectivity provide recreational opportunities and maintain river access and beaches for camping or picnicking.	Thank you for your comment.

Submission Number	Comment Location	Commenter	Topic	Comment Number	Comment	Disposition/Response to Comment
3	Email, paragraph 9	American Whitewater	Use determinations	3.5	Table 3.2 Use Determination for Proposed Actions by River Use Class: Dams proposed on Class 1, 2, or 3 river segments should not be found allowable if they are determined to impact river recreation, navigability, or flow regime.	FFSL is obligated to manage sovereign lands and resources for the protection of the Public Trust values, which include navigability and recreation. A dam may not be allowed in a Class 1, 2, or 3 area if a site-specific analysis indicates that it is inconsistent with the protection of the Public Trust. No change to the GRCMP has been made.
3	Email, paragraph 10	American Whitewater	Hydrology goals and objectives	3.6	Table 3.7 Hydrology Goals and Objections Common to All Classes: American Whitewater suggests the addition of a fifth Hydrology goal as indicated below. There are many recreational benefits associated with hydrology. Regulated and predictable flow regimes allow for vegetation to impedes on access and channel width. Beach maintenance is achieved with flows that support sediment supply and transport. This addition Hydrology Goal expands the hydrological benefits beyond the aquatic and riparian habitats. •Hydrology Goal 5: Recognize the importance of flows supporting healthy recreational processes. o Objective: Support research of preferential flows for all recreation types. o Objective: Identify existing recreational use to develop metric for protection of that use o Objective: Coordinate with agencies and partners to develop management strategies so projected declines to stream flows do not affect river recreation. o Objective: Collaborate with and encourage management agencies and partners to promote healthy flow regimes, especially those supporting river recreation. o Objective: Consider water quality during the authorization application process.	Based on your suggestions, FFSL has added a Hydrology Goal 5 to Table 3.7 of the GRCMP, along with three supporting objectives.
3	Email, paragraph 11	American Whitewater	Recreation objectives	3.7	Section 3.5 Community Resources - Recreation: American Whitewater supports the protection of areas of high wildlife habitat value or other sensitive areas. Camping and walking on banks in such sensitive areas should be avoided. However, paddling – canoeing, kayaking, and rafting – are likely some of the oldest forms of travel and exploration besides walking. Each river is a natural trail through the landscape, reflecting the character of the geology and natural beauty. Paddling is human-powered, place-based, low-impact, quiet, non-consumptive, skill-based, and Wilderness-compliant. With proper education and etiquette messaging, paddlesports should not be limited in sensitive areas.	It is possible that protection of a sensitive resource could require a temporary limitation on paddle sports. Any required recreation restrictions would be developed on a case-by-case basis, based on the particular resource protection need. No change to the GRCMP has been made.
3	Email, paragraph 12	American Whitewater	Recreation objectives	3.8	Table 3.19 Recreation Goals and Objectives Common to All Classes – Recreation Goal 4 Objective 2 "Limit new bridges and dams because they tend to degrade the experience of boaters on the river": American Whitewater strongly supports this objective.	Thank you for your comment.
3	Email, paragraph 13	American Whitewater	Access best management practices	3.9	Figure 3.15 Best Management Practices for access in the planning area: Camping opportunities should be identified between boater access points where those segments are over 10 miles apart.	This suggestion is outside FFSL's jurisdiction because we are not the adjacent upland landowner where camping would occur. No change to the GRCMP has been made.

