Operation of Flaming Gorge Dam Final Environmental Impact Statement

Final Biological Opinion Technical Appendix

FINAL BIOLOGICAL OPINION TECHNICAL APPENDIX

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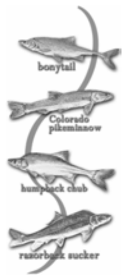

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FISH AND WILDLIFE SERVICE
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6-UT-05-F-006
05-1380

September 6, 2005

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P.O. Box 11606
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RE: Final Biological Opinion on the Operation of Flaming Gorge Dam
(Consultation # 6-UT-05-F-006)

Dear Sirs,

This letter transmits the enclosed Final Biological Opinion on the Preferred Alternative of the Flaming Gorge Dam Environmental Impact Statement. Reclamation proposes to modify the operations of Flaming Gorge Dam, to the extent possible, to achieve U.S. Fish and Wildlife Service flow and temperature recommendations identified in the Upper Colorado River Endangered Fish Recovery Program report "Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam" (Muth et al. 2000).

I would like to take this opportunity to commend you on your significant contributions, past and present, to the recovery of the endangered fishes of the Colorado River system. Implementation of the revised flow recommendations for Flaming Gorge Dam is the culmination of 13 years of effort by Reclamation, Western, U.S. Fish and Wildlife Service and the Recovery Program and represents a significant achievement as we seek ways to recover the endangered fishes and provide for future water development. I would also like to express my appreciation to you and your staffs for your cooperation and considerable efforts in successfully completing this consultation. If you have any questions please feel free to contact Mr. Larry Crist or myself at 801-975-3330 ext. 126 or ext. 124, respectively.

Sincerely,

Henry R. Maddux
Utah Field Supervisor

Memorandum

To: Regional Director, Bureau of Reclamation, Upper Colorado Regional Office, Salt Lake City, Utah

Area Manager, Bureau of Reclamation, Provo Area Office, Provo, Utah

Area Manager, Western Area Power Administration, Salt Lake City, Utah

From: Field Supervisor, Utah Field Office Fish and Wildlife Service
Salt Lake City, Utah

Subject: Final Biological Opinion on the Operation of Flaming Gorge Dam

In accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.), and the Interagency Cooperation Regulations (50 CFR 402), this transmits the Fish and Wildlife Service's (Service) final biological opinion for impacts to federally listed endangered species for Reclamation's proposed action to operate Flaming Gorge Dam to protect and assist in recovery of populations and designated critical habitat of the four endangered fishes found in the Green and Colorado River Basins. Reference is made to your February 1, 2005, correspondence (received in our Utah Field office on February 1, 2005) requesting initiation of formal consultation for the subject project. Based on the information presented in the biological assessment and the Operation of Flaming Gorge Environmental Impact Statement that you provided, I concur that the proposed action may adversely effect the threatened Ute ladies'-tresses (*Spiranthes diluvialis)* and the endangered Colorado pikeminnow *(Ptychocheilus lucius*), humpback chub (*Gila cypha*), bonytail (*Gila elegans*), and razorback sucker (*Xyrauchen texanus*) and critical habitat.

Based on the information provided in the biological assessment, I also concur that the proposed operation of Flaming Gorge Dam may affect, but is not likely to adversely affect, the bald eagle (*Haliaeetus leucocephalus*) and southwestern willow flycatcher (*Empidonax traillii extimus*). In addition, I concur with the determination of no effect for the California condor (*Gymnogyps californiannus)*, black-footed ferret (*Mustela* nigripes) and Canada lynx (*Lynx* canadensis). The bald eagle's preferred prey are fish and waterfowl, and the proposed action involves implementation of flow recommendations that should support its prey and benefit the riparian forest that eagles use for roosting. The southwestern willow flycatcher nests in riparian corridors, islands and sandbars vegetated with willow, tamarisk and other shrubs. The species may occur in low numbers during the summer along the Green River downstream of Ouray, Utah, though subspecific identity has not been confirmed. Riparian habitats utilized by the southwestern willow flycatcher are expected to benefit from implementation of a flow recommendations for the endangered fishes that would result in a more natural flow regime. The California condor is not a resident in the Green River subbasin and would not be affected. The proposed action would also have no effect on black-footed ferret's and lynx since their upland habitats and their prey base are not affected by Flaming Gorge Dam operations.

Consultation History

Construction of Flaming Gorge Dam predates the Endangered Species Act of 1973 and as a result consultation on its construction has never been required. Consultation on operations at Flaming Gorge Dam and other Reclamation projects in the Green River subbasin first started in the late 1970s and early 1980s. The earliest link between operations at Flaming Gorge Dam and other Reclamation consultations was in November 1979 when the Service issued a jeopardy biological opinion for the Upalco Unit of the Central Utah Project and stipulated in the Reasonable and Prudent Alternative (RPA) that Flaming Gorge would compensate for depletions of the project.

On February 27, 1980, the Service requested consultation under Section 7 of the ESA for projects currently under construction in the Upper Colorado River Basin and for the continued operation of all existing Reclamation projects in the basin, including the Colorado River Storage Project (CRSP). Reclamation agreed with the request and formal consultation on the operation of Flaming Gorge Dam was initiated on March 27, 1980. Issuance of a final biological opinion by the Service for the operation of Flaming Gorge Dam was delayed until data collection and studies related to habitat requirements for the endangered fishes could be completed and used to recommend specific flows in the Green River downstream from the dam. Between 1980 and 1991 there were a series of agreements between Reclamation and the Service delaying the issuance of a biological opinion until sufficient information was collected. Existing dam operations were initially evaluated for potential effects on endangered fishes from 1979 to 1984. In 1984 the Service and Reclamation reached an interim flow agreement that constrained summer flows to benefit the endangered fishes and between 1985 and 1991 effects of the constrained summer flows were studied. Reclamation served as the lead agency for this consultation, with Western Area Power Administration (Western) becoming a party to the consultation in 1991.

During this same period, the Service issued a final biological opinion (USFWS 1980) for the Strawberry Aqueduct and Collection System (SACS), a major feature of the Central Utah Project. The SACS biological opinion determined that flow depletions from the Duchesne and Green Rivers would likely jeopardize the continued existence of the endangered Colorado pikeminnow and humpback chub. The SACS biological opinion also included a RPA that stated "Jeopardy from the Bonneville Unit, considered with the other CUP units, could be avoided by operating Flaming Gorge Dam in a more environmentally sensitive manner. Since modification of the Flaming Gorge penstock in 1978, this reservoir could be operated with much less impact on endangered fishes. Modified operations would not only compensate for effects of CUP, but also could help restore the Green River to a healthy condition for the listed fishes."

Using information collected from 1979 to 1991, the Biological Opinion on the Operation of Flaming Gorge Dam (1992 FGBO) was issued on November 25, 1992 (USFWS 1992a). The opinion stated that the then-current operation of Flaming Gorge Dam was likely to jeopardize the continued existence of the endangered fishes in the Green River. Flow recommendations in the 1992 FGBO for spring, summer, autumn, and winter were based on the best available information and professional judgment of researchers who had collected and analyzed much of the data. The recommended flows were intended to restore a more natural hydrograph and to provide a flow regime that would allow for enhancement and recovery of endangered and other native fishes in the Green River. Because of data limitations and the desire to protect areas believed to be crucial for protection of the endangered fishes, the 1992 FGBO only recommended target flows for the Green River at the U.S. Geological Survey (USGS) gage near Jensen, Utah (located 157 km, or 98 mi, downstream from the dam). The 1992 FGBO also called for refining operations so that temperature regimes, especially downstream of the confluence of the Green and Yampa Rivers, would more closely resemble historic conditions and to examine the feasibility and effects of releasing warmer water during the late spring/summer period.

The 1992 FGBO described elements of a Reasonable and Prudent Alternative (RPA) that would offset jeopardy to the endangered fishes (USFWS 1992a). The RPA included the following elements:

- Refine the operation of Flaming Gorge Dam so that flow and temperature regimes of the Green River more closely resemble historic conditions.

- Conduct a 5-year research program that includes winter and spring research flows, to allow for potential refinement of flows for these seasons.

- Determine the feasibility and effects of releasing warmer water during the late spring/summer period and investigate the feasibility of retrofitting the river bypass tubes to include power generation, thereby facilitating higher spring releases.

- Legally protect Green River flows from Flaming Gorge Dam to Lake Powell.

- Initiate discussions with the Service after conclusion of the 5-year research program to examine further refinement of flows for the endangered Colorado River fish. Under this element, results of the research program will be used to reevaluate and, if necessary, refine recommendations presented in the biological opinion.

The five-year research program concluded in 1996. At that time, the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin (Recovery Program) developed a report that summarized research and developed flow recommendations that were based on all the available information. That report (Muth et al. 2000) provided the basis for Reclamation's proposed action evaluated in their EIS and this biological opinion.

During the time that consultation for the 1992 FGBO was ongoing, other ESA related activities were occurring in the basin. In 1984, the Department of the Interior, Colorado, Wyoming, Utah, water users, and environmental groups formed a coordinating committee to discuss a process to recover the endangered fishes while new and existing water development proceeded in the Upper Colorado River Basin in compliance with Federal and State law and interstate compacts.

After 4 years of negotiations, the Secretary of the Interior; Governors of Wyoming, Colorado, and Utah; and the Administrator of the Western Area Power Administration (Western) cosigned a Cooperative Agreement on January 21-22, 1988, to implement the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin (Recovery Program). Current participants in the Recovery Program include: the Service, Reclamation, National Park Service, Western, Colorado, Utah, Wyoming, Western Resource Advocates, The Nature Conservancy, Colorado Water Congress, Utah Water Users Association, Wyoming Water Development Association, and the Colorado River Energy Distributors Association. The goal of the Recovery Program is to recover the listed species while providing for new and existing water development in the Upper Colorado River Basin. All participants agreed to cooperatively work toward the successful implementation of a recovery program that will provide for recovery of the endangered fish species, consistent with Federal law and all applicable State laws and systems for water resource development and use. Each signatory assumed certain responsibilities in implementing the Recovery Program. In particular, the refined operation of Federal reservoirs by Reclamation to reduce or eliminate impacts to endangered fish and contribute to their recovery was identified as critical to the Recovery Program. To further define and clarify processes outlined in sections 4.1.5, 4.1.6, and 5.3.4 of the Recovery Program (USFWS 1987), the *Section 7 Consultation, Sufficient Progress, and Historic Projects Agreement* (Section 7 Agreement) and *Recovery Implementation Program Recovery Action Plan* (RIPRAP) were developed in 1993 and updated yearly (USFWS 2003). The Section 7 Agreement established a framework for conducting section 7 consultations on depletion impacts related to new projects and impacts associated with existing projects in the upper basin. Procedures outlined in the Section 7 Agreement are used to determine if sufficient progress is being accomplished in the recovery of endangered fishes to enable the Recovery Program to serve as a reasonable and prudent alternative to avoid the likelihood of jeopardy and/or adverse modification of critical habitat.

Since the inception of the Recovery Program, the Service has consulted on over 700 projects depleting water from the Upper Colorado River Basin. The Recovery Program, through its implementation of the RIPRAP, has avoided the likelihood of jeopardy and/or adverse modification of critical habitat on behalf of these projects.

The RIPRAP outlines specific recovery actions, including such measures as acquiring and managing aquatic habitat and water, re-operating existing reservoirs to provide instream flows for fishes, constructing fish passage facilities, controlling nonnative fishes, and propagating and stocking listed fish species. It also stipulates which entity is responsible for taking action, when these actions would be undertaken, and how they would be funded. The RIPRAP was finalized on October 15, 1993, and has been reviewed and updated annually.

One high priority RIPRAP element under the FY 2004 Green River Action Plan: Green River above Duchesne River I.A.3.d., is to operate Flaming Gorge Dam to provide winter and spring flows and revised summer/fall flows, pursuant to the new Flaming Gorge biological opinion. Implementation of this priority RIPRAP item by Reclamation through adoption of Flow Recommendations is intended to offset in part the adverse effects of water depletions by other projects and fulfill a commitment by Reclamation to refine operations at its facilities, including

Flaming Gorge to assist in meeting instream flow requirements for endangered fishes (USFWS 1987).

Other consultations that rely on Flaming Gorge Dam as a RPA to offset their depletions include; the 1998 programmatic biological opinion for the Duchesne River Basin (447,000 af) and the 2000 Narrows Project (5,717 af). Projects covered under the programmatic biological opinion for the Duchesne River include; Strawberry Valley Project, Provo River Project, Moon Lake Project, Midview Exchange, Ute Indian Irrigation Project, and the Central Utah Project which includes the Bonneville, Uintah and Upalco Units. Consultations that received non-jeopardy biological opinions but also depend operation of Flaming Gorge Dam to meet flow recommendation as part of continued sufficient progress of the Recovery Program to offset water depletions include the Price-San Rafael Unit of the Salinity Control Program (1992) and the Programmatic Biological Opinion on the Management Plan for Endangered Fishes in the Yampa River Basin.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

Scope of Biological Opinion

Emergencies

This biological opinion does not cover emergency operations at Flaming Gorge Dam. Where emergency circumstances mandate the need to consult in an expedited manner, consultation may be conducted informally through alternative procedures that are consistent with the requirements of section 7 (a)-(d) of the Act. This provision applies to situations involving acts of God, disasters, casualties, national defense or security emergencies, etc. (50 CFR 402.05). The timing and nature of emergencies are typically not predictable but at Flaming Gorge Dam they may be associated with dam safety, personal safety of individuals or groups associated with recreation or other activities on the river or power system conditions. Emergencies associated with dam safety could include unforeseen releases or operations to protect dam infrastructure. Emergencies associated with the safety of individuals or groups may be associated with river rescue or recovery operations. Types of emergency powerplant operations are discussed in Section 1.6 of the Operation of Flaming Gorge Dam Environmental Impact Statement (FGEIS) and include insufficient generation capacity, transmission (overload and voltage control), load shedding and system restoration. Emergency operations are typically of short duration as a result of emergencies occurring at the dam or within the transmission network. In the event of an emergency, Reclamation and/or Western will contact the Service in a timely manner for advice on measures to minimize the effects of the response on species and critical habitat, and formal consultation, if needed, will be conducted after the fact. This should not be interpreted to mean that an emergency response should be delayed if it is not possible to contact the Service. Spills associated with normal dam operations or to meet the proposed action are not considered emergencies and are covered in this biological opinion.

Action Area

Under the proposed action, Flaming Gorge Dam would be operated to achieve the flow and temperature regimes recommended in Muth et al. (2000), while maintaining all authorized purposes of the Flaming Gorge Unit of the CRSP, particularly those related to the development of water resources in accordance with the Colorado River Compact. The flow and temperature recommendations describe the peak flows, durations, water temperatures, and base flow criteria believed by the Service to be necessary for the survival and recovery of endangered fishes. This biological opinion addresses the effects of the proposed action and associated flow regime on the endangered Colorado pikeminnow, humpback chub, bonytail and razorback sucker and the threatened Ute ladies'-tresses in the Green River downstream of Flaming Gorge Dam

The flow and temperature recommendations include specified peak and base flows (Table 1) to be achieved in the three portions of the Green River defined as follows:

- **Reach 1:** Flaming Gorge Dam to the Yampa River confluence (river kilometer [RK] 555 to 660, or river mile [RM] 345 to 410). Flow in this reach, which is measured at the USGS gage near Greendale, Utah, is almost entirely regulated by releases from Flaming Gorge Dam.

- **Reach 2:** Yampa River confluence to White River confluence (RK 396 to 555, or RM 246 to 345). Flow in this reach is measured at the USGS gage near Jensen, Utah. In this reach, tributary flows from the Yampa River combine with releases from Flaming Gorge Dam to provide a less regulated flow regime than in Reach 1.

- **Reach 3:** White River confluence to Colorado River (RK 0 to 396 or RM 0 to 246). Flow in this reach is measured at the USGS gage near Green River, Utah. In this reach, the Green River is further influenced by tributary flows from the White, Duchesne, Price, and San Rafael Rivers.

These three reaches (Figure 1) of the Green River and the adjacent 100 year floodplain constitute the action area considered in this biological opinion.

Flow and Temperature Recommendations

The proposed action would provide increased interannual variability in peak and base flows. Such variability is thought to support in-channel and floodplain geomorphic processes that would maintain the ecosystem dynamics to which the endangered fishes are adapted. Not all objectives for each species can or need to be met within each year. Different species occupy different ecological niches, and distinct life stages benefit from different specific hydrologic conditions. For all species, short-term adverse effects of high or low flows would be offset by longer-term benefits. The flow patterns of the proposed action approximate unregulated flow conditions more closely than the flow conditions required under the 1992 FGBO. The magnitude, duration, and timing of releases from Flaming Gorge Dam would be tied to the anticipated hydrologic condition in a given year. This approach would tend to mimic the natural hydrology of the Green River subbasin and provide within-year and between-year variability.

Forecasted runoff volume would be used to determine the magnitude, duration, and timing of releases from Flaming Gorge Dam to enhance downstream habitat conditions. When above-average runoff conditions are forecasted, bypass tubes or the spillway at Flaming Gorge Dam would be used to increase peak spring flows in downstream reaches. During average or drier years, spring releases would be at maximum power plant levels or greater to achieve specific target peak flows in downstream reaches. Peak releases from Flaming Gorge Dam would be timed to coincide with peak and immediate post-peak flows of the Yampa River to maximize the magnitude and duration of the peak, restore in-channel processes, inundate floodplain habitats, and extend the duration of peak flows in Reaches 2 and 3. Similar to peak flows, base flows during summer–winter would be tied to annual hydrologic conditions and would be higher in wetter years than in drier years.
Under the proposed action, hydrologic conditions in any given year would be placed in one of the following categories:

- **Wet (0–10% exceedance[1]).** Annual forecasted runoff volume is larger than almost all of the historic runoff volumes (10% probability of occurrence).

- **Moderately wet (10–30% exceedance).** Annual forecasted runoff volume is larger than most of the historic runoff volumes (20% probability of occurrence).

- **Average (30–70% exceedance).** Annual forecasted runoff volume is larger than about half of the historic runoff volumes (40% probability of occurrence).

- **Moderately dry (70–90% exceedance).** Annual forecasted runoff volume is less than most of the historic runoff volumes (20% probability of occurrence).

- **Dry (90–100% exceedance).** Annual forecasted runoff volume is less than almost all of the historic runoff volumes (10% probability of occurrence).