Submission Number	Comment Location	Commenter	Topic	Comment Number	Comment	Disposition/Response to Comment
3	Email, paragraph 14	American Whitewater	Public safety objectives	3.10	Table 3.21 Public Safety Goals and Objectives Common to All Classes – Public Safety Goal 1 Objective 1 "Support removal or maintenance of temporary navigational hazards such as large woody debris and garbage": There are several considerations to be assessed when removing large woody debris for recreational safety. The ecological benefits of large woody debris need to be weighed against the threated posed to recreationists. Please see American Whitewater's guidance on integrating recreational boating considerations with in-stream modifications. https://www.americanwhitewater.org/content/Document/view/documentid/1006/	Edits have been made to this objective for clarification.
4	Email, paragraph 6	TJ Cook, Utah Division of Wildlife Resources (DWR)	Native plant species for restoration	4.1	**Table 2.4 Native Plant Species in the Planning Area Recommended for Restoration** DWR would like to include several species to help with restoration, including New Mexico privet, Utah bee plant, globemallow, coneflower, and milkvetch.	The suggested species have been added to Table 2.4, with the exception of coneflower.
4	Email, paragraph 7	TJ Cook, DWR	Fish	4.2	**Figure 2.22 Abundant and common native and nonnative fish species map** This map could be misunderstood without briefly explaining that sections of the river which were left off, could provide important habitats for native fish. Unless the reader takes in the whole plan, he or she may conclude, erroneously, that no fish exist in that stretch and that it therefore does not need to be considered for potential impacts.	A note has been added to the map explaining that "Sections of the Green River not shown on this map also provide important habitat for native fish."
4	Email, paragraph 8	TJ Cook, DWR	Wildlife	4.3	**Table 2.7 Special-status wildlife species** Bat species, including Allen's big-ear bat, fringed myotis, and spotted bat should all have descriptive verbiage similar to "This species is likely to occur at least sporadically along these river segments." Other presence/absence changes for specific sections are still being analyzed. UDWR [DWR] will coordinate with FFSL staff on species-specific information.	The text was changed to "This species is likely to occur at least sporadically along these river segments" for Allen's big-eared bat. The text for the remaining bats indicates that they could be present in all three segments.
4	Email, paragraph 9	TJ Cook, DWR	Fish	4.4	**Table 2.8: Presence/absence changes for specific sections are still being analyzed** DWR will coordinate with FFSL staff on species-specific information.	FFSL previously reviewed Table 2.8 and made changes in coordination with DWR. No additional changes have been made to this table.
4	Email, paragraph 10	TJ Cook, DWR	Fish	4.5	**Conservation Agreement Fish Species** In both the bluehead sucker and flannelmouth sucker sections, it currently reads: "The flannelmouth sucker is found…but is reduced in abundance in some areas because of predation and hybridization with the white sucker." In order to clarify that white sucker are not predating on flannelmouth sucker or bluehead sucker we suggest the addition of an Oxford comma, or editing the sentence to say "..is reduced in abundance in some areas because of hybridization with the white sucker, and predation.	Edits have been made to this sentence for clarification.
5	Email, MB comments, paragraph 1, 2, and 3	Bureau of Land Management (BLM)	Technical edit	5.1	1. Page 10 READS: Both wilderness areas are now withdrawn from all forms of appropriation under mining laws and are now closed to future mineral development. Should READ: Both BLM wilderness areas are withdrawn from mineral entry, on the date of wilderness designation subject to valid existing rights. BLM will continue to honor valid existing rights while preserving wilderness character to the greatest extent possible. Is there a reason Mineral Bottom access point is not identified or Green River State Park?	Suggested edits to the text have been made, with some modification. Mineral Bottom and Green River State Park boater access points are mentioned on page 175 of the GRCMP.