These exceedance intervals were chosen to provide guidance for setting peak- and base-flow targets under different hydrologic conditions so as to achieve the desired hydrologic variability. In reality, annual runoff volume is a continuous variable, and any categorization scheme is somewhat arbitrary. Release patterns in any given year would reflect where within the wet to dry continuum the hydrologic condition in that year falls.

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1 Exceedance values refer to the percentage of recorded flows that have been higher than that value. An exceedance value is equivalent to 1 minus the percentile.

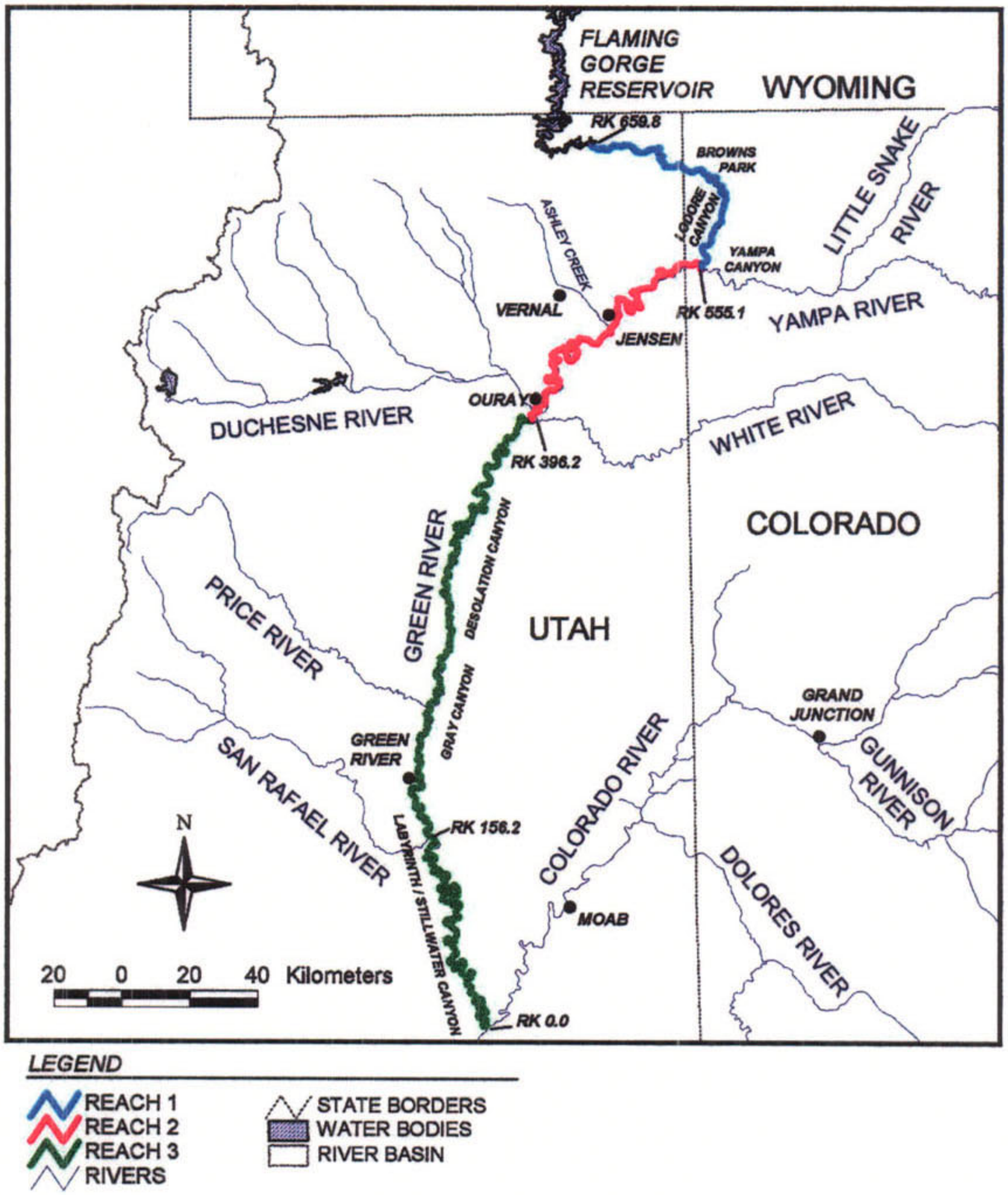

FIGURE 1 Map of the Green River Downstream of Flaming Gorge Dam (Source: Muth et al. 2000)

Due to the fact that it was not feasible to cover every contingency in the flow recommendations, the authors of the flow recommendations recommended that real-time data and other available year-specific information would be factored into annual implementation of the proposed action. Yearly patterns of releases from Flaming Gorge Dam to meet the recommended flows and temperatures for each hydrologic condition could then be adjusted on the basis of information about hydrology, the status of endangered fish life stages and populations, and habitat conditions. Muth et al. (2000) recommended that Reclamation, Western, and the Service establish a technical working group of biologists and hydrologists to help refine release plans for each year and provide advice on modifying releases during changing hydrologic conditions.

Table 1 summarizes the recommended peak and base flows from Muth et al. (2000) for all three reaches of the Green River. Under the proposed action, Flaming Gorge Dam would be operated with the goal of achieving these recommended flows as often as possible while maintaining the other authorized purposes of Flaming Gorge Dam and Reservoir.

Operations under the Proposed Action

This section describes the process that Reclamation would use to implement the proposed action while maintaining other authorized purposes and assuring safe operations of Flaming Gorge Dam under normal operational conditions. Operational plans, however, may be altered temporarily to respond to emergencies. Safe operation of Flaming Gorge Dam is of paramount importance, and is applicable to all dam operations under the proposed action. In order to safely and efficiently operate Flaming Gorge Dam, forecasted future inflows must be incorporated into the decision making process. These forecasted future inflows are provided by the National Weather Service through the River Forecast Center and are issued as monthly or seasonal (April through July) volumes of unregulated inflow that are anticipated to occur during the forecast period. A forecast error is the volume difference between the forecasted and actual inflow volume for the period. Forecast errors mostly are attributable to hydrologic variability and to a much lesser degree the forecasting procedure. Consequently, forecast errors will always be a factor associated with the operation of Flaming Gorge Dam.

Analysis of the historic forecast errors at Flaming Gorge Dam was performed by the Colorado River Forecasting Service Technical Committee (CRFSTC) in April 1987. They determined the magnitude of 5% exceedance forecast errors associated with the various forecast products issued by the Colorado River Basin Forecast Center (CBRFC). These errors occur in one out of every 20 years on average and errors of greater magnitude occur less frequently. From the information provided by the CRFSTC, forecast errors at the 1% exceedance level (1 out of every 100 years) were computed.

Safe operation of Flaming Gorge Dam limits the risk of uncontrolled spills to 1% when the greatest foreseeable forecast error occurs. In other words, safe operation must assure that 99% of the foreseeable forecast errors can be successfully routed through Flaming Gorge Reservoir without uncontrolled spills occurring. To limit this risk, Reclamation maintains vacant storage

TABLE 1 Recommended Magnitudes and Duration of Maximum Spring Peak and Summer-to-Winter Base Flows and Temperatures for Endangered Fishes in the Green River Downstream From Flaming Gorge Dam as Identified in the 2000 Flow and Temperature Recommendations

		Hydrologic Conditions and 2000 Flow and Temperature Recommendations[a]				
Location	**Flow and Temperature Characteristics**	**Wet (0–10% Exceedance)**	**Moderately Wet (10–30% Exceedance)**	**Average (30–70% Exceedance)**	**Moderately Dry (70–90% Exceedance)**	**Dry (90–100% Exceedance)**
Reach 1 Flaming Gorge Dam to Yampa River	Maximum Spring Peak Flow	≥8,600 cfs (244 cubic meters per second [m3/s])	≥4,600 cfs (130 m3/s)	≥4,600 cfs (130 m3/s)	≥4,600 cfs (130 m3/s)	≥4,600 cfs (130 m3/s)
	Peak flow duration is dependent upon the amount of unregulated inflows into the Green River and the flows needed to achieve the recommended flows in Reaches 2 and 3.					
	Summer-to-Winter Base Flow	1,800–2,700 cfs (50–60 m^3/s)	1,500–2,600 cfs (42–72 m^3/s)	800–2,200 cfs (23–62 m^3/s)	800–1,300 cfs (23–37 m^3/s)	800–1,000 cfs (23–28 m^3/s)
Above Yampa River Confluence	Water Temperature Target	≥ 64 °F (18 °C) for 3-5 weeks from mid-August to March1	≥ 64 °F (18 °C) for 3-5 weeks from mid-August to March 1	≥ 64 °F (18 °C) for 3-5 weeks from mid-July to March 1	≥ 64 °F (18 °C) for 3-5 weeks from June to March 1	≥ 64 °F (18 °C) for 3-5 weeks from mid-June to March 1
Reach 2 Yampa River to White River	Maximum Spring Peak Flow	≥26,400 cfs (748 m^3/s)	≥20,300 cfs (575 m^3/s)	≥18,600 cfs[b] (527 m^3/s) ≥8,300 cfs[c] (235 m3/s)	≥8,300 cfs (235 m^3/s)	≥8,300 cfs (235 m^3/s)
	Peak Flow Duration	Flows greater than 22,700 cfs (643 m^3/s) should be maintained for 2 weeks or more, and flows 18,600 cfs (527 m^3/s) for 4 weeks or more.	Flows greater than 18,600 cfs (527 m^3/s) should be maintained for 2 weeks or more.	Flows greater than 18,600 cfs (527 m^3/s) should be maintained for at 2 weeks in at least 1 of 4 average years.	Flows greater than 8,300 cfs (235 m^3/s) should be maintained for at least 1 week.	Flows greater than 8,300 cfs (235 m^3/s) should be main-tained for 2 days or more except in extremely dry years (98% exceedance).
	Summer-to-Winter Base Flow	2,800–3,000 cfs (79–85 m^3/s)	2,400–2,800 cfs (69–79 m^3/s)	1,500–2,400 cfs (43–67 m^3/s)	1,100–1,500 cfs (31–43 m^3/s)	900–1,100 cfs (26–31 m^3/s)

TABLE 1 (Cont.)

Location	Flow and Temperature Characteristics	Hydrologic Conditions and 2000 Flow and Temperature Recommendations[a]				
		Wet (0–10% Exceedance)	**Moderately Wet** (10–30% Exceedance)	**Average** (30–70% Exceedance)	**Moderately Dry** (70–90% Exceedance)	**Dry** (90–100% Exceedance)
Below Yampa River Confluence	Water Temperature Target	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.
Reach 3 White River to Colorado River	Maximum Spring Peak Flow	≥39,000 cfs (1,104 m^3/s)	≥24,000 cfs (680 m^3/s)	≥22,000 cfs[d] (623 m^3/s)	≥8,300 cfs (235 m^3/s)	≥8,300 cfs (235 m^3/s)
	Peak Flow Duration	Flows greater than 24,000 cfs (680 m^3/s) should be maintained for 2 weeks or more, and flows 22,000 cfs (623 m^3/s) for 4 weeks or more.	Flows greater than 22,000 cfs (623 m^3/s) should be maintained for 2 weeks or more.	Flows greater than 22,000 cfs (623 m^3/s) should be maintained for 2 weeks in at least 1 of 4 average years.	Flows greater than 8,300 cfs (235 m^3/s) should be maintained for at least 1 week.	Flows greater than 8,300 cfs (235 m^3/s) should be maintained for 2 days or more except in extremely dry years (98% exceedance).
	Summer-to-Winter Base Flow	3,200–4,700 cfs (92–133 m^3/s)	2,700–4,700 cfs (76–133 m^3/s)	1,800–4,200 cfs (52–119 m^3/s)	1,500–3,400 cfs (42–95 m^3/s)	1,300-2,600 cfs (32–72 m^3/s)

[a] Recommended flows as measured at the USGS gage located near Greendale, Utah, for Reach 1; Jensen, Utah, for Reach 2; and Green River, Utah, for Reach 3.
[b] Recommended flows ≥18,600 cfs (527 m^3/s) in 1 of 2 average years.
[c] Recommended flows ≥8,300 cfs (235 m^3/s) in other average years.
[d] Recommended flows ≥22,000 cfs (623 m^3/s) in 1 of 2 average years.

space in the reservoir at various times of the year to absorb the additional inflow volume if a forecast error occurs. Reservoir elevation is intentionally drawn down by Reclamation during the fall and winter months to accommodate additional inflow.

The upper limit draw-down levels for safe operation were determined through routing studies of forecast error scenarios. These scenarios were based on the 1% exceedance forecast errors. The scenario that had the largest risk of an uncontrolled spill was routed through the reservoir beginning in May with various reservoir elevations and various inflow volumes that were based on historic records. The highest elevations, where the largest risk scenario successfully routed the inflow volume through the reservoir without an uncontrolled spill, was established as the upper limit draw-down levels for that forecast volume.

Inter-agency coordination would be used to implement the flow and temperature recommendations of Muth et al. (2000). A technical working group representing Reclamation, Service, and Western, as well as other qualified individuals who choose to participate on a voluntary basis, would convene at various times throughout the year to discuss future operational plans and to refine these plans to best meet the needs of the endangered fish. Release patterns for all seasons would be discussed by this technical working group and recommendations would incorporate real time and year specific information identified in Table 5.3 of Muth et al. (2000). These meetings would also provide an opportunity to discuss historic operations in terms of the accomplishments and short comings of meeting the flow and temperature recommendations. Reclamation would maintain an administrative record of these meetings to document the planning process.

Operations in May through July (Spring Period)

Under the proposed action, Reclamation would establish the hydrologic classification for the spring period (May through July) based on the forecasted unregulated inflow to Flaming Gorge Reservoir for the April through July period. This forecast is issued by the River Forecast Center beginning in early January and is updated twice per month until the end of July. Reclamation would classify the hydrology of the Green River system into one of the five hydrologic classifications described above (wet, moderately wet, average, moderately dry, and dry).

The hydrologic classification would be used to establish the range of flow magnitudes and durations that could be targeted for the approaching spring release period. These targets would be incorporated into a spring operations plan. This plan would be prepared each year by Reclamation in coordination with the technical working group prior to the spring Flaming Gorge Working Group meeting. Various year-specific factors listed in Table 5.3 of Muth et al. (2000) along with the established hydrologic classification would be considered in the development of the operations plan.

It is expected that in most years, the flow magnitudes and durations achieved in Reach 2 each spring would be consistent with the flow magnitudes and durations described in Muth et al. (2000) for the hydrologic classification established in May of each year. However, because factors listed in Muth et al. (2000) are also considered, particularly runoff conditions in the Yampa River, there would be some years where the peak flows that occur in Reach 2 achieve the targets for either one or two classifications higher (wetter) or one classification lower (drier) than the actual classification established for the Green River. It is anticipated that in some years, when the hydrologic classification for the Green River is average, that conditions would be such that it would be possible to achieve the targets established for either the moderately wet or wet classifications. Conversely, there would be some years classified as moderately wet when the conditions would be such that targets established for the average classification would be met. There could also be years classified as wet where moderately wet targets would be achieved because of year-specific conditions. It would be Reclamation's responsibility in coordination with the technical working group to assure that over the long term, Flaming Gorge Dam operations are consistent with the Muth et al. (2000) flow and temperature recommendations.

The operations plan would describe the current hydrologic classification of the Green River subbasin and the hydrologic conditions in the Yampa River Basin, including the most probable runoff patterns for the two basins. The operations plan would also identify the most likely Reach 2 flow magnitudes and durations that would be targeted for the upcoming spring release. Because hydrologic conditions often change during the April through July runoff period, the operations plan would contain a range of operating strategies that could be implemented under varying hydrologic conditions. Flow and duration targets for these alternate operating strategies would be limited to those described for one classification lower or two classifications higher than the classification for the current year.

In years classified as wet, bypass releases would usually be required for both safe operation of the dam and to meet the flow recommendations. In some years classified as wet, spillway releases would be necessary for safe operation of the dam. Releases above powerplant capacity in these wet years would be expected to be made for a period of about 4 to 9 weeks. The exact magnitude of the release and duration of the release would depend upon the year-specific conditions of factors listed in Table 5.3 of Muth et al. (2000) as well as the carryover storage from the previous year. Wet year high releases would be expected to occur from mid-May to early July (and in very wet years through July). The bypass and spillway releases, required for safe operation of the dam in wet years, would be timed with the objective to meet Reach 2 wet or moderately wet year targets depending upon the hydrologic conditions in the Yampa River. The initiation of bypass and spillway releases would take place in mid to late May coincident with the Yampa River peak. In extremely wet years, releases above powerplant capacity could be initiated in April or early-May before the Yampa River peak.

In years classified as moderately wet, bypass releases would usually (but not always) be required for safe operation of the dam. Occasionally, some use of the spillway might also be required in moderately wet years for safe operation of the dam. Bypass volume in moderately wet years would be less than in wet years and would generally occur for a period of about 1 to 7 weeks. The timing of these releases would be from mid May to June and could sometimes extend into July. Releases from Flaming Gorge Reservoir in moderately wet years would be timed with the objective of meeting Reach 2 wet, moderately wet, or average year targets depending upon the hydrologic conditions in the Yampa River basin and other factors.

In years classified as average, bypass releases would not likely be required for safe operation of the dam, but would periodically be needed to meet the objectives of the flow and temperature recommendations of Muth et al. (2000). In most average years, spring peak releases would be limited to power-plant capacity (about 130 m^3/s [4,600 cfs]) with peak releases taking place for about one to eight weeks usually in mid-May to late-June (but occasionally extending into July). In about one out of three average years, bypass releases from Flaming Gorge Dam might be required to achieve the Reach 2 flow recommendation peak and duration targets. In these years, the objective would be to achieve targeted flows in Reach 2 of 527 m^3/s (18,600 cfs) for two weeks. To conserve water, bypass releases in these average years would be made only to the extent necessary to achieve this target. It can be expected that bypass releases, when required to meet flow recommendations in average years would be implemented for a period of less than two weeks. In some years classified as average, the targets that would be achieved during the spring would be moderately wet or wet targets as a result of Yampa River flows.

The objective in dry and moderately dry years would be to conserve reservoir storage while meeting the recommended peak flow targets in Reach 2. The bypass tubes and the spillway would not be used to meet flow targets in moderately dry and dry years but on rare occasion might be needed to supplement flows that cannot be released through the power plant because of maintenance requirements. In dry years, a peak release (power-plant capacity or less) of one day to one week would occur during the spring and this release would be timed with the peak of the Yampa River. In moderately dry years, a one to two week power-plant capacity release would occur during the spring and would be timed with the peak and post peak of the Yampa River.

After the spring flow objectives have been achieved, Reclamation would establish a release regime within powerplant capacity that gradually decreases the release rate limited to the down ramp rates described in Muth et al. (2000) until the beginning of the base flow period which begins some time between mid-June and mid-August, depending on the hydrologic classification set during the spring.

The bypass tubes and the spillway at Flaming Gorge Dam have been utilized historically, as needed, for safe operation of the dam. In years with high inflow, bypass releases, and sometimes spillway releases, may be required under the proposed action to meet the flow and temperature recommendations. Bypass and spillway releases, required for safe operation of the dam and to meet the flow and temperature recommendations, would be scheduled coincident with Yampa River peak and post peak flow (the mid-May to mid-June time period) with the objective of meeting flow recommendation targets in Reach 2. There would be some years (moderately wet years and average years) where use of the bypass would not be required for safe operation but would be needed to meet the flow recommendations. As part of the annual planning process discussed above, Reclamation would consult with the Service and Western and coordinate with the technical working group and make a determination whether bypasses should be attempted to achieve the targeted Reach 2 magnitudes and durations.

Cavitation resulting from use of the spillway has been shown to cause excessive erosion in concrete spillway structures at other Reclamation dams. In 1984, the spillway at Flaming Gorge Dam was retrofitted with air slots that have been tested and deemed successful in reducing cavitation. However, should damage to the spillway become excessive as a result of increased use repairs would be made and use of the spillway could be limited to levels that do not cause damage or to only times when hydrologically necessary.

<u>Operations in August through February (Base-Flow Period)</u>

Under the proposed action, Reclamation would classify the hydrology of the Green River during the base-flow period into one of the five hydrologic classifications (wet, moderately wet, average, moderately dry, and dry). For the month of August, the hydrologic classification would be based on the percentage exceedance of the volume of unregulated inflow into Flaming Gorge Reservoir during the spring period. For the months of September through February, the percentage exceedance would be based on the previous month's volume of unregulated inflow into Flaming Gorge Reservoir. If the unregulated inflow during the previous month is such that the percentage exceedance falls into a different classification than the classification assigned for the previous month, then the hydrologic classification for the current month could be shifted by one classification to reflect the change in hydrology. This shift would only be made when the reservoir condition indicates that the shift would be necessary to achieve the March 1 drawdown level of 1,837 m (6,027 ft) above sea level. Otherwise the hydrologic classification for the current month would remain the same as for the previous month.

The range of acceptable base flows for Reach 2 would be selected from the flow and temperature recommendations for the hydrologic classification set for the current month. Reclamation would make releases to achieve flows in Reach 2 that are within the acceptable range that also assure that the reservoir elevation on March 1 would be no higher than 1,837 m (6,027 ft) above sea level.

The flow and temperature recommendations for the base-flow period allow for some operational flexibility, and the proposed action accommodates this flexibility. Under the proposed action, the flows that would occur in Reach 2 during the base-flow period would be allowed to vary from the targeted flow by ± 40% from August through November and by ± 25% from December through February as long as the day to day change is limited to 3% of the average daily flow and the variation is consistent with all other applicable flow and temperature recommendations. Reclamation would utilize the allowed flexibility to the extent possible, to efficiently manage the authorized resources of Flaming Gorge Dam. Flaming Gorge Dam would be operated through the base-flow period so that the water surface elevation would not be greater than 1,837 m (6,027 ft) above sea level on March 1.

During the base-flow period, hourly release patterns from Flaming Gorge Dam would be patterned so that they produce no more than a 0.1-m (0.3-ft) stage change each day at the Jensen gage.

Operations in March and April (Transition Period)

Muth et al. (2000) make no specific flow recommendations for the period from March 1 through the initiation of the spring peak release (typically this occurs in mid to late May). For the proposed action, releases during this transition period would be made to manage the reservoir elevation to an appropriate drawdown level based on the forecasted unregulated inflow into Flaming Gorge Reservoir for the April through July period. Appropriate drawdown levels under normal operations during the transition period are those that would allow for safe operation of the dam through the spring.

Implied in the drawdown levels is the assumption that upstream regulation above Flaming Gorge Reservoir remains relatively consistent with historic regulation. In the event that less storage space would be available above Flaming Gorge Reservoir during the spring, these drawdown levels may have to be lower than those specified for safe operation of Flaming Gorge Dam. In extremely wet years, the drawdown level for May 1 could be lower than what is specified to maintain safe operation of the dam.

Reclamation would determine the appropriate reservoir drawdown based on the percentage exceedance of the forecasted volume of unregulated inflow into Flaming Gorge Reservoir between April and July. The forecast is issued two times each month during March and April. Under normal operations during the transition period, releases would be between 23 m^3/s (800 cfs) and power-plant capacity (130 m^3/s [4,600 cfs]).

Releases during the transition period would be patterned to be consistent with the release patterns of the preceding base-flow period. Muth et al. (2000) do not make recommendations for hourly fluctuation patterns during the transition period. However, Reclamation would maintain the fluctuation pattern limitations of the base flow period to provide operational consistency as has been done historically.

Use of Adaptive Management in Implementing the Proposed Action

This biological opinion and the Operation of Flaming Gorge Draft EIS present a number of uncertainties regarding the endangered fish associated with implementing the proposed action. These uncertainties would be addressed by integrating an adaptive management process into the current framework of dam operations, while maintaining the authorized purposes of the Flaming Gorge Unit of the CRSP. This would involve using research and monitoring to test the outcomes of implementing the proposed action and employing the knowledge gained to further refine operations as required. It is expected that any refinements in operation of Flaming Gorge Dam would be within the scope of the current proposed action and that implementation of refinements would occur with appropriate Section 7 consultation (formal or informal). Research and monitoring studies would be conducted within the framework of the ongoing Recovery Program with regard to native fish, undesirable nonnative fish, and related habitat issues. These studies may involve research or test flow releases from Flaming Gorge Dam. As participants in the Recovery Program, Reclamation, Western and the Service would be involved in the identification, discussion, implementation and approval of new tasks within the Recovery Program to address refinement of flows below Flaming Gorge Dam.

Uncertainties about riparian vegetation and geomorphic surfaces, particularly as they may affect Ute ladies'-tresses will be addressed through a monitoring plan developed by Reclamation, Western, Service, NPS, and other knowledgeable scientists. Recommendations for actions to assist riparian vegetation health and Ute ladies'-tresses conservation developed as a result of the monitoring efforts will be will be coordinated by the Service and forwarded to Reclamation or other entities as appropriate. Any requests for flows to benefit Utes'-ladies tresses would be reconciled by the Service with flow needs for other endangered species.

Conservation Measures

Conservation measures are actions that the action agency agrees to implement to further the recovery of the species under review. Section 4.21 of the draft EIS for Operation of Flaming Gorge Dam specifies ten environmental commitments related to implementation of the proposed action. Several of those commitments are reiterated here in order to clarify operations under the proposed action:

- The Flaming Gorge Working Group, an informal stakeholder group, which meets two times per year, would continue to function as a means of providing information to and gathering input from stakeholders and interested parties on dam operations, as described in Section 1.5 of the draft EIS.

- The adaptive management process will rely on the Recovery Program for monitoring and research studies to test the outcomes of implementing the proposed action and proposing refinements to dam operations.

- Reclamation agrees to develop a process for operating the selective withdrawal structure consistent with the objectives of improving temperature conditions for the endangered native fish. Such a process would include identification of lines of communication for planning and making changes to selective withdrawal release levels, coordination with other agencies, recognition of equipment limitations that may affect the ability to release warmer water, and the costs and equipment impacts associated with operating at higher temperatures.

- Reclamation, in coordination with the Service, National Park Service, and other knowledgeable scientists, agrees to develop and implement a monitoring plan for Ute ladies'-tresses populations for determination of possible effects from the proposed action. Possible effects to be monitored include response to any habitat changes (such as geomorphic, hydrologic, and vegetation) associated with the proposed action.

- Reclamation will establish the Technical Working Group, as detailed in Section 2.5.3 of the draft EIS, consisting of biologists and hydrologists involved with endangered fish recovery issues. The Technical Working Group would meet at various times throughout the year to comment and provide input on endangered fish needs and implementation of the flow recommendations.

- Implementation of the proposed action will include development of an administrative record and annual report to document annual operations and the information used to develop those operations. Over time, it is expected that these data will be of benefit in correlating and analyzing conditions for the endangered fish species and their habitat downstream from Flaming Gorge Dam.

Monitoring and research to evaluate the effects of modified flows and temperatures will be conducted through the Recovery Program, and include (1) investigations to determine the effects of increased spillway releases and the concomitant release of fishes from the reservoir on the downstream fish community; (2) an evaluation of the effects of increased release temperatures on the downstream fish community, and (3) an evaluation of increased floodplain inundation in Reach 2 on the fish community. Reclamation, Western and the Service will use any new information collected in these studies and other studies to determine the need for management actions or modification of operations as determined appropriate.

STATUS OF THE SPECIES AND CRITICAL HABITAT

Colorado Pikeminnow

Species/Critical Habitat Description

The Colorado pikeminnow is the largest cyprinid fish (minnow family) native to North America and evolved as the main predator in the Colorado River system. It is an elongated pike-like fish that during predevelopment times may have grown as large as 6 feet in length and weighed nearly 100 pounds (Behnke and Benson 1983). Today, Colorado pikeminnow rarely exceed 3 feet in length or weigh more than 18 pounds; such fish are estimated to be 45-55 years old (Osmundson et al. 1997). The mouth of this species is large and nearly horizontal with long slender pharyngeal teeth (located in the throat), adapted for grasping and holding prey. The diet of Colorado pikeminnow longer than 3 or 4 inches consists almost entirely of other fishes (Vanicek and Kramer 1969). Males become sexually mature earlier and at a smaller size than do females, though all are mature by about age 7 and 500 mm (20 inches) in length (Vanicek and Kramer 1969, Seethaler 1978, Hamman 1981). Adults are strongly countershaded with a dark, olive back, and a white belly. Young are silvery and usually have a dark, wedge-shaped spot at the base of the caudal fin.

Critical habitat was designated for Colorado pikeminnow on March 21, 1994 (59 FR 13374). Designated critical habitat makes up about 29% of the species' original range and occurs exclusively in the Upper Colorado River Basin. River reaches (including the 100-year floodplain) that make up critical habitat for Colorado pikeminnow in the Green River system include the Yampa River from Craig, Colorado, downstream to the Green River; Green River downstream of the Yampa River to the confluence with the Colorado River; and White River from Rio Blanco Reservoir downstream to the Green River.

> Colorado: Moffat County. The Yampa River and its 100-year floodplain from the State Highway 394 bridge in T. 6 N., R. 91 W., section 1 (6th Principal Meridian) to the confluence with the Green River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian).
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> Utah: Uintah, Carbon, Grand, Emery, Wayne and San Juan Counties; and Colorado: Moffat County. The Green River and its 100 year floodplain from the confluence with the Yampa River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian) to the confluence with the Colorado River in T. 30 S., R. 19 E., section 7 (Salt Lake Meridian).

Colorado: Rio Blanco County and Utah: Uintah County. The White River and its 100-year floodplain from Rio Blanco Lake Dam in T.1N., R96W., section 6 (6^{th} Principal Meridian) to the confluence with the Green River in T.9S., R20E., section 4 (Salt Lake Meridian).

The Service has identified water, physical habitat, and the biological environment as the primary constituent elements of critical habitat (59 FR 13374). Water includes a quantity of water of sufficient quality delivered to a specific location in accordance with a hydrologic regime required for the particular life stage for each species. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. In addition, oxbows, backwaters, and other areas in the 100-year floodplain, when inundated, provide access to spawning, nursery, feeding, and rearing habitats. Food supply, predation, and competition are important elements of the biological environment.

Status and Distribution

Based on early fish collection records, archaeological finds, and other observations, the Colorado pikeminnow was once found throughout warmwater reaches of the entire Colorado River Basin down to the Gulf of California, and including reaches of the upper Colorado River and its major tributaries, the Green River and its major tributaries, and the Gila River system in Arizona (Seethaler 1978). Colorado pikeminnow apparently were never found in colder, headwater areas. The species was abundant in suitable habitat throughout the entire Colorado River Basin prior to the 1850s (Seethaler 1978). By the 1970s they were extirpated from the entire lower basin (downstream of Glen Canyon Dam) and portions of the upper basin as a result of major alterations to the riverine environment. Having lost some 75 to 80 percent of its former range due to habitat loss, the Colorado pikeminnow was federally listed as an endangered species in 1967 (Miller 1961, Moyle 1976, Tyus 1991, Osmundson and Burnham 1998). Full protection under the Act of 1973 occurred on January 4, 1974.

Colorado pikeminnow are presently restricted to the Upper Colorado River Basin and inhabit warmwater reaches of the Colorado, Green, and San Juan rivers and associated tributaries. The Colorado pikeminnow recovery goals (USFWS 2002a) identify occupied habitat of wild Colorado pikeminnow as follows: the Green River from Lodore Canyon to the confluence of the Colorado River; the Yampa River downstream of Craig, Colorado; the Little Snake River from its confluence with the Yampa River upstream into Wyoming; the White River downstream of Taylor Draw Dam; the lower 89 miles of the Price River; the lower Duchesne River; the upper Colorado River from Palisade, Colorado, to Lake Powell; the lower 34 miles of the Gunnison River; the lower mile of the Dolores River; and 150 miles of the San Juan River downstream from Shiprock, New Mexico, to Lake Powell.

Recovery goals for the Colorado pikeminnow (USFWS 2002a) were approved on August 1, 2002. According to these recovery goals, downlisting can be considered if, over a 5-year period:

- a genetically and demographically viable, self-sustaining population is maintained in the Green River subbasin such that (a) the trends in separate adult (age 7+; > 450 mm total length) point estimates for the middle Green River and the lower Green River do not decline significantly, and (b) mean estimated recruitment of age-6 (400–449 mm total length) naturally produced fish equals or exceeds mean annual adult mortality for the Green River subbasin, and (c) each population point estimate for the Green River subbasin exceeds 2,600 adults (2,600 is the estimated minimum viable population needed to ensure long-term genetic and demographic viability); and

- a self-sustaining population of at least 700 adults (number based on inferences about carrying capacity) is maintained in the upper Colorado River subbasin such that (a) the trend in adult point estimates does not decline significantly, and (b) mean estimated recruitment of age-6 naturally produced fish equals or exceeds mean annual adult mortality; and

- a target number of 1,000 age-5+ fish (> 300 mm total length; number based on estimated survival of stocked fish and inferences about carrying capacity) is established through augmentation and/or natural reproduction in the San Juan River subbasin; and

- certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

Delisting can be considered if, over a 7-year period beyond downlisting:

- a genetically and demographically viable, self-sustaining population is maintained in the Green River subbasin such that (a) the trends in separate adult point estimates for the middle Green River and the lower Green River do not decline significantly, and (b) mean estimated recruitment of age-6 naturally produced fish equals or exceeds mean annual adult mortality for the Green River subbasin, and (c) each population point estimate for the Green River subbasin exceeds 2,600 adults; and

- either the upper Colorado River subbasin self-sustaining population exceeds 1,000 adults or the upper Colorado River subbasin self-sustaining population exceeds 700 adults and San Juan River subbasin population is self-sustaining and exceeds 800 adults (numbers based on inferences about carrying capacity) such that for each population (a) the trend in adult point estimates does not decline significantly, and (b) mean estimated recruitment of age-6 naturally produced fish equals or exceeds mean annual adult mortality; and

- certain site-specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained.

Life History

The Colorado pikeminnow is a long-distance migrator; adults move hundreds of miles to and from spawning areas, and require long sections of river with unimpeded passage. 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. Spawning occurs after spring runoff at water temperatures typically between 18 and 23 °C. After hatching and emerging from spawning substrate, larvae drift downstream to nursery backwaters that are restructured by high spring flows and maintained by relatively stable base flows. Flow recommendations have been developed that specifically consider flow-habitat relationships in habitats occupied by Colorado pikeminnow in the upper basin, and were designed to enhance habitat complexity and to restore and maintain ecological processes. The following is a description of observed habitat uses in the Upper Colorado River Basin.

Colorado pikeminnow live in warm-water reaches of the Colorado River mainstem and larger tributaries, and require uninterrupted stream passage for spawning migrations and dispersal of young. The species is adapted to a hydrologic cycle characterized by large spring peaks of snow-melt runoff and low, relatively stable base flows. High spring flows create and maintain in-channel habitats, and reconnect floodplain and riverine habitats, a phenomenon described as the spring flood-pulse (Junk et al. 1989; Johnson et al. 1995). Throughout most of the year, juvenile, subadult, and adult Colorado pikeminnow use relatively deep, low-velocity eddies, pools, and runs that occur in nearshore areas of main river channels (Tyus and McAda 1984; Valdez and Masslich 1989; Tyus 1990, 1991; Osmundson et al. 1995). In spring, however, Colorado pikeminnow adults use floodplain habitats, flooded tributary mouths, flooded side canyons, and eddies that are available only during high flows (Tyus 1990, 1991; Osmundson et al. 1995). Such environments may be particularly beneficial for Colorado pikeminnow because other riverine fishes gather in floodplain habitats to exploit food and temperature resources, and may serve as prey. Such low-velocity environments also may serve as resting areas for Colorado pikeminnow. River reaches of high habitat complexity appear to be preferred.

Because of their mobility and environmental tolerances, adult Colorado pikeminnow are more widely distributed than other life stages. Distribution patterns of adults are stable during most of the year (Tyus 1990, 1991; Irving and Modde 2000), but distribution of adults changes in late spring and early summer, when most mature fish migrate to spawning areas (Tyus and McAda 1984; Tyus 1985, 1990, 1991; Irving and Modde 2000). High spring flows provide an important cue to prepare adults for migration and also ensure that conditions at spawning areas are suitable for reproduction once adults arrive. Specifically, bankfull or much larger floods mobilize coarse sediment to build or reshape cobble bars, and they create side channels that Colorado pikeminnow sometimes use for spawning (Harvey et al. 1993).