Submission Number	Comment Location	Commenter	Topic	Comment Number	Comment	Disposition/Response to Comment
5	Email, MB comments, paragraph 4	BLM	Technical edit	5.2	2. Page 169 The statement "the permit is issued free of charge by…" should read "the permit is issued by.."	The words "free of charge" have been removed from the text.
5	Email, MB, comments, paragraph 5	BLM	Technical edit	5.3	3. Page 175 The statement "The agreement establishes an interagency river permit for noncommercial trips with applicable river rules. Permits are required for all commercial boating trips." Should read "The agreement establishes an interagency river permit for noncommercial trips with applicable river rules. Special Recreation Permits (SRPs) are required for all commercial boating trips.	The suggested edit has been made.
5	Email, MB comments, paragraph 6	BLM	Technical clarification	5.4	4. Page 177 Bull Bottom and Junes Loop and Bottom could be included in the newly designated Wilderness and off limits to bike	"Bull Bottom" and "Junes Loop and Bottom" have been removed from the list.
5	Email, MB comments, paragraphs 7 and 8	BLM	FFSL jurisdiction	5.5	5. Page 179 "The volume of watercraft, both motorized and non-motorized, has the potential to exacerbate safety issues and to disturb the experience for shore-based recreationists trying to avoid crowds. FFSL's ability to address this concern is limited because this activity occurs on the water and not on the bed or banks of the Green River" Does this mean FFSL does not manage the user on the water? Just banks and bed?	The Utah Division of State Parks and Recreation (DSPR) has primary responsibility for boating rules and enforcement (e.g., speeding, wakes, proper equipment); FFSL does not have jurisdiction to enforce boating rules. However, FFSL does reserve the right to manage uses above sovereign lands. For example, a do-it-yourself boater floating a sovereign land section for a period of 15 days or greater is required to get a right-of-entry permit.
5	Email, MB comments, paragraph 9	BLM	Technical edit	5.6	6. Page 190 Would the BLM be considered a permitting agency for Special Recreation permits and the free permit for Labyrinth Canyon?	Yes. The permitting agency paragraph provides a few examples only and is not all-inclusive.
5	Email, MB comments, paragraph 10	BLM	Technical edits	5.7	7. Page 210 Wouldn't the majority of access locations and infrastructure be located on BLM land? Should we be listed as Management Agency, Permitting Agency, or Intersecting Agencies? Mention of coordination with the BLM to identify and develop new access points, new trash and recycling receptacles near recreation infrastructure and at other places where users approach the river.	"BLM" has been added as a permitting and management agency to tables as requested in your comments on the Colorado River CMP. The second objective under Access Goal 1 in Table 3.20 has been modified in response to your suggestion.
5	Email, MB comments, paragraph 11	BLM	Aesthetic beauty	5.8	8. Page 211 "Maintain or improve aesthetic beauty when designing new recreation facilities" For projects on BLM lands we use the Visual Resources Contrast Rating Handbook which compares the project with the major features in the existing landscape. This assessment process provides a means for determining visual impacts and for identifying measures to mitigate the impacts. We would be happy to share our visual resource management techniques.	Thank you for the information.

Submission Number	Comment Location	Commenter	Topic	Comment Number	Comment	Disposition/Response to Comment
5	Email, Moab Field Office comments, paragraph 23	BLM	Miscellaneous	5.9	Items to consider: • need to consider the BLM 3 rivers withdrawal along Colorado and Green Rivers; • need to consider the potential impact of WSR designation on Green River; • as Brian Mueller noted during the June agency meeting, there is a need to better define on public maps river segments which are currently not adjudicated; • need to consider implications of new wilderness designation on west side of Labyrinth Canyon along the Green River; • need to define high water mark (extent of sovereignty) more precisely; "bank" may be hard to define (a moving target); • BLM is awaiting a draft MOU from FFSL that will facilitate collaborative and complimentary management of the Green and Colorado Rivers. This MOU will provide specifics and be a working document that will provide objectives and goals as well as how the two agencies will work together to achieve the best possible management of the unique resources.	The Three Rivers Withdrawal is discussed on page 143 of the GRCMP. The Wild and Scenic River designation is discussed on page 9 of the GRCMP. Maps have been reviewed to ensure that they indicate which segments of the river are currently not adjudicated (this only applies to the Colorado River). The new wilderness designation is discussed on page 10 of the GRCMP. Please see Section 1.2 of the GRCMP for an explanation of ordinary high water mark (OHWM) and sovereign land boundaries. The subsection titled Green River Management explains how the OHWM definition is practically applied. Thank you for your comment on the MOU (memorandum of understanding).



APPENDIX B – LIST OF PREPARERS

Table B-1. List of Preparers for the Green River Comprehensive Management Plan

First Name	Last Name	Title/Role
SWCA Environmental Consultants		
Tom	Hale	Project manager
Gretchen	Semerad	Project manager
Linda	Burfitt	Lead editor
Ralph	Burrillo	Cultural resources lead
Diane	Bush	Technical editor
Dave	Epstein	Water resources lead
Jeremy	Eyre	Geology, paleontology, mineral resources lead
Reilly	Jensen	Graphic designer
Rachel	Johnson	Geographic information system specialist
Kerri	Linehan	Technical editor
Audrey	McCulley	Ecosystems lead
Debbi	Smith	Formatter
Rich	Valdez	Fisheries subject matter expert
Independent Consultant		
Jack	Schmidt	River geomorphology advisor
Alex	Walker	Fluvial geomorphologist
CRSA		
Melissa	Fryer	Design renderings lead
J. Kelly	Gillman	Planning lead
Susie	Petheram	Communications strategy coordinator (former)
River Science Institute, Inc.		
John	Gangemi	River-based recreation advisor
Hansen, Allen & Luce, Inc.		
Greg	Poole	Water resources engineer

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