Colorado pikeminnow spawning sites in the Green River subbasin have been well documented. The two principal locations are in Yampa Canyon on the lower Yampa River and in Gray Canyon on the lower Green River (Tyus 1990, 1991). These reaches are 42 and 72 km long, respectively, but most spawning is believed to occur at one or two short segments within each of the two reaches. Another spawning area may occur in Desolation Canyon on the lower Green

River (Irving and Modde 2000), but the location and importance of this area has not been verified. Although direct observation of Colorado pikeminnow spawning was not possible because of high turbidity, radiotelemetry indicated spawning occurred over cobble-bottomed riffles (Tyus 1990). High spring flows and subsequent post-peak summer flows are important for construction and maintenance of spawning substrates (Harvey et al. 1993). In contrast with the Green River subbasin, where known spawning sites are in canyon-bound reaches, currently suspected spawning sites in the upper Colorado River subbasin are at six locations in meandering, alluvial reaches (McAda 2000).

After hatching and emerging from the spawning substrate, Colorado pikeminnow larvae drift downstream to backwaters in sandy, alluvial regions, where they remain through most of their first year of life (Holden 1977; Tyus and Haines 1991; Muth and Snyder 1995). Backwaters and the physical factors that create them are vital to successful recruitment of early life stages of Colorado pikeminnow, and age-0 Colorado pikeminnow in backwaters have received much research attention (e.g., Tyus and Karp 1989; Haines and Tyus 1990; Tyus 1991; Tyus and Haines 1991; Bestgen et al. 1997). It is important to note that these backwaters are formed after cessation of spring runoff within the active channel and are not floodplain features. Colorado pikeminnow larvae occupy these in-channel backwaters soon after hatching. They tend to occur in backwaters that are large, warm, deep (average, about 0.3 m in the Green River), and turbid (Tyus and Haines 1991). Recent research (Day et al. 1999a, 1999b; Trammell and Chart 1999) has confirmed these preferences and suggested that a particular type of backwater is preferred by Colorado pikeminnow larvae and juveniles. Such backwaters are created when a secondary channel is cut off at the upper end, but remains connected to the river at the downstream end. These chute channels are deep and may persist even when discharge levels change dramatically. An optimal river-reach environment for growth and survival of early life stages of Colorado pikeminnow has warm, relatively stable backwaters, warm river channels, and abundant food (Muth et al. 2000).

Threats to the Species

Major declines in Colorado pikeminnow populations occurred during the dam-building era of the 1930s through the 1960s. Behnke and Benson (1983) summarized the decline of the natural ecosystem, pointing out that dams, impoundments, and water use practices drastically modified the river's natural hydrology and channel characteristics throughout the Colorado River Basin. Dams on the mainstem broke the natural continuum of the river ecosystem into a series of disjunct segments, blocking native fish migrations, reducing temperatures downstream of dams, creating lacustrine habitat, and providing conditions that allowed competitive and predatory nonnative fishes to thrive both within the impounded reservoirs and in the modified river segments that connect them. The highly modified flow regime in the lower basin coupled with the introduction of nonnative fishes decimated populations of native fish.

The primary threats to Colorado pikeminnow are stream flow regulation and habitat modification; competition with and predation by nonnative fishes; and pesticides and pollutants (USFWS 2002a). The existing habitat, altered by these threats, has been modified to the extent that it impairs essential behavior patterns, such as breeding, feeding, and sheltering. These impairments are described in further detail below.

Stream flow regulation includes mainstem dams that cause the following adverse effects to Colorado pikeminnow and its habitat:

- block migration corridors,
- changes in flow patterns, reduced peak flows and increased base flows,
- release cold water, making temperature regimes less than optimal,
- change river habitat into lake habitat, and
- retain sediment that is important for forming and maintaining backwater habitats

In the Upper Basin, 435 miles of Colorado pikeminnow habitat has been lost by reservoir inundation from Flaming Forge Reservoir on the Green River, Lake Powell on the Colorado River, and Navajo Reservoir on the San Juan River. Cold water releases from these dams have eliminated suitable habitat for native fishes, including Colorado pikeminnow, from river reaches downstream for approximately 50 miles below Flaming Gorge Dam and Navajo Dam. In addition to main stem dams, many dams and water diversion structures occur in and upstream from critical habitat that reduce flows and alter flow patterns, which adversely affect critical habitat. Diversion structures in critical habitat divert fish into canals and pipes where the fish are permanently lost to the river system. It is unknown how many endangered fish are lost in irrigation systems, but in some years, in some river reaches, majority of the river flow is diverted into unscreened canals. High spring flows maintain habitat diversity, flush sediments from spawning habitat, increase invertebrate food production, form gravel and cobble deposits important for spawning, and maintain backwater nursery habitats (McAda 2000; Muth et al. 2000). Peak spring flows in the Green River at Jensen, Utah, have decreased 13–35 percent and base flows have increased 10–140 percent due to regulation by Flaming Gorge Dam (Muth et al. 2000).

To summarize the threat of streamflow regulation to critical habitat, we first consider the direct effects on two of the primary constituent elements: water and physical habitat. The quantity of water of sufficient quality has been reduced during critical periods of the year; most notably during the spring runoff period when high seasonal flows serve to connect floodplain habitats, shape in-channel habitats, and provide important behavioral cues to spawning adult fish. Stream flow regulation affects the quality of water in several ways: a). colder than normal, hypolimnetic releases from main channel impoundments render historically occupied reaches unsuitable for native fish; b). elevated baseflows can result in reduced temperature and changes in the distribution and abundance of shoreline nursery habitats for endangered fish. Stream flow regulation also indirectly affects the third constituent element: the biological environment. A reduction in the magnitude and durations of the spring peak limits floodplain inundation. Floodplain inundation provides a critical seasonal source of nutrients / food items for fish in a big river ecosystem.

Predation and competition from nonnative fishes have been clearly implicated in the population reductions or elimination of native fishes in the Colorado River Basin (Dill 1944, Osmundson and Kaeding 1989, Behnke 1980, Joseph et al. 1977, Lanigan and Berry 1979, Minckley and Deacon 1968, Meffe 1985, Propst and Bestgen 1991, Rinne 1991). Data collected by

Osmundson and Kaeding (1991) indicated that during low water years nonnative minnows capable of preying on or competing with larval endangered fishes greatly increased in numbers. More than 50 nonnative fish species were intentionally introduced in the Colorado River Basin prior to 1980 for sportfishing, forage fish, biological control and ornamental purposes (Minckley 1982, Tyus et al. 1982, Carlson and Muth 1989). Nonnative fishes compete with native fishes in several ways. The capacity of a particular area to support aquatic life is limited by physical habitat conditions. Increasing the number of species in an area usually results in a smaller population of most species. The size of each species population is controlled by the ability of each life stage to compete for space and food resources and to avoid predation. Some life stages of nonnative fishes appear to have a greater ability to compete for space and food and to avoid predation in the existing altered habitat than do some life stages of native fishes. Tyus and Saunders (1996) cite numerous examples of both indirect and direct evidence of predation on razorback sucker eggs and larvae by nonnative species. Introductions of nonnative species affect critical habitat by degrading one of its primary constituent elements; the biological environment. Predation and competition, although considered a normal component of the Colorado River ecosystem, are out of balance due to introduced nonnative fish species.

Threats from pesticides and pollutants include accidental spills of petroleum products and hazardous materials; discharge of pollutants from uranium mill tailings; and high selenium concentration in the water and food chain (USFWS 2002a). Accidental spills of hazardous material into critical habitat, particularly when considering water of sufficient quality as a primary constituent element, can cause immediate mortality when lethal toxicity levels are exceeded. Pollutants from uranium mill tailings cause high levels of ammonia that exceed water quality standards. High selenium levels may adversely affect reproduction and recruitment (Hamilton and Wiedmeyer 1990; Stephens et al. 1992; Hamilton and Waddell 1994; Hamilton et al. 1996; Stephens and Waddell 1998; Osmundson et al. 2000).

Management actions identified in the recovery goals for Colorado pikeminnow (USFWS 2002a) to minimize or remove threats to the species included:

- provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations;
- provide passage over barriers within occupied habitat to allow adequate movement and, potentially, range expansion;
- investigate options for providing appropriate water temperatures in the Gunnison River;
- minimize entrainment of subadults and adults in diversion canals;
- ensure adequate protection from overutilization;
- ensure adequate protection from diseases and parasites;
- regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries;
- control problematic nonnative fishes as needed;
- minimize the risk of hazardous-materials spills in critical habitat; and
- remediate water-quality problems.

Status of Colorado pikeminnow and Critical Habitat in the Action Area

Preliminary population estimates presented in the Recovery Goals (USFWS 2002a) for the three Colorado pikeminnow populations (Green River Subbasin, Upper Colorado River Subbasin, San Juan River Subbasin) ranged from 6,600 to 8,900 wild adults. These numbers provided a general indication of the total wild adult population size at the time the Recovery Goals were developed, however, it was also recognized that the accuracy of the estimates vary among populations.

Monitoring of Colorado pikeminnow populations is ongoing, and sampling protocols and the reliability of the population estimates are being assessed by the Service and cooperating entities. A recent draft report on the status of Colorado pikeminnow in the Green River subbasin (Bestgen et al. 2004) presented population estimates for adult (>450 mm total length (TL)) and recruit-sized (400–449 mm TL) Colorado pikeminnow. The Service recognizes that at this time, the report is draft and the analysis of the data is preliminary, however, the Service finds this is the best scientific information available regarding current population status in the Green River subbasin. The draft report suggests that over the study period (2001 to 2003) there was a decline in abundance of Colorado pikeminnow in the Green River subbasin from 3,338 (95 percent confidence interval, 2815 to 3861) animals in 2001 to 2,324 (95 percent confidence interval 1395 to 3252) animals in 2003. In the Yampa River estimates of adult abundance declined from 322 animals in 2000 to 250 animals in 2003. Adult abundance estimates in the White River declined from 1,115 animals in 2000 to 465 animals in 2003 and recruit-sized estimates declined from 44 animals in 2000 to zero in 2003. In the middle Green River (Yampa River confluence to Desolation Canyon) abundance estimates for adults ranged from 1,629 animals in 2000 to 747 animals in 2003 and estimates of abundance of recruit-sized fish ranged from 103 animals in 2000 to 50 animals in 2003. Estimates for the Desolation-Gray Canyon reach of the Green River ranged from 681 adults in 2001 to 585 adults in 2003 and recruit-sized estimates ranged from 162 animals in 2001 to 64 animals in 2003. In the lower Green River (Green River, Utah to the confluence of the Colorado River) abundance estimates were 366 adults in 2001 and 273 adults in 2003 and recruit-sized estimates ranged from 70 in 2001 to 104 in 2003. Studies indicate that significant recruitment of Colorado pikeminnow may not occur every year, but occurs in episodic intervals of several years (Osmundson and Burnham 1998).

All life stages of Colorado pikeminnow in the Green River demonstrate wide variations in abundance at seasonal, annual, or longer time scales, but reasons for shifts in abundance are poorly understood. Bestgen et al. (1998) captured drifting larvae produced from the two main spawning areas in the Green River system and found order-of-magnitude differences in abundance from year to year. They reported that low- or high-discharge years were often associated with poor reproduction but could not ascribe a specific cause-effect mechanism (Bestgen et al. 1998). In general, similar numbers of age-0 fish were found in autumn in the middle Green River, in spite of different-sized cohorts of larvae produced each summer in the Yampa River. Conversely, numbers of Colorado pikeminnow larvae produced in the lower Green River were similar among years but resulted in variable age-0 fish abundance in autumn.

In the Green River subbasin, radio-telemetry studies have shown that distribution of adults changes in late spring and early summer when most mature fish migrate to spawning areas in the lower Yampa River in Yampa Canyon and the lower Green River in Gray Canyon (Tyus and

McAda 1984; Tyus 1985; Tyus 1990; Tyus 1991; Irving and Modde 2000). Those fish remain in spawning areas for 3–8 weeks before returning to home ranges. Because adult Colorado pikeminnow converge on spawning areas from throughout the Green River system to reproduce at these two known localities, migration cues are an important part of the reproductive life history. In general, adults begin migrating in late spring or early summer. Migrations began earlier in low-flow years and later in high-flow years (Tyus and Karp 1989; Tyus 1990; Irving and Modde 2000). Migrations to the Yampa River spawning area occur coincident with, and up to 4 weeks after, peak spring runoff when water temperatures are usually 14–16 °C (Tyus 1990; Irving and Modde 2000). Rates of movement for individuals are not precisely known, but 2 individuals made the approximately 400 km migration from the White River below Taylor Draw Dam to the Yampa River spawning area in less than 2 weeks. Alteration of the natural hydrograph may alter the environmental cues triggering these spawning migrations.

High magnitude flows of infrequent occurrence are necessary to create and maintain spawning habitat. Infrequent intense flooding redistributes and creates spawning bars (O'Brien 1984). Annual lower-level flooding followed by recessional flows dissect and secondarily redistribute gravels, preparing them for spawning (Harvey et al. 1993). These studies conducted at a known spawning location in Yampa Canyon show that both processes are important for habitat maintenance and activities that reduce or re-time the annual peak or reduce the frequency of high magnitude flows are likely to reduce essential spawning habitat in amount and quality.

Similar to adults, distribution of early life stages of Colorado pikeminnow is dynamic on a seasonal basis and linked to habitat in the mainstem Green River downstream of spawning areas. After hatching and emergence from spawning substrate, larvae are dispersed downstream. A larva may drift for only a few days, but larvae occur in main channels of the Yampa and Green rivers for 3–8 weeks depending on length of the annual reproductive period (Nesler et al. 1988; Tyus and Haines 1991; Bestgen et al. 1998). The Yampa River spawning area consistently produces more larvae than the spawning area in the lower Green River (Bestgen et al. 1998).

Currently, two primary reaches of Colorado pikeminnow nursery habitat are present in the Green River system. The upper one occurs from near Jensen, Utah, downstream to the Duchesne River confluence. The lower one occurs from near Green River, Utah, downstream to the Colorado River confluence (Tyus and Haines 1991; McAda et al. 1994a; McAda et al. 1994b; McAda et al. 1997). Larvae from the lower Yampa River are thought to mostly colonize backwaters in alluvial valley reaches between Jensen, Utah, and the Ouray National Wildlife Refuge. Most floodplain habitat along the current-day Green River is concentrated in this reach. Although the density of age-0 fish in autumn was usually higher in the lower than in the middle Green River (Tyus and Haines 1991; McAda et al. 1994a), differences in habitat quantity may have confounded abundance estimates. The reach of the Green River defined mostly by Desolation and Gray Canyons also provides nursery habitat for Colorado pikeminnow (Tyus and Haines 1991; Day et al. 1999b). These backwaters are especially important during the Colorado pikeminnow's critical first year of life.

Backwaters and physical factors that create them are vital to successful recruitment of early life stages of Colorado pikeminnow. Occasional very high spring flows are needed to transport sediment and maintain or increase channel complexity. Sediment transport from the Little Snake

River provides an estimated 60 percent of the total sediment supply to the Green River and is important to maintain equilibrium channel morphology and ensure continued creation and maintenance of backwater nursery habitats for Colorado pikeminnow and humpback chub (Hawkins and O'Brien 2001). During high-discharge events, the elevation of sand bars increases and if high flows persist through summer, few backwaters are formed (Tyus and Haines 1991). Post-runoff low flows sculpt and erode sand bars and create complex backwater habitat critical for early life stages of all native fishes, particularly Colorado pikeminnow. Deeper, chute-channel backwaters are preferred by age-0 Colorado pikeminnow in the Green River (Tyus and Haines 1991; Day and Crosby 1997, Day et al. 1999a; Trammell and Chart 1999). Alterations to the amount and timing of flows defining the natural hydrology and sediment transport processes may inhibit the processes that create and maintain these habitats.

Past research indicated that certain discharge levels may optimize backwater habitat availability below Jensen for age-0 Colorado pikeminnow (Pucherelli et al. 1990; Tyus and Haines 1991; Tyus and Karp 1991). However, many geomorphic processes are dynamic over time and driven by the level of spring flows, the frequency of large floods, and post-peak discharge levels (Bell et al. 1998; Rakowski and Schmidt 1999). Consequently, flows to achieve optimum backwater availability may be different each year and dependent upon year-to-year bar topography (Rakowski and Schmidt 1999).

Muth et al. (2000) summarized flow and temperature needs of Colorado pikeminnow in the Green River subbasin as:

> "...Colorado pikeminnow are widespread in the system, occurring in both the main stem and tributaries. The Green River downstream of its confluence with the Yampa River supports the largest population of adults and nearly all larval and juvenile rearing areas; thus, this portion of the system is critical for sustaining Colorado pikeminnow populations. Reproduction of Colorado pikeminnow occurred in all years studied, and the current abundance of adults is comparatively high.
>
> However, the abundance of larval and age-0 stages is highly variable among years and is currently low compared to the abundance observed in the late 1980s. Recruitment has been low or nonexistent in some reaches and years.
>
> Habitat requirements of Colorado pikeminnow vary by season and life stage. In spring, adults utilize warmer off-channel and floodplain habitats for feeding and resting. Declining flow, increasing water temperature, photoperiod, and perhaps other factors in early summer provide cues for reproduction. Declining flow in summer also removes fine sediments from spawning substrates, and increases in water temperature also aid gonadal maturation. Reproduction begins when water temperatures reach 16–22°C. After hatching and swim-up, larvae drift downstream and occupy channel-margin backwaters. The potential for cold shock to Colorado pikeminnow larvae drifting from the Yampa River and into the Green River in summer could be eliminated or reduced if warmer water was provided in Reach 1 (Flaming Gorge Dam to the Yampa River confluence). Warm water also promotes fast growth of Colorado pikeminnow, which reduces effects of size-dependent regulatory processes such as predation. This warmer water also may provide conditions suitable for spawning in Lodore Canyon of Reach 1 and would enhance growth of early life stages in nursery habitats (e.g., backwaters) throughout Reach 2 (Yampa River to the White River confluence). Low, relatively stable base flows create

warm, food-rich backwaters that are thought to promote enhanced growth and survival of early life stages through autumn and winter. Similarly, low, relatively stable winter flows may enhance overwinter survival by reducing disruption of ice cover and habitat.

In-channel habitats used by Colorado pikeminnow are formed and maintained by spring peak flows that rework existing sediment deposits, scour vegetation from deposits, and create new habitats. The magnitudes of these flows were highly variable prior to flow regulation, and this variability appears to be important for maintaining high-quality habitats. In-channel habitats preferred by young Colorado pikeminnow are relatively deep (mean, 0.3 m) chute-channel backwaters. High peak flows maintain these habitats by periodically removing accumulated sediments and rebuilding the deposits that provide the structure for formation of backwaters after flows recede."

Critical Habitat for Colorado pikeminnow is located throughout Reaches 2 and 3 of the action area. As was discussed above, all primary constituent elements (water, physical habitat, and biological environment) have been affected throughout designated critical habitat on the Green River and in other occupied areas (Reach 1) and could be further influenced through implementation of the proposed action. To date, water quantity and quality has been affected by flow regulation and land management practices (irrigated agriculture), which has resulted in increased concentrations of contaminants (most notably selenium). Physical habitat (spring adult staging areas (floodplain), spawning and nursery habitats) has been affected through flow regulation, land management practices (diking), and encroachment of nonnative vegetation (primarily tamarisk). The biological environment has been altered primarily due to the introduction of numerous species of nonnative fish disrupting the natural balance of competition and predation. All constituent elements of designated Colorado pikeminnow critical habitat along the Green River will be considered in our analysis of the effects of the proposed action.

Razorback Sucker

Species/Critical Habitat Description

Like all suckers (family Catostomidae, meaning "down mouth"), the razorback sucker has a ventral mouth with thick lips covered with papillae and no scales on its head. In general, suckers are bottom browsers, sucking up or scraping off small invertebrates, algae, and organic matter with their fleshy, protrusible lips (Moyle 1976). The razorback sucker is the only sucker with an abrupt sharp-edged dorsal keel behind its head. The keel becomes more massive with age. The head and keel are dark, the back is olive-colored, the sides are brownish or reddish, and the abdomen is yellowish white (Sublette et al. 1990). Adults often exceed 3 kg (6 pounds) in weight and 600 mm (2 feet) in length. Like Colorado pikeminnow, razorback suckers are long-lived, living 40-plus years.

Critical habitat was designated for razorback sucker on March 21, 1994 (59 FR 13374). Designated critical habitat makes up about 49% of the species' original range and occurs in both the Upper and Lower Colorado River Basins (USFWS 1994). The primary constituent elements are the same as those described for Colorado pikeminnow.

River reaches (including the 100-year floodplain) of critical habitat for razorback sucker in the Green River system include the lower 89 km (55 mi) of the Yampa River (i.e., from the mouth of Cross Mountain Canyon to the confluence with the Green River), the Green River between the confluences of the Yampa and Colorado Rivers, the lower 29 km (18 mi) of the White River, and the lower 4 km (2.5 mi) of the Duchesne River.

> Colorado: Moffat County. The Yampa River and its 100-year floodplain from the mouth of Cross Mountain Canyon in T. 6 N., R. 98 W., section 23 (6th Principal Meridian) to the confluence with the Green River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian).
>
> Utah: Uintah County; and Colorado: Moffat County. The Green River and its 100-year floodplain from the confluence with the Yampa River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian) to Sand Wash in T. 11 S., R. 18 E., section 20 (6th Principal Meridian).
>
> Utah: Uintah, Carbon, Grand, Emery, Wayne, and San Juan Counties. The Green River and its 100-year floodplain from Sand Wash at river mile 96 at T. 11 S., R. 18 E., section 20 (6th Principal Meridian) to the confluence with the Colorado River in T. 30 S., R. 19 E., section 7 (6th Principal Meridian).
>
> Utah: Uintah County. The White River and its 100-year floodplain from the boundary of the Uintah and Ouray Indian Reservation at river mile 18 in T. 9S., R. 22E., section 21 (Salt Lake Meridian) to the confluence with the Green River in T. 9 S., R. 20 E., section 4 (Salt Lake Meridian).
>
> Utah: Uintah County. The Duchesne River and its 100-year floodplain from river mile 2.5 in T. 4S., R. 3E., section 30 (Salt Lake Meridian) to the confluence with the Green River in T. 5 S., R. 3 E., section 5 (Uintah Meridian).

The Service has identified water, physical habitat, and the biological environment as the primary constituent elements of critical habitat (59 FR 13374). Water includes a quantity of water of sufficient quality delivered to a specific location in accordance with a hydrologic regime required for the particular life stage for each species. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. In addition, oxbows, backwaters, and other areas in the 100-year floodplain, when inundated, provide access to spawning, nursery, feeding, and rearing habitats. Food supply, predation, and competition are important elements of the biological environment. The Service gave special consideration to habitats required for razorback sucker reproduction and recruitment when critical habitat was designated.

Status and Distribution

On March 14, 1989, the Service was petitioned to conduct a status review of the razorback sucker. Subsequently, the razorback sucker was designated as endangered under a final rule published on October 23, 1991 (56 FR 54957). The final rule stated "Little evidence of natural recruitment has been found in the past 30 years, and numbers of adult fish captured in the last 10 years demonstrate a downward trend relative to historic abundance. Significant changes have occurred in razorback sucker habitat through diversion and depletion of water, introduction of nonnative fishes, and construction and operation of dams" (56 FR 54957). Recruitment of razorback suckers to the population continues to be a problem.

Historically, razorback suckers were found in the mainstem Colorado River and major tributaries in Arizona, California, Colorado, Nevada, New Mexico, Utah, Wyoming, and in Mexico (Ellis 1914; Minckley 1983). Bestgen (1990) reported that this species was once so numerous that it was commonly used as food by early settlers and, further, that commercially marketable quantities were caught in Arizona as recently as 1949. In the Upper Basin, razorback suckers were reported in the Green River to be very abundant near Green River, Utah, in the late 1800s (Jordan 1891). An account in Osmundson and Kaeding (1989) reported that residents living along the Colorado River near Clifton, Colorado, observed several thousand razorback suckers during spring runoff in the 1930s and early 1940s. In the San Juan River drainage, Platania and Young (1989) relayed historical accounts of razorback suckers ascending the Animas River to Durango, Colorado, around the turn of the century.

Currently, the largest concentration of razorback sucker remaining in the Colorado River Basin is in Lake Mohave on the border of Arizona and California. Estimates of the wild stock in Lake Mohave have fallen precipitously in recent years from 60,000 as late as 1991, to 25,000 in 1993 (Marsh 1993, Holden 1994), to about 9,000 in 2000 (USFWS 2002b). Until recently, efforts to introduce young razorback sucker into Lake Mohave have failed because of predation by non-native species (Minckley et al. 1991, Clarkson et al. 1993, Burke 1994). While limited numbers of razorback suckers persist in other locations in the Lower Colorado River, they are considered rare or incidental and may be continuing to decline.

In the Upper Colorado River Basin, above Glen Canyon Dam, razorback suckers are found in limited numbers in both lentic (lake-like) and riverine environments. The largest populations of razorback suckers in the upper basin are found in the upper Green and lower Yampa rivers (Tyus 1987). In the Colorado River, most razorback suckers occur in the Grand Valley area near Grand Junction, Colorado; however, they are increasingly rare. Osmundson and Kaeding (1991) reported that the number of razorback sucker captures in the Grand Junction area has declined dramatically since 1974. Between 1984 and 1990, intensive collecting effort captured only 12 individuals in the Grand Valley (Osmundson and Kaeding 1991). The wild population of razorback sucker is considered extirpated from the Gunnison River (Burdick and Bonar 1997).

Razorback suckers are in imminent danger of extirpation in the wild. As Bestgen (1990) pointed out:

> "Reasons for decline of most native fishes in the Colorado River Basin have been attributed to habitat loss due to construction of mainstream dams and subsequent interruption or alteration of natural flow and physio-chemical regimes, inundation of river reaches by reservoirs, channelization, water quality degradation, introduction of nonnative fish species and resulting competitive interactions or predation, and other man-

induced disturbances (Miller 1961, Joseph et al. 1977, Behnke and Benson 1983, Carlson and Muth 1989, Tyus and Karp 1989). These factors are almost certainly not mutually exclusive, therefore it is often difficult to determine exact cause and effect relationships."

The virtual absence of any recruitment suggests a combination of biological, physical, and/or chemical factors that may be affecting the survival and recruitment of early life stages of razorback suckers. Within the Upper Basin, recovery efforts endorsed by the Recovery Program include the capture and removal of razorback suckers from all known locations for genetic analyses and development of discrete brood stocks. These measures have been undertaken to develop refugia populations of the razorback sucker from the same genetic parentage as their wild counterparts such that, if these fish are genetically unique by subbasin or individual population, then separate stocks will be available for future augmentation. Such augmentation may be a necessary step to prevent the extinction of razorback suckers in the Upper Basin.

Recovery goals for the razorback sucker (USFWS 2002b) were approved on August 1, 2002. According to these recovery goals, downlisting can be considered if, over a 5-year period:

- genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and either in the upper Colorado River subbasin or the San Juan River subbasin such that (a) the trend in adult (age 4+; > 400 mm total length) point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 (300–399 mm total length) naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 5,800 adults (5,800 is the estimated minimum viable population needed to ensure long-term genetic and demographic viability); and

- a genetic refuge is maintained in Lake Mohave of the lower basin recovery unit; and

- two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit (e.g., mainstem and/or tributaries) such that (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 5,800 adults; and

- certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

Delisting can be considered if, over a 3-year period beyond downlisting:

- genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and either in the upper Colorado

River subbasin or the San Juan River subbasin such that (a) the trend in adult point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 5,800 adults; and

- a genetic refuge is maintained in Lake Mohave; and
- two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit such that (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 5,800 adults; and
- certain site-specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained.

Life History

McAda and Wydoski (1980) and Tyus (1987) reported springtime aggregations of razorback suckers in off-channel habitats and tributaries; such aggregations are believed to be associated with reproductive activities. Tyus and Karp (1990) and Osmundson and Kaeding (1991) reported off-channel habitats to be much warmer than the mainstem river and that razorback suckers presumably moved to these areas for feeding, resting, sexual maturation, spawning, and other activities associated with their reproductive cycle. Prior to construction of large mainstem dams and the suppression of spring peak flows, low velocity, off-channel habitats (seasonally flooded bottomlands and shorelines) were commonly available throughout the Upper Basin (Tyus and Karp 1989; Osmundson and Kaeding 1991). Dams changed riverine ecosystems into lakes by impounding water, which eliminated these off-channel habitats in reservoirs. Reduction in spring peak flows eliminates or reduces the frequency of inundation of off-channel habitats. The absence of these seasonally flooded riverine habitats is believed to be a limiting factor in the successful recruitment of razorback suckers in their native environment (Tyus and Karp 1989; Osmundson and Kaeding 1991). Wydoski and Wick (1998) identified starvation of larval razorback suckers due to low zooplankton densities in the main channel and loss of floodplain habitats which provide adequate zooplankton densities for larval food as one of the most important factors limiting recruitment.

While razorback suckers have never been directly observed spawning in turbid riverine environments within the Upper Basin, captures of ripe specimens (in spawning condition), both males and females, have been recorded (Valdez et al. 1982a; McAda and Wydoski 1980; Tyus 1987; Osmundson and Kaeding 1989; Tyus and Karp 1989; Tyus and Karp 1990; Osmundson and Kaeding 1991; Platania 1990) in the Yampa, Green, Colorado, and San Juan rivers. Sexually mature razorback suckers are generally collected on the ascending limb of the hydrograph from mid-April through June and are associated with coarse gravel substrates (depending on the specific location).

Outside of the spawning season, adult razorback suckers occupy a variety of shoreline and main channel habitats including slow runs, shallow to deep pools, backwaters, eddies, and other relatively slow velocity areas associated with sand substrates (Tyus 1987; Tyus and Karp 1989; Osmundson and Kaeding 1989; Valdez and Masslich 1989; Osmundson and Kaeding 1991; Tyus and Karp 1990).

Habitat requirements of young and juvenile razorback suckers in the wild are not well known, particularly in native riverine environments. Prior to 1991, the last confirmed documentation of a razorback sucker juvenile in the Upper Basin was a capture in the Colorado River near Moab, Utah (Taba et al. 1965). In 1991, two early juvenile (36.6 and 39.3 mm total length (TL)) razorback suckers were collected in the lower Green River near Hell Roaring Canyon (Gutermuth et al. 1994). Juvenile razorback suckers have been collected in recent years from Old Charley Wash, a wetland adjacent to the Green River (Modde 1996). Between 1992 and 1995 larval razorback suckers were collected in the middle and lower Green River and within the Colorado River inflow to Lake Powell (Muth 1995). In 2002, eight larval razorback suckers were collected in the Gunnison River (Osmundson 2002). No young razorback suckers have been collected in recent times in the Colorado River.

Threats to the Species

A marked decline in populations of razorback suckers can be attributed to construction of dams and reservoirs, introduction of nonnative fishes, and removal of large quantities of water from the Colorado River system. Dams on the mainstem Colorado River and its major tributaries have segmented the river system, blocked migration routes, and changed river habitat into lake habitat. Dams also have drastically altered flows, temperatures, and channel geomorphology. These changes have modified habitats in many areas so that they are no longer suitable for breeding, feeding, or sheltering. Major changes in species composition have occurred due to the introduction of numerous nonnative fishes, many of which have thrived due to human-induced changes to the natural riverine system. These nonnative fishes prey upon and compete with razorback suckers.

The primary threats to razorback sucker critical habitat are stream flow regulation and habitat modification (affecting both the water and physical habitat constituent elements); competition with and predation by nonnative fishes; and pesticides and pollutants (USFWS 2002b) (affecting the biological environment). The existing habitat, altered by these threats, has been modified to the extent that it impairs essential behavior patterns, such as breeding, feeding, and sheltering. The threats to razorback sucker are essentially the same threats identified for Colorado pikeminnow.

Management actions identified in the recovery goals for razorback sucker (USFWS 2002b) to minimize or remove threats to the species included:

- provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations;
- provide passage over barriers within occupied habitat to allow unimpeded movement and, potentially, range expansion;
- investigate options for providing appropriate water temperatures in the Gunnison River;
- minimize entrainment of subadults and adults in diversion/out-take structures;
- ensure adequate protection from overutilization;
- ensure adequate protection from diseases and parasites;
- regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries;
- control problematic nonnative fishes as needed;
- minimize the risk of hazardous-materials spills in critical habitat;
- remediate water-quality problems; and
- minimize the threat of hybridization with white sucker.

Status of Razorback Sucker and Critical Habitat in the Action Area

The largest concentration of razorback suckers in the Upper Basin exists in low-gradient flat-water reaches of the middle Green River between and including the lower few miles of the Duchesne River and the Yampa River (Tyus 1987; Tyus and Karp 1990; Muth 1995; Modde and Wick 1997; Muth et al. 2000). This area includes the greatest expanse of floodplain habitat in the Upper Colorado River Basin, between Pariette Draw at river mile (RM) 238 and the Escalante Ranch at RM 310 (Irving and Burdick 1995).

Lanigan and Tyus (1989) used a demographically closed model with capture-recapture data collected from 1980 to 1988 and estimated that the middle Green River population consisted of about 1,000 adults (mean, 948; 95 percent confidence interval, 758–1,138). Based on a demographically open model and capture-recapture data collected from 1980 to 1992, Modde et al. (1996) estimated the number of adults in the middle Green River population at about 500 fish (mean, 524; 95 percent confidence interval, 351–696). That population had a relatively constant length frequency distribution among years (most frequent modes were in the 505–515 mm-TL interval) and an estimated annual survival rate of 71 percent. Bestgen et al. (2002) estimated the current population of wild razorback sucker in the middle Green River to be about 100, based on data collected in 1998 and 1999. There are no current population estimates of razorback sucker in the Yampa River due to low numbers captured in recent years.

The lower Yampa River provides adult habitat, spawning habitat, and potential nursery areas occur downstream in the Green River (USFWS 1998a). Modde and Smith (1995) reported that adult razorback suckers were collected between RM 13 and RM 0.1 of the Yampa River. They also reported only one juvenile razorback sucker has been collected in the Yampa River. The single fish (389 mm) was collected at RM 39 in June 1994. The Green River from the confluence with the Yampa River to Sand Wash has the largest existing riverine population of razorback sucker (Lanigan and Tyus 1989, Modde et al. 1996). Razorback suckers are rarely found upstream as far as the confluence with the Little Snake River (McAda and Wydoski 1980 and Lanigan and Tyus 1989). Tyus and Karp (1990) located concentrations of ripe razorback suckers at the mouth of the Yampa River during the spring in 1987-1989. Ripe fish were captured in runs associated with bars of cobble, gravel, and sand substrates in water averaging 0.63 m deep and mean velocity of 0.74 m/s.

Razorback suckers are permanent residents of the Green River below its confluence with the Yampa River and are reliant on in-channel habitat for spawning and flooded off-channel habitats for several aspects of their life history. In turn, these habitats are created and maintained by the natural hydrology and sediment transport provided by the Yampa River.

Spring migrations by adult razorback suckers were associated with spawning in historic accounts (Jordan 1891; Hubbs and Miller 1953; Sigler and Miller 1963; Vanicek 1967), and a variety of local and long-distance movements and habitat-use patterns have been subsequently documented. Spawning migrations (one-way movements of 30.4–106.0 km) observed by Tyus and Karp (1990) included movements between the Ouray and Jensen areas of the Green River and between the Jensen area and the lower Yampa River. Initial movement of adult razorback suckers to spawning sites was influenced primarily by increases in river discharge and secondarily by increases in water temperature (Tyus and Karp 1990; Modde and Wick 1997; Modde and Irving 1998). Flow and temperature cues may serve to effectively congregate razorback suckers at spawning sites, thus increasing reproductive efficiency and success. Reduction in spring peak flows may hinder the ability of razorback suckers to form spawning aggregations, because spawning cues are reduced (Modde and Irving 1998).

Captures of ripe fish and radio-telemetry of adults in spring and early summer were used to locate razorback sucker spawning areas in the middle Green River. McAda and Wydoski (1980) found a spawning aggregation of 14 ripe fish (2 females and 12 males) over a cobble bar at the mouth of the Yampa River during a 2-week period in early to mid-May 1975. These fish were collected from water about 1 m deep with a velocity of about 1 m/s and temperatures ranging from 7 to 16°C (mean, 12°C). Tyus (1987) captured ripe razorback suckers in three reaches: 1) Island and Echo parks of the Green River in Dinosaur National Monument, including the lower mile of the Yampa River; 2) the Jensen area of the Green River from Ashley Creek (RM 299) to Split Mountain Canyon (RM 319); and 3) the Ouray area of the Green River, including the lower few miles of the Duchesne River. The Jensen area contributed 73 percent of the 60 ripe razorback suckers caught over coarse sand substrates or in the vicinity of gravel and cobble bars in those 3 reaches during spring 1981, 1984, and 1986.

Recently, tuberculate or ripe razorback suckers have been collected from reaches of the lower Green River in Labyrinth Canyon near the mouth of the San Rafael River at RM 97 (Tyus 1987, Miller and Hubert 1990, Muth 1995, Chart et al. 1999). Muth et al. (1998) suggested that many of the 439 razorback sucker larvae collected from the lower Green River between RM 28 and 97 during spring and early summer 1993–1996 had been spawned downstream of RM 110 (lower end of the Green River Valley reach), possibly near the mouth of the San Rafael River.

Substantial numbers of razorback sucker adults have been found in flooded off-channel habitats in the vicinity of mid-channel spawning bars shortly before or after spawning. Tyus (1987) located concentrations of ripe fish associated with warm floodplain habitats and in shallow eddies near the mouths of tributary streams. Similarly, Holden and Crist (1981) reported capture of 56 adult razorback suckers in the Ashley Creek-Jensen area of the middle Green River from 1978 to 1980, and about 19 percent of all ripe or tuberculate razorback suckers collected during 1981–1989 ($N = 57$) were from flooded lowlands (e.g., Old Charlie Wash and Stewart Lake Drain) and tributary mouths (e.g., Duchesne River and Ashley Creek) (Tyus and Karp 1990). Radio-telemetry and capture-recapture data compiled by Modde and Wick (1997) and Modde and Irving (1998) demonstrated that most razorback sucker adults in the middle Green River moved into flooded environments (e.g., floodplain habitats and tributary mouths) soon after spawning. Tyus and Karp (1990, 1991) and Modde and Wick (1997) suggested that use of warmer, more productive flooded habitats by adult razorback suckers during the breeding season is related to temperature preferences (23–25°C; Bulkley and Pimental 1983) and abundance of appropriate foods (Jonez and Sumner 1954; Vanicek 1967; Marsh 1987; Mabey and Shiozawa 1993; Wolz and Shiozawa 1995; Modde 1997; Wydoski and Wick 1998). Twelve ripe razorback suckers were caught in Old Charlie Wash during late May–early June 1986, presumably due to the abundant food in the wetland (Tyus and Karp 1991). Eight adult razorback suckers collected from Old Charlie Wash in late summer 1995 entered the wetland when it was connected to the river during peak spring flows (Modde 1996). Reduced spring flooding caused by lower regulated river discharges, channelization, and levee construction has restricted access to floodplain habitats used by adult razorback suckers for temperature conditioning, feeding, and resting (Tyus and Karp 1990; Modde 1997; Modde and Wick 1997; Wydoski and Wick 1998). The fact that these fish actively seek out this habitat suggests that the conditioning it provides them is important to their continued successful reproduction.

Razorback sucker larvae were collected each year in the Green River during 1992–1996. Over 99 percent (N = 1,735) of the larvae caught in the middle Green River during spring and early summer were from reaches including, and downstream of, the presumed spawning area near the Escalante Ranch (Muth et al. 1998). Based on the few larvae ($N = 6$) recorded from collections in the Echo Park reach in 1993, 1994, and 1996, reproduction by razorback suckers at the lower Yampa River spawning site appeared minimal, but sampling efforts in the two reaches immediately downstream of that site were comparatively low (Muth et al. 1998). Mean catch per unit effort (CPUE) was highly variable among years and river reaches but it is unclear whether this was a true measure of population abundance or was biased by differences in sampling efficiency (Muth et al. 1998). Numbers of razorback sucker larvae captured per year ranged from 20 in 1992 to 1,217 in 1994 for the middle Green River and from 5 in 1995 to 222 in 1996 for the lower Green River.

Collections in the lower Green River during 1993–1996 produced the first ever captures of razorback sucker larvae from this section of river. In the lower Labyrinth-upper Stillwater Canyon reach, 363 razorback suckers were caught; all from flooded side canyons, washes, backwaters, and side channels. Razorback sucker larvae were collected in the Echo Park area of the Green River in 1993, 1994, 1996, indicating successful spawning in the lower Yampa River (Muth et al. 1998).

Historically, floodplain habitats inundated and connected to the main channel by overbank flooding during spring-runoff discharges would have been available as nursery areas for young razorback suckers in the Green River. Tyus and Karp (1990) associated low recruitment with reductions in floodplain inundation since 1962 (closure of Flaming Gorge Dam), and Modde et al. (1996) associated years of high spring discharge and floodplain inundation in the middle Green River (1983, 1984, and 1986) with subsequent suspected recruitment of young adult razorback suckers. These floodplain habitats are essential for the survival and recruitment of larval fish. Relatively high zooplankton densities in these warm, productive habitats are necessary to provide adequate zooplankton densities for larval food. Loss or degradation of these productive floodplain habitats probably represents one of the most important factors limiting recruitment in this species (Wydoski and Wick 1998). The importance of these habitats is further underscored by the relationship between larval growth and mortality due to non-native predators (Bestgen et al. 1997). Predation by adult red shiners on larvae of native catostomids in flooded and backwater habitats of the Yampa, Green, or Colorado Rivers was documented by Ruppert et al.(1993) and Muth and Wick (1997). Water depletions and changes in timing of flows may reduce the quantity and availability of floodplain habitat, thus reducing larval growth and recruitment.

Muth et al. (2000) summarized flow and temperature needs of razorback sucker in the Green River subbasin as:

> "Current levels of recruitment of young razorback suckers are not sufficient to sustain populations in the Green River system; wild stocks are composed primarily of older individuals that continue to decline in abundance. Lack of adequate recruitment has been attributed to extremely low survival of larvae and juveniles. Reproduction by razorback suckers in the Green River was documented through captures of larvae each year during 1992□1996, but mortality of larvae was apparently high, possibly as a result of low growth rates and the effect of small body size on competition and the risk of predation. Only six juveniles have been collected from Green River backwaters since 1990, but 73 juveniles were collected from the Old Charlie Wash managed wetland in Reach 2 during 1995/1996.
>
> Floodplain areas inundated and temporarily connected to the main channel by spring peak flows appear to be important habitats for all life stages of razorback sucker, and the seasonal timing of razorback sucker reproduction suggests an adaptation for utilizing these habitats. However, the frequency, magnitude, and duration of seasonal overbank flooding in the Green River have been substantially reduced since closure of Flaming Gorge Dam. Restoring access to these warm and productive habitats, which are most abundant in Reach 2 within the Ouray NWR area, would provide the growth and conditioning environments that appear crucial for recovery of self-sustaining razorback sucker populations. In addition, lower, more stable flows during winter may reduce flooding of low-velocity habitats and reduce the breakup of ice cover in overwintering areas and may enhance survival of adults.
>
> Spring peak flows must be of sufficient magnitude to inundate floodplain habitats and timed to occur when razorback sucker larvae are available for transport into these flooded areas. Overbank flows of sufficient duration would provide quality nursery environments

and may enhance the growth and survival of young fish. Because at least some young razorback suckers entrained in more permanent ponded (depression) sections of floodplains may survive through subsequent winters, spring inundation will need to be repeated at sufficiently frequent intervals to provide access back into the main channel."

Critical Habitat for razorback sucker is located throughout Reaches 2 and 3 of the action area. As was discussed above, all primary constituent elements (water, physical habitat, and biological environment) have been affected throughout designated critical habitat on the Green River and to a lesser extent in other occupied areas (Reach 1). Habitat in those areas could be further affected through implementation of the proposed action. To date, water quantity and quality has been affected by flow regulation and land management practices (irrigated agriculture), which has resulted in increased concentrations of contaminants (most notably selenium). Physical habitat (spring adult staging areas (floodplain), spawning and nursery habitats) has been affected through flow regulation, land management practices (diking), and encroachment of nonnative vegetation (primarily tamarisk). The biological environment has been altered primarily due to the introduction of numerous species of nonnative fish disrupting the natural balance of competition and predation. All constituent elements of designated razorback sucker critical habitat along the Green River will be considered in our analysis of the effects of the proposed action.

Humpback Chub

Species/Critical Habitat Description

The humpback chub is a medium-sized freshwater fish (less than 500 mm) of the minnow family. The adults have a pronounced dorsal hump, a narrow flattened head, a fleshy snout with an inferior-subterminal mouth, and small eyes. It has silvery sides with a brown or olive colored back.

The humpback chub is endemic to the Colorado River Basin and is part of a native fish fauna traced to the Miocene epoch in fossil records (Miller 1946; Minckley et al. 1986). Humpback chub remains have been dated to about 4000 B.C., but the fish was not described as a species until the 1940s (Miller 1946), presumably because of its restricted distribution in remote white water canyons (USFWS 1990). Because of this, its original distribution is not known. The humpback chub was listed as endangered on March 11, 1967.

Until the 1950s, the humpback chub was known only from Grand Canyon. During surveys in the 1950s and 1960s humpback chub were found in the upper Green River including specimens from Echo Park, Island Park, and Swallow Canyon (Smith 1960, Vanicek et al. 1970). Individuals were also reported from the lower Yampa River (Holden and Stalnaker 1975b), the White River in Utah (Sigler and Miller 1963), Desolation Canyon of the Green River (Holden and Stalnaker 1970) and the Colorado River near Moab (Sigler and Miller 1963).

Critical habitat was designated for humpback chub on March 21, 1994 (59 FR 13374). Designated critical habitat makes up about 28% of the species' original range and occurs in both the Upper and Lower Colorado River Basins. Although humpback chub life history and habitat use differs greatly from the other endangered Colorado River fish the Service determined that the primary constituent elements (water, physical habitat, and biological environment) of their critical habitat were the same.

Critical habitat for humpback chub in the Green River system include the Yampa River within Dinosaur National Monument, Green River from its confluence with the Yampa River downstream to the southern boundary of Dinosaur National Monument, and the Green River within Desolation and Gray Canyons.

> Colorado, Moffat County. The Yampa River from the boundary of Dinosaur National Monument in T. 6 N., R. 99 W., section 27 (6th Principal Meridian) to the confluence with the Green River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian).
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> Utah, Uintah County; and Colorado, Moffat County. The Green River from the confluence with the Yampa River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian) to the southern boundary of Dinosaur National Monument in T. 6 N., R. 24 E., section 30 (Salt Lake Meridian).
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> Utah, Uintah and Grand Counties. The Green River (Desolation and Gray Canyons) from Sumner's Amphitheater in T. 12 S., R. 18 E., section 5 (Salt Lake Meridian) to Swasey's Rapid in T. 20 S., R. 16 E., section 3 (Salt Lake Meridian).

Status and Distribution

Failure to recognize *Gila cypha* as a species until 1946 complicated interpretation of historic distribution of humpback chubs in the Green River (Douglas et al. 1989, 1998). Best available information indicates that before Flaming Gorge Dam, humpback chubs were distributed in canyon regions throughout much of the Green River, from the present site of Flaming Gorge Reservoir downstream through Desolation and Gray canyons (Vanicek 1967; Holden and Stalnaker 1975a; Holden 1991). In addition, the species occurred in the Yampa and White rivers. Pre-impoundment surveys of the Flaming Gorge Reservoir basin (Bosley 1960; Gaufin et al. 1960; McDonald and Dotson 1960; Smith 1960) reported both humpback chubs and bonytails from the Green River near Hideout Canyon, now inundated by Flaming Gorge Reservoir.

Historic collection records of humpback chub exist from the Yampa and White rivers, both tributaries to the Green River. Tyus (1998) verified the presence of seven humpback chubs in collections of the University of Colorado Museum, collected from the Yampa River in Castle Park between 19 June and 11 July 1948. A single humpback chub was found in the White River near Bonanza, Utah, in June 1981 (Miller et al. 1982b), and a possible bonytail-humpback chub intergrade was also captured in July 1978 (Lanigan and Berry 1981).

Present concentrations of humpback chub in the Upper Basin occur in canyon-bound river reaches ranging in length from 3.7 km (Black Rocks) to 40.5 km (Desolation and Gray Canyons). Humpback chubs are distributed throughout most of Black Rocks and Westwater Canyons (12.9 km), and in or near whitewater reaches of Cataract Canyon (20.9 km), Desolation and Gray Canyons (65.2 km), and Yampa Canyon (44.3 km), with populations in the separate canyon reaches ranging from 400 to 5,000 adults (see population dynamics). The Utah Division of Wildlife Resources has monitored the fish community in Desolation and Gray Canyons since 1989 and has consistently reported captures of age-0, juvenile, and adult *Gila,* including humpback chub, indicating a reproducing population (Chart and Lentsch 1999b). Distribution of humpback chubs within Whirlpool and Split Mountain Canyons is not presently known, but it is believed that numbers of humpback chub in these sections of the Green River are low.

The Yampa River is the only tributary to the Green River presently known to support a reproducing humpback chub population. Between 1986 and 1989, Karp and Tyus (1990) collected 130 humpback chubs from Yampa Canyon and indicated that a small but reproducing population was present. Continuing captures of juveniles and adults within Dinosaur National Monument indicate that a population persists in Yampa Canyon (T. Modde, U.S. Fish and Wildlife Service, personal communication). Small numbers of humpback chub also have been reported in Cross Mountain Canyon on the Yampa River and in the Little Snake River about 10 km upstream of its confluence with the Yampa River (Wick et al. 1981; Hawkins et al. 1996).

Recovery goals for the humpback chub (USFWS 2002c) were approved on August 1, 2002. According to these recovery goals, downlisting can be considered if, over a 5-year period:

- the trend in adult (age 4+; > 200 mm total length) point estimates for each of the six extant populations does not decline significantly; and

- mean estimated recruitment of age-3 (150–199 mm total length) naturally produced fish equals or exceeds mean annual adult mortality for each of the six extant populations; and

- two genetically and demographically viable, self-sustaining core populations are maintained, such that each point estimate for each core population exceeds 2,100 adults (2,100 is the estimated minimum viable population needed to ensure long-term genetic and demographic viability); and

- certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

Delisting can be considered if, over a 3-year period beyond downlisting:

- the trend in adult point estimates for each of the six extant populations does not decline significantly; and

- mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each of the six extant populations; and

- three genetically and demographically viable, self-sustaining core populations are maintained, such that each point estimate for each core population exceeds 2,100 adults; and

- certain site-specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained.

Life History

Unlike Colorado pikeminnow and razorback sucker, which are known to make extended migrations of up to several hundred miles to spawning areas in the Green and Yampa rivers, humpback chubs in the Green River do not appear to make extensive migrations (Karp and Tyus 1990). Radio-telemetry and tagging studies on other humpback chub populations have revealed strong fidelity by adults for specific locations with little movement to areas outside of home canyon regions. Humpback chubs in Black Rocks (Valdez and Clemmer 1982), Westwater Canyon (Chart and Lentsch 1999a), and Desolation and Gray Canyons (Chart and Lentsch 1999b) do not migrate to spawn.

Generally, humpback chub show fidelity for canyon reaches and move very little (Miller et al. 1982a; Archer et al. 1985; Burdick and Kaeding 1985; Kaeding et al. 1990). Movements of adult humpback chub in Black Rocks on the Colorado River were essentially restricted to a 1-mile reach. These results were based on the recapture of Carlin-tagged fish and radiotelemetry studies conducted from 1979 to 1981 (Valdez et al. 1982) and 1983 to 1989 (Archer et al. 1985; Kaeding et al. 1990).

In the Green River and upper Colorado River, humpback chubs spawned in spring and summer as flows declined shortly after the spring peak (Valdez and Clemmer 1982; Valdez et al. 1982; Kaeding and Zimmerman 1983; Tyus and Karp 1989; Karp and Tyus 1990; Chart and Lentsch 1999a, 1999b). Similar spawning patterns were reported from Grand Canyon (Kaeding and Zimmerman 1983; Valdez and Ryel 1995, 1997). Little is known about spawning habitats and behavior of humpback chub. Although humpback chub are believed to broadcast eggs over mid-channel cobble and gravel bars, spawning in the wild has not been observed for this species. Gorman and Stone (1999) reported that ripe male humpback chubs in the Little Colorado River aggregated in areas of complex habitat structure (i.e., matrix of large boulders and travertine masses combined with chutes, runs, and eddies, 0.5–2.0 m deep) and were associated with deposits of clean gravel.

Chart and Lentsch (1999b) estimated hatching dates for young *Gila* collected from Desolation and Gray Canyons between 1992 and 1995. They determined that hatching occurred on the descending limb of the hydrograph as early as 9 June 1992 at a flow of 139 m^3/s and as late as 1 July 1995 at a flow of 731 m^3/s. Instantaneous daily river temperatures on hatching dates over all years ranged from 20 to 22 °C.

Newly hatched larvae average 6.3–7.5 mm TL (Holden 1973; Suttkus and Clemmer 1977; Minckley 1973; Snyder 1981; Hamman 1982; Behnke and Benson 1983; Muth 1990), and 1-month-old fish are approximately 20 mm long (Hamman 1982). Unlike Colorado pikeminnow and razorback sucker, no evidence exists of long-distance larval drift (Miller and Hubert 1990; Robinson et al. 1998). Upon emergence from spawning gravels, humpback chub larvae remain in the vicinity of bottom surfaces (Marsh 1985) near spawning areas (Chart and Lentsch 1999a).

Backwaters, eddies, and runs have been reported as common capture locations for young-of-year humpback chub (Valdez and Clemmer 1982). These data indicate that in Black Rocks and Westwater Canyon, young utilize shallow areas. Habitat suitability index curves developed by Valdez et al. (1990) indicate young-of-year prefer average depths of 2.1 feet with a maximum of 5.1 feet. Average velocities were reported at 0.2 feet per second.

Valdez et al. (1982) Wick et al. (1979) and Wick et al. (1981) found adult humpback chub in Black Rocks and Westwater Canyons in water averaging 50 feet in depth with a maximum depth of 92 feet. In these localities, humpback chub were associated with large boulders and steep cliffs.

Threats to the Species

Although historic data are limited, the apparent range-wide decline in humpback chubs is likely due to a combination of factors including alteration of river habitats by reservoir inundation, changes in stream discharge and temperature, competition with and predation by introduced fish species, and other factors such as changes in food resources resulting from stream alterations (USFWS 1990).

The primary threats to humpback chub are stream flow regulation and habitat modification (affecting constituent elements: water and physical habitat); competition with and predation by nonnative fishes; parasitism; hybridization with other native *Gila* species; and pesticides and pollutants (USFWS 2002c) (all affecting constituent element: biological environment). The existing habitat, altered by these threats, has been modified to the extent that it impairs essential behavior patterns, such as breeding, feeding, and sheltering. The threats to humpback chub in relation to flow regulation and habitat modification, predation by nonnative fishes, and pesticides and pollutants are essentially the same threats identified for Colorado pikeminnow.

The humpback chub population in the Grand Canyon is threatened by predation from nonnative trout in the Colorado River below Glen Canyon Dam. This population is also threatened by the Asian tapeworm reported in humpback chub in the Little Colorado River (USFWS 2002c). No Asian tapeworms have been reported in the upper basin populations.

Hybridization with roundtail chub (*Gila robusta*) and bonytail, where they occur with humpback chub, is recognized as a threat to humpback chub. A larger proportion of roundtail chub have been found in Black Rocks and Westwater Canyon during low flow years (Kaeding et al. 1990; Chart and Lentsch 2000), which increase the chances for hybridization.

Management actions identified in the recovery goals for humpback chub (USFWS 2002c) to minimize or remove threats to the species included:

- provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations,

- investigate the role of the mainstem Colorado River in maintaining the Grand Canyon population,
- investigate the anticipated effects of and options for providing warmer water temperatures in the mainstem Colorado River through Grand Canyon,
- ensure adequate protection from overutilization,
- ensure adequate protection from diseases and parasites,
- regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries,
- control problematic nonnative fishes as needed,
- minimize the risk of increased hybridization among *Gila* spp, and
- minimize the risk of hazardous-materials spills in critical habitat.

Status of Humpback Chub and Critical Habitat in the Action Area

Monitoring humpback chub populations is ongoing, and sampling protocols and reliability of population estimates are being assessed by the Service and cooperating entities. The humpback chub recovery goals (USFWS 2002c) provided the following preliminary population estimates for adults in the six populations:

Black Rocks, Colorado River, Colorado -- 900–1,500
Westwater Canyon, Colorado River, Utah -- 2,000–5,000
Yampa Canyon, Yampa River, Colorado -- 400–600
Desolation/Gray Canyons, Green River, Utah -- 1,500
Cataract Canyon, Colorado River, Utah -- 500
Grand Canyon, Colorado River and Little Colorado River, Arizona -- 2,000–4,700

Low numbers of humpback chub have been captured in Whirlpool Canyon and Split Mountain Canyon on the Green River in Dinosaur National Monument; however, these fish were considered part of the Yampa River population in the Recovery Goals (USFWS 2002c), and not separate populations.

Tyus and Karp (1991) found that in the Yampa and Green rivers in Dinosaur National Monument, humpback chubs spawn during spring and early summer following peak flows at water temperatures of about 20°C. They estimated that the spawning period for humpback chub ranges from May into July, with spawning occurring earlier in low-flow years and later in high-flow years; spawning was thought to occur only during a 4–5 week period (Karp and Tyus 1990). Similar to the Yampa and Green rivers, peak hatch of *Gila* larvae in Westwater Canyon on the Colorado River appears to occur on the descending limb of the hydrograph following spring runoff at maximum daily water temperatures of approximately 20 to 21°C (Chart and Lentsch 1999a). Tyus and Karp (1989) reported that humpback chubs occupy and spawn in and near shoreline eddy habitats and that spring peak flows were important for reproductive success because availability of these habitats is greatest during spring runoff.

High spring flows that simulate the magnitude and timing of the natural hydrograph provide a number of benefits to humpback chubs in the Yampa and Green rivers. Bankfull and overbank flows provide allochthonous energy input to the system in the form of terrestrial organic matter and insects that are utilized as food. High spring flows clean spawning substrates of fine sediments and provide physical cues for spawning. High flows also form large recirculating eddies used by adult fish. High spring flows (50 percent exceedance or greater) have been implicated in limiting the abundance and reproduction of some nonnative fish species under certain conditions (Chart and Lentsch 1999a, 1999b) and have been correlated with increased recruitment of humpback chubs (Chart and Lentsch 1999b).

Critical habitat for humpback chub includes canyon reaches of the Green River (Whirlpool, Split Mountain, Desolation, and Gray Canyons), which have been affected by stream flow regulation. However, Whirlpool and Desolation Canyons have recently been invaded by high numbers of smallmouth bass changing the biological environment of critical habitat.

Muth et al. (2000) summarized flow and temperature needs of humpback chub in the Green River subbasin as:

> "...The habitat requirements of the humpback chub are incompletely understood. It is known that fish spawn on the descending limb of the spring hydrograph at temperatures greater than 17°C. Rather than migrate, adults congregate in near-shore eddies during spring and spawn locally. They are believed to be broadcast spawners over gravel and cobble substrates. Young humpback chubs typically use low-velocity shoreline habitats, including eddies and backwaters, that are more prevalent under base-flow conditions. After reaching approximately 40□50 mm TL, juveniles move into deeper and higher-velocity habitats in the main channel.
> Increased recruitment of humpback chubs in Desolation and Gray Canyons was correlated with moderate to high water years from 1982 to 1986 and in 1993 and 1995. Long, warm growing seasons, which stimulate fish growth, and a low abundance of competing and predatory nonnative fishes also have been implicated as potential factors that increase the survival of young humpback chubs.
>
> High spring flows increase the availability of the large eddy habitats utilized by adult fish. High spring flows also maintain the complex shoreline habitats that are used as nursery habitat by young fish during subsequent base flows. Low-velocity nursery habitats that are used by young fish are warmer and more productive at low base flows."

Bonytail

Species/Critical Habitat Description

Bonytail are medium-sized (less than 600 mm) fish in the minnow family. Adult bonytail are gray or olive colored on the back with silvery sides and a white belly. The adult bonytail has an elongated body with a long, thin caudal peduncle. The head is small and compressed compared to the rest of the body. The mouth is slightly overhung by the snout and there is a smooth low hump behind the head that is not as pronounced as the hump on a humpback chub.

The bonytail is endemic to the Colorado River Basin and was historically common to abundant in warm-water reaches of larger rivers of the basin from Mexico to Wyoming. The species experienced a dramatic, but poorly documented, decline starting in about 1950, following construction of several mainstem dams, introduction of nonnative fishes, poor land-use practices, and degraded water quality (USFWS 2002d).

Currently, no self-sustaining populations of bonytail are known to exist in the wild, and very few individuals have been caught anywhere within the basin. An unknown, but small number of wild adults exist in Lake Mohave on the mainstem Colorado River. Since 1977, only 11 wild adults have been reported from the upper basin (Valdez et al. 1994).

A total of 499 km (312 miles) of river has been designated as critical habitat for the bonytail in the Colorado River Basin, representing about 14% of the species' historic range (59 FR 13374). River reaches that have been designated as critical habitat in the Green River extend from the confluence with the Yampa River downstream to the boundary of Dinosaur National Monument and Desolation and Gray Canyons. In addition, critical habitat has been designated in the Yampa River from the upstream boundary of Dinosaur National Monument to its confluence with the Green River.

> Colorado, Moffat County. The Yampa River from the boundary of Dinosaur National Monument in T. 6 N., R. 99 W., section 27 (6th Principal Meridian) to the confluence with the Green River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian).
> Utah, Uintah County; and Colorado, Moffat County. The Green River from the confluence with the Yampa River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian) to the boundary of Dinosaur National Monument in T. 6 N., R. 24 E., section 30 (Salt Lake Meridian).
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> Utah, Uintah and Grand Counties. The Green River (Desolation and Gray Canyons) from Sumner's Amphitheater in T. 12 S., R. 18 E., section 5 (Salt Lake Meridian) to Swasey's Rapid (river mile 12) in T. 20 S., R. 16 E., section 3 (Salt Lake Meridian).

The Service has identified water, physical habitat, and the biological environment as the primary constituent elements of bonytail critical habitat (59 FR 13374). Water includes a quantity of water of sufficient quality delivered to a specific location in accordance with a hydrologic regime required for the particular life stage for each species. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. In addition, oxbows, backwaters, and other areas in the 100-year floodplain, when inundated, provide access to spawning, nursery, feeding, and rearing habitats. Food supply, predation, and competition are important elements of the biological environment. Recent information collected by the Recovery Program suggests that floodplain habitats may be more important to the survival and recovery of the bonytail than the Service originally thought.

Status and Distribution

The bonytail is the rarest native fish in the Colorado River. Little is known about its specific habitat requirements or cause of decline, because the bonytail was extirpated from most of its historic range prior to extensive fishery surveys. It was listed as endangered on April 23, 1980. Currently, no documented self-sustaining populations exist in the wild. Formerly reported as widespread and abundant in mainstem rivers (Jordan and Evermann 1896), its populations have been greatly reduced. Remnant populations presently occur in the wild in low numbers in Lake Mohave and several fish have been captured in Lake Powell and Lake Havasu (USFWS 2002d). The last known riverine area where bonytail were common was the Green River in Dinosaur National Monument, where Vanicek (1967) and Holden and Stalnaker (1970) collected 91 specimens during 1962-1966. From 1977 to 1983, no bonytail were collected from the Colorado or Gunnison rivers in Colorado or Utah (Wick et al. 1979, 1981; Valdez et al. 1982; Miller et al. 1984). However, in 1984, a single bonytail was collected from Black Rocks on the Colorado River (Kaeding et al. 1986). Several suspected bonytail were captured in Cataract Canyon in 1985-1987 (Valdez 1990). Current stocking plans for bonytail identify the middle Green River and the Yampa River in Dinosaur National Monument as the highest priority for stocking in Colorado and the plan calls for 2,665 fish to be stocked per year over the next six years (Nesler et al. 2003).

Recovery goals for the bonytail (USFWS 2002d) were approved on August 1, 2002. According to these recovery goals, downlisting can be considered if, over a 5-year period:

- genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and upper Colorado River subbasin such that (a) the trend in adult (age 4+; > 250 mm total length) point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 (150–249 mm total length) naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 4,400 adults (4,400 is the estimated minimum viable population needed to ensure long-term genetic and demographic viability); and

- a genetic refuge is maintained in a suitable location (e.g., Lake Mohave, Lake Havasu) in the lower basin recovery unit; and

- two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit (e.g., mainstem and/or tributaries) such that (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 4,400 adults; and

- certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

Delisting can be considered if, over a 3-year period beyond downlisting:

- genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and upper Colorado River subbasin such that (a) the trend in adult point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 4,400 adults; and

- a genetic refuge is maintained in the lower basin recovery unit; and

- two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit such that (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 4,400 adults; and

- certain site-specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained.

Life History

The bonytail is considered a species that is adapted to mainstem rivers, where it has been observed in pools and eddies (Vanicek 1967; Minckley 1973). Spawning of bonytail has nev been observed in a river, but ripe fish were collected in Dinosaur National Monument during June and early July suggesting that spawning occurred at water temperatures of about 18°C (Vanicek and Kramer 1969). Similar to other closely related *Gila* species, bonytail probably spawn in rivers in spring over rocky substrates; spawning has been observed in reservoirs ov rocky shoals and shorelines. It has been recently hypothesized that flooded bottomlands ma provide important bonytail nursery habitat. Of five specimens captured most recently in the upper basin, four were captured in deep, swift, rocky canyons (Yampa Canyon, Black Rocks Cataract Canyon, and Coal Creek Rapid), but the fifth was taken in Lake Powell. Since 197 bonytails captured in the lower basin were caught in reservoirs.

Threats to the Species

The primary threats to bonytail are stream flow regulation and habitat modification (affectin constituent elements: water and physical habitat); competition with and predation by nonnati fishes; hybridization with other native *Gila* species; and pesticides and pollutants (USFWS 2002d) (affecting constituent element: biological environment). The existing habitat, altered these threats, has been modified to the extent that it impairs essential behavior patterns, such breeding, feeding, and sheltering. The threats to bonytail in relation to flow regulation and habitat modification, predation by nonnative fishes, and pesticides and pollutants are essentially the same threats identified for Colorado pikeminnow. Threats to bonytail in relation to hybridization are essentially the same threats identified for humpback chub.

Management actions identified in the recovery goals for bonytail (USFWS 2002d) to minimize or remove threats to the species included:

- provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations;
- provide passage over barriers within occupied habitat to allow unimpeded movement and, potentially, range expansion;
- investigate options for providing appropriate water temperatures in the Gunnison River;
- minimize entrainment of subadults and adults at diversion/out-take structures;
- investigate habitat requirements for all life stages and provide those habitats;
- ensure adequate protection from overutilization;
- ensure adequate protection from diseases and parasites;
- regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries;
- control problematic nonnative fishes as needed;
- minimize the risk of increased hybridization among *Gila* spp.;
- minimize the risk of hazardous-materials spills in critical habitat; and
- remediate water-quality problems.

Status of Bonytail and Critical Habitat in the Action Area

Bonytail were extirpated between Flaming Gorge Dam and the Yampa River, primarily because of rotenone poisoning and cold-water releases from the dam (USFWS 2002c). Surveys from 1964 to 1966 found large numbers of bonytail in the Green River in Dinosaur National Monument downstream of the Yampa River confluence (Vanicek and Kramer 1969). Surveys from 1967 to 1973 found far fewer bonytail (Holden and Stalnaker 1975). Few bonytail have been captured after this period, and the last recorded capture in the Green River was in 1985 (USFWS 2002d). Bonytail are so rare that it is currently not possible to conduct population estimates. A stocking program is being implemented to reestablish populations in the upper Colorado River basin.

In the Green River, Vanicek (1967) reported that bonytails were generally found in pools and eddies in the absence of, although occasionally adjacent to, strong current and at varying depths generally over silt and silt-boulder substrates. Adult bonytail captured in Cataract, Desolation, and Gray Canyons were sympatric with humpback chub in shoreline eddies among emergent boulders and cobble, and adjacent to swift current (Valdez 1990). The diet of the bonytail is presumed similar to that of the humpback chub (USFWS 2002d).

The only known bonytail that presently occur in the Yampa River are the individuals recently reintroduced at Echo Park, near the confluence with the Green River. In July of 2000 approximately 5,000 juveniles (5 to 10 cm) were stocked. Between 1998 and 2003, the number of bonytail stocked in the Green River subbasin was 189,438 fish, with majority of the fish being juveniles at the time of stocking.

Critical habitat for bonytail includes canyon reaches of the Green River (Whirlpool, Split Mountain, Desolation, and Gray Canyons), which have been affected by stream flow regulation. However, Whirlpool and Desolation Canyons have recently been invaded by high numbers of smallmouth bass changing the biological environment of critical habitat.

Although sufficient information on physical processes that affect bonytail habitats was not available to recommend specific flow and temperature regimes in the Green River to benefit this species, Muth et al. (2000) concluded that flow and temperature recommendations made for Colorado pikeminnow, razorback sucker, and humpback chub would presumably benefit bonytail and would not limit their its future recovery potential.

Ute Ladies'-Tresses

Species/Critical Habitat Description

The Ute ladies'-tresses is a perennial orchid (family Orchidaceae). Its leaves are up to 1.5 cm (0.6 in.) wide and 28 cm (11 in.) long; the longest leaves are near the base. The usually solitary flowering stem is 20 to 50 cm (8 to 20 in.) tall, terminating in a spike of 3 to 15 white or ivory flowers. Flowering is generally from late July through August. However, depending on location and climatic conditions, it may bloom in early July or may still be in flower as late as early October. No critical habitat has been designated for the species.

Status and Distribution

The current range of Ute ladies'-tresses includes Colorado, Idaho, Montana, Nebraska, Utah, Washington, and Wyoming, with an historical occurrence in Nevada. Ute ladies'-tresses are known from 11 counties in Utah, and 10 counties in Colorado.

Populations of Ute ladies'-tresses orchids are known from three broad general areas of the interior western United States: near the base of the eastern slope of the Rocky Mountains in southeastern Wyoming and adjacent Nebraska and north-central and central Colorado; in the upper Colorado River basin, particularly in the Uinta Basin; and in the Bonneville Basin along the Wasatch Front and westward in the eastern Great Basin, in north-central and western Utah, extreme eastern Nevada and southeastern Idaho. The orchid has recently been discovered in southwestern Montana and in the Okanagan area and along the Columbia River in north-central Washington.

Life History

Ute ladies'-tresses orchid is endemic to moist soils or wet meadows near springs, lakes, or perennial streams. The range in elevation of known Ute ladies'-tresses orchid occurrences in Utah is from 1,300 to 2,100 meters (4,300 to 7,000 feet) (Stone 1993). The orchid occurs along riparian edges, gravel bars, old oxbows, high flow channels, and moist to wet meadows along perennial streams. It typically occurs in stable wetland and seepy areas associated with old landscape features within historical floodplains of major rivers. It is also found in wetland and seepy areas near freshwater lakes or springs (U.S. Fish and Wildlife Service 1992b, L. Jordan, U.S. Fish and Wildlife Service, pers. comm., 1998). Jennings (1990) and Coyner (1989) observed that Ute ladies'-tresses orchids seem to require "permanent sub-irrigation," indicating a close affinity with floodplain areas where the water table is near the surface throughout the growing season and into the late summer or early autumn. This observation has been corroborated by ground water monitoring research conducted in Dinosaur National Monument (Martin and Wagner 1992), Boulder, Colorado (T. Naumann, City of Boulder Open Space Department, pers. comm., 1993), and Diamond Fork Canyon, Utah (Black 1998). Soils are generally silty-loam, but occurrences in peat and other highly organic substrates are known (Hreha and Wallace 1994, L. Jordan, U.S. Fish and Wildlife Service, pers. comm., 1998).

The Ute ladies'-tresses orchid occurs primarily in areas where the vegetation is relatively open and not overly dense or overgrown (Coyner 1989 and Jennings 1989, 1990). A few populations in eastern Utah and Colorado are found in riparian woodlands, but generally the species seems intolerant of shade, preferring open, grass, sedge, and forb-dominated sites. Where colonies occur in more wooded areas, plants are usually found on the edges of small openings and along trails. Plants usually occur as scattered groups comprised of a few individuals (5 to 50) and occupy relatively small areas within the riparian system. However, large and dense colonies are known from several of the more stable historic floodplain meadow sites (Stone 1993, L. Jordan, U.S. Fish and Wildlife Service, pers. comm., 1998).

The Ute ladies'-tresses orchid appears to be well adapted to disturbance caused by water movement through floodplains (T. Naumann, City of Boulder Open Space Department, pers. comm., 1992, L. Riedel, National Park Service, pers. comm., 1994). In riparian settings, the species is most typically found in mid-successional habitats (i.e. well established soils and vegetation) within older floodplain features (for example, oxbows and high flow channels). These sites may receive periodic inundation that helps maintain their hydrologic and vegetation characteristics. However, they are generally scoured or significantly reworked by flows that occur at a frequency of approximately 10 years.

Very little is known about the life history and demography of the Ute ladies'-tresses orchid. The orchid first appears aboveground as a rosette of thickened grasslike leaves that is very difficult to distinguish from other vegetation. A distinctive flower stalk appears in late summer (July through September), at which point location, identification, and population size estimates are typically determined. Some individuals remain under ground or do not flower each year (Arft 1993). The percentage of flowering individuals in a population can range from 23% to 79% (Ward and Naumann 1998). Thus, fluctuations in numbers of observed flowering individuals do not necessarily correspond to population fluctuations or indicate habitat alterations. The life span of individuals is unknown.

Ute ladies'-tresses orchid requires pollinators for reproduction. Because of the unique anatomy of orchid flowers, only certain insects can affect pollination. To date, both bumblebees (***Bombus*** spp.) and anthophorans (*Anthophora* spp.) (Sipes and Tepedino, 1995a, 1995b) have been identified as species able to accomplish pollination. These insects visit the orchids for the nectar and pollination is accomplished incidentally. Because these pollinators require both pollen and nectar to nourish their young, other flowering species (that provide pollen) must also be available in the same area and at the same time. Furthermore, these insects must have suitable habitat nearby.

Population estimates are generally based upon observations of flowering individuals, although on occasion it is possible to observe and count non-flowering individuals that have produced vegetative aboveground growth (basal rosette). Information on establishment, recruitment, and longevity is lacking. Therefore, it is usually undeterminable whether a marked individual that fails to flower has died or is merely dormant. Criteria have not been established for determining mortality based on the number of seasons without appearance of aboveground parts.

Apparent population numbers, based on flowering individuals, fluctuate greatly, confounding at least short-term estimates of population trends. For example, in Diamond Fork Canyon in Utah, one colony was counted as 203 individuals in 1992 and 2,214 individuals in 1993. Another colony had 27 individuals in 1992, 615 individuals in 1993, and 91 individuals in 1994 (Central Utah Water Conservancy District 1998) The Van Vleet colony at City of Boulder Open Space had nearly 5,500 flowering individuals in 1986, only about 200 in 1987, and over 3,000 in 1992 (Arft 1995). Without a better understanding of life history and species response to environmental factors, it would likely require decades of monitoring at a site to determine long term population dynamics.

Although the range of the orchid is large, it typically occurs as localized clusters of colonies. Most colonies are small, with fewer that 100 individuals, and many fewer than 10. A few colonies have large numbers of individuals, in some cases between 5,000 and 10,000 individuals, however, these large colonies may be the only occurrence of the orchid in that portion of its range. In 1995, the total estimated population size was 20,500 individuals. With discoveries since 1995, population estimates have increased. However, as of the date of this document, the total population size of Ute ladies'-tresses orchid is estimated at less than 60,000 individuals.

Threats to the Species

The Ute ladies'-tresses was federally listed as threatened on January 17, 1992 (USFWS 1992b). As stated and documented in the final listing rule, this action was taken, in part, because of (1) the threats of habitat loss and modification and (2) because the orchid's small population and low reproductive rate make it vulnerable to other threats.

Threats to populations of Ute ladies'-tresses include modification of riparian habitats by urbanization, stream channelization and other hydrologic changes, conversion of lands to agriculture and development, heavy summer livestock grazing, and hay mowing during the flowering period. Most populations are small and vulnerable to extirpation by habitat changes or local catastrophic events (USFWS 1992b). Several historic populations in Utah and Colorado have been extirpated.

Status of Ute's Ladies-Tresses in the Action Area

A large number of colonies of Ute ladies'-tresses occur along the Green River within Reach 1. The occurrence of Ute ladies'-tresses is influenced by river-channel geometry, hydrology, and depositional and erosional patterns (Ward and Naumann 1998). Surveys conducted in 1999 located colonies of Ute ladies'-tresses at 10 sites in Red Canyon, 23 sites in upper Browns Park, and two sites in lower Browns Park (Grams et al. 2002). Surveys in 1998 had identified colonies at the two sites in lower Browns Park and at 81 sites in Lodore Canyon (Ward and Naumann 1998). The numbers of Ute ladies'-tresses at these locations were generally low, ranging from one to 50; however, several sites in Lodore Canyon contained hundreds of flowering individuals.

Within Reach 1, most Ute ladies'-tresses occur on the post-dam floodplain and intermediate bench geomorphic surfaces; both of these features formed in response to Flaming Gorge Dam operations (Ward and Naumann 1998; Grams et al. 2002). The post-dam floodplain is a relatively flat surface that is inundated annually by 130 m^3/s (4,600 cfs) flows, and averages 0.8 m (2.6 ft) above the elevation of base flow (23 m^3/s [800 cfs]). The intermediate bench which is also a relatively flat surface, is higher in elevation, is a greater distance from the river margin, and averages 1.9 m (6.2 ft) above base flow. The intermediate bench is inundated only by flows that exceed powerplant capacity, such as occurred in 1997 (244 m^3/s [8,600 cfs]) and 1999 (308 m^3/s [10,900 cfs]) (Grams et al. 2002). Nearly all of the occupied sites in Red Canyon and upper Browns Park occur at or just downstream of rapids or riffles, and most occur on the intermediate bench (Grams et al. 2002).

In Lodore Canyon, Ute ladies'-tresses occurs most commonly on channel expansion cobble bars, which are located downstream of tributary debris fans. As in Browns Park, Lodore Canyon substrates supporting Ute ladies'-tresses typically consist of cobbles in a sand matrix or a sand veneer over cobbles. Species associated with Ute ladies'-tresses include wild licorice, redtop (*Agrostis stolonifera*), marsh paintbrush (*Castilleja exilis*), sea milkwort (*Glaux maritima*), Western evening primrose (*Oenothera elata*), and silverweed cinquefoil (*Potentilla anserina*) (Ward and Naumann 1998). Otherwise suitable surfaces that have been invaded by tamarisk may support few or no Ute ladies'-tresses.

Within Reach 2, Green River flows are strongly influenced by flows from the Yampa River, and suitable habitat for Ute ladies'-tresses is less common (Ward and Naumann 1998). In Island Park and Rainbow Park, Ute ladies'-tresses typically occurs on post-dam floodplain and intermediate bench surfaces, which are inundated more frequently than in Reach 1. In this portion of the river, the post-dam floodplain averages 1.3 m (4.3 ft) above base flow and is inundated at about 455 m^3/s (16,100 cfs), the post-dam 2-year flood. The intermediate bench averages 2.4 m (7.9 ft) above base flow and likely is inundated by flows above 600 m^3/s (20,000 cfs). Most occurrences of Ute ladies'-tresses were found on surfaces approximately 1 m (3 ft) above the 93 m^3/s (3,300 cfs) elevation. In this reach, nine colonies of Ute ladies'-tresses were found in Island and Rainbow Parks in 1998, and two colonies were found below Split Mountain Canyon (Ward and Naumann 1998). An additional three colonies were found below Split Mountain Canyon in 1999 (Grams et al. 2002). Species associated with Ute ladies'-tresses in Reach 2 include wild licorice, prairie cordgrass (*Spartina pectinata*), coyote willow, western goldenrod (*Solidago occidentalis*), common dogbane, common scouring rush (*Equisetum hyemale*), common reed, and marsh paintbrush. Although terraces dominated by Fremont cottonwood and box elder are generally too dry for Ute ladies'-tresses, and average 4.2 m (14 ft) above base flow, a small colony of Ute ladies'-tresses (about 20 individual plants) was located on such a terrace in Island Park. The site showed no evidence of inundation (Ward and Naumann 1998). No Ute ladies'-tresses have been found in Reach 3.

ENVIRONMENTAL BASELINE

The environmental baseline represents the past and present impacts of all Federal, State, or private actions and other human activities in an action area, the anticipated impacts of all proposed Federal projects in an action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions that are contemporaneous with the consultation in process (USFWS and NMFS 1998b). Environmental baselines do not include the effects of the Federal action(s) under review in the consultation. As such, the environmental baseline for this biological opinion is represented by the current physical and biological conditions within the Green River. For the purposes of this consultation baseline hydrology is considered to be those flows that would be released to meet the flow objectives for the 1992 FGBO which has also been defined as the No Action Alternative in the FGEIS. The hydrologic model developed by Clayton and Gilmore (2002) provides the baseline flow conditions for the Green River under existing (No Action) conditions and the proposed action.

The current condition of the physical environment and status of the listed species considered in this opinion also reflect the effects of past and ongoing activities and events. Consequently, the description of the environmental baseline presented herein includes a description of the changes that have occurred in the environment (including those resulting from flow regulation) and how those changes have affected listed species and their habitats.

General Description of the Green River subbasin

The Green River subbasin occupies a total area of 115,800 km^2 (45,000 mi^2) in Wyoming, Colorado, and Utah. The Green River originates in the Wind River Range of Wyoming and flows south about 1,230 km (764 mi) through Colorado and Utah, joining the Colorado River in Canyonlands National Park. The Green River is the largest tributary of the Colorado River. Nearly half of the flow of the Colorado River at its confluence with the Green River is from the Green River subbasin.

Precipitation varies considerably across the Green River subbasin. In the semiarid rangelands, which make up most of the basin's area, annual precipitation is generally less than 25 cm (10 in.). In contrast, many of the mountainous areas that rim the upper portion of the basin receive, on average, more than 1.0 m (3.3 ft) of precipitation per year.

Most of the total annual stream flow in the Green River subbasin is provided by snowmelt. Because of this, natural flow is very high in late spring and early summer and diminishes rapidly in midsummer. Although flows in late summer through autumn can increase following rain events, natural flow in late summer through winter is generally low.

Dams and reservoirs have been constructed in the basin mainly to supply water for irrigated agriculture. The largest depletion in the Green River subbasin occurs in the Duchesne River Basin. In addition to depleting flow volume, reservoirs modify the pattern of flow in the Green River to meet demands of irrigation, power generation, recreation, and other uses. Of the reservoirs in the basin, Flaming Gorge, which is capable of storing approximately twice the annual inflow, has the largest effect on Green River flow patterns.

Historic and current operations of Flaming Gorge Dam have reduced the sediment load in the river downstream. This reduction results primarily from the presence of the dam, which traps sediment. Following completion of the dam, Andrews (1986) estimated that mean annual sediment discharge at the USGS gage near Jensen, Utah, decreased by 54% compared with the average annual pre-dam suspended sediment load. Similarly, the decrease in mean-annual sediment load at the USGS gage near Green River, Utah, was estimated to be 48% following completion of Flaming Gorge Dam (Andrews 1986). Andrews (1986) also noted that the decrease in mean annual suspended sediment load at Jensen is approximately equal to the incoming sediment load to Flaming Gorge Reservoir. At Green River, Andrews (1986) noted that the decrease in suspended sediment load following reservoir closure greatly exceeded the amount of sediment trapped in the reservoir. Sediment inflow to the Green River downstream from the Duchesne River exceeds the transport of sediment out of Reach 3 (Andrews 1986).

Description of the Green River Downstream of Flaming Gorge Dam

The longitudinal profile of the Green River downstream from Flaming Gorge Dam includes steep- and low-gradient segments, and the gradients of these segments do not systematically decrease in a downstream direction. In general, low-gradient reaches of the river have sandy substrates, while steeper-gradient segments have gravel or cobble substrates (Schmidt 1996).

Reach 1, between Flaming Gorge Dam and the Yampa River confluence, is about 104 km (65 mi) long (Figure 1). Reach 1 is straight to meandering and, with the exception of Browns Park, tightly confined by the adjacent steep-walled canyon topography of Red Canyon and Lodore Canyon. Except for usually minor flow contributions from tributary streams, flow in Reach 1 is completely regulated by Flaming Gorge Dam. The mean annual discharge (about 60 m^3/s [2,100 cfs]) has not been affected by Flaming Gorge Dam operations, but the pattern of flow has changed. Prior to regulation, the seasonal flow pattern for Reach 1 featured high spring flows and low summer, autumn, and winter base flows. Releases for power generation have resulted in relatively more uniform monthly release volumes but greater within-day variation.

Reach 2, between confluences with the Yampa River and White River, is about 158 km (98 mi) long (Figure 1). This reach is relatively long and meandering, with numerous segments that hav different geomorphic characteristics. Included in this reach are Whirlpool Canyon, Rainbow Park, Island Park, Split Mountain Canyon, and the alluvial areas of the Uinta Basin. Bed materials range from cobbles to sand, and vegetated and unvegetated islands are common. The Uinta Basin portion of Reach 2 contains important nursery habitats for the Colorado pikeminno (in-channel backwaters) and razorback sucker (inundated floodplains). Reach 2 exhibits a more natural flow and sediment regime than Reach 1 because of inputs from the relatively unregulate Yampa River. Despite this input, the magnitude of the mean annual flood at the Jensen gage has decreased 26% since closure of Flaming Gorge Dam. The Yampa River adds about 1.7 million metric tons (1.9 million tons) of sediment to the Green River annually.

Reach 3, between the White River and Colorado River confluences, is about 394 km (245 mi) long (Figure 1). The White and Duchesne Rivers, at the upper end of Reach 3, add considerable sediment (about 4.4 million metric tons or 4.9 million tons per year) to the Green River. A portion of the flow of the Duchesne River is diverted out of the Green River subbasin. Before entering Desolation and Gray Canyons in Reach 3, the Green River meanders through the Uinta Basin. Numerous sandbars occur in this portion of the reach at low flow, and low-elevation floodplain areas are prominent. In Desolation and Gray Canyons, gravel bars are abundant, and many of the banks are composed of coarse debris-flow material or talus. Recirculating eddies are also prevalent, and there are many regions of stagnant flows in these canyons. The lower 148 km (92 mi) of the Green River flows through the low gradient Labyrinth and Stillwater Canyons.

Green River Flows

Flow in the Green River is dominated by snowmelt; consequently, there was a great deal of seasonal variability in the flow regime prior to regulation. Regulation has resulted in a reduction of flows from April through July and an increase in flows from August through March (Table 2). Reach 1, whose flow is dominated by releases from Flaming Gorge Dam, has been most affected (Figure 2). The effects of regulation are reduced in Reaches 2 and 3, because intervening tributaries, especially the Yampa River, contribute flows with seasonal distributions that are less affected by regulation. Nevertheless, flow variability in the system has been reduced in all three reaches.

TABLE 2 Percent Change in Mean Monthly Flow of the Green River Because of Regulation

	Percent Change in Mean Flow											
River Reach/Gage	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Reach 1/Greendale	+80	+120	+246	+214	+143	+8	-30	-50	-70	-46	+16	+72
Reach 2/Jensen	+52	+71	+140	+121	+82	+6	-13	-17	-35	-32	+10	+54
Reach 3/Green River	+31	+39	+89	+83	+53	+6	-10	-13	-27	-28	+2	+34

The magnitude of annual spring peak flows has been reduced since construction of Flaming Gorge Dam(Figure 2). Before construction of Flaming Gorge Dam, median spring peak flow in Reach 1 was about 330 m^3/s (11,700 cfs); it was reduced to about 85 m^3/s (3,000 cfs) after the dam was built. Releases greater than 200 m^3/s (7,000 cfs) have occurred five times since the dam was completed; such releases occurred in 1983, 1984, 1986, 1997, and 1999. The Flaming Gorge hydrology model (Clayton and Gilmore 2002) predicted that under baseline operations to meet the requirements of the existing 1992 FGBO, safe evacuation of water from the reservoir during wetter years would necessitate use of the bypass tubes in 23% of all years and use of the spillway in 5% of all years.

The frequency of high peak flows also has been reduced by regulation. The difference between regulated and unregulated flows is greatest in Reach 1, with effects of regulation diminishing downstream (Figure 2). At the Jensen gage (Reach 2), the median peak flow was 669 m^3/s (23,625 cfs) without regulation and 448 m^3/s (15,820 cfs) with regulation (Table 3). At the Green River gage (Reach 3), the median peak flow has been reduced from 788 m^3/s (27,800 cfs) to 575 m^3/s (20,300 cfs). The percent reduction in peak flows is provided in Table 5.

The duration and timing of peak flows have also been affected by regulation. Unregulated flows of 475 and 575 m^3/s (16,800 and 20,300 cfs) were exceeded at the Jensen gage 8% and 4% of the time, respectively. With regulation, however, these two flows are exceeded only 3% and 1% of the time. On average, peak flows now occur earlier in the year than they did before regulation. For Reaches 2 and 3, regulated peak flows generally occur about a week earlier than unregulated peak flows.

TABLE 3 Probabilities of Exceedance for Regulated and Unregulated Flows of the Green River at the USGS Stream Gages near Jensen (Reach 2) and Green River, Utah (Reach 3), 1963–1996

Probability of Exceedance (%)	Recurrence Interval (years)	Flow at Jensen Gage (m^3/s)[a]		Flow at Green River Gage (m^3/s)[a]	
		Regulated	Unregulated	Regulated	Unregulated
50	2	448	669	575	788
20	5	618	934	836	1,132
10	10	727	1,076	1,003	1,321
5	20	827	1,192	1,158	1,477
1	100	1,045	1,396	1,495	1,753

[a] To convert from m^3/s to cfs, multiply by 35.3.

TABLE 4 Percent Reduction in Annual Peak Flows of the Green River because of Regulation at Various Exceedance Values, 1963–1996

	Percent Flow Reduction Because of Regulation at Various % Exceedance Values								
River Reach/Gage	10	20	30	40	50	60	70	80	90
Reach 1/Greendale	-61	-73	-70	-67	-63	-61	-60	-58	-52
Reach 2/Jensen	-32	-34	-34	-34	-33	-32	-30	-28	-23
Reach 3/Green River	-24	-26	-27	-27	-27	-26	-25	-23	-19

About 70% of the annual natural flow of the Green River occurs between April and July as a result of melting snow. During the remainder of the year, natural flows (base flows) are generally low. The source of unregulated base flows is predominately groundwater, with occasional augmentation by rain and snowmelt. Regulation and the establishment of the 23-m^3/s (800-cfs) minimum release from Flaming Gorge Reservoir have resulted in higher base flows than occurred pre-dam.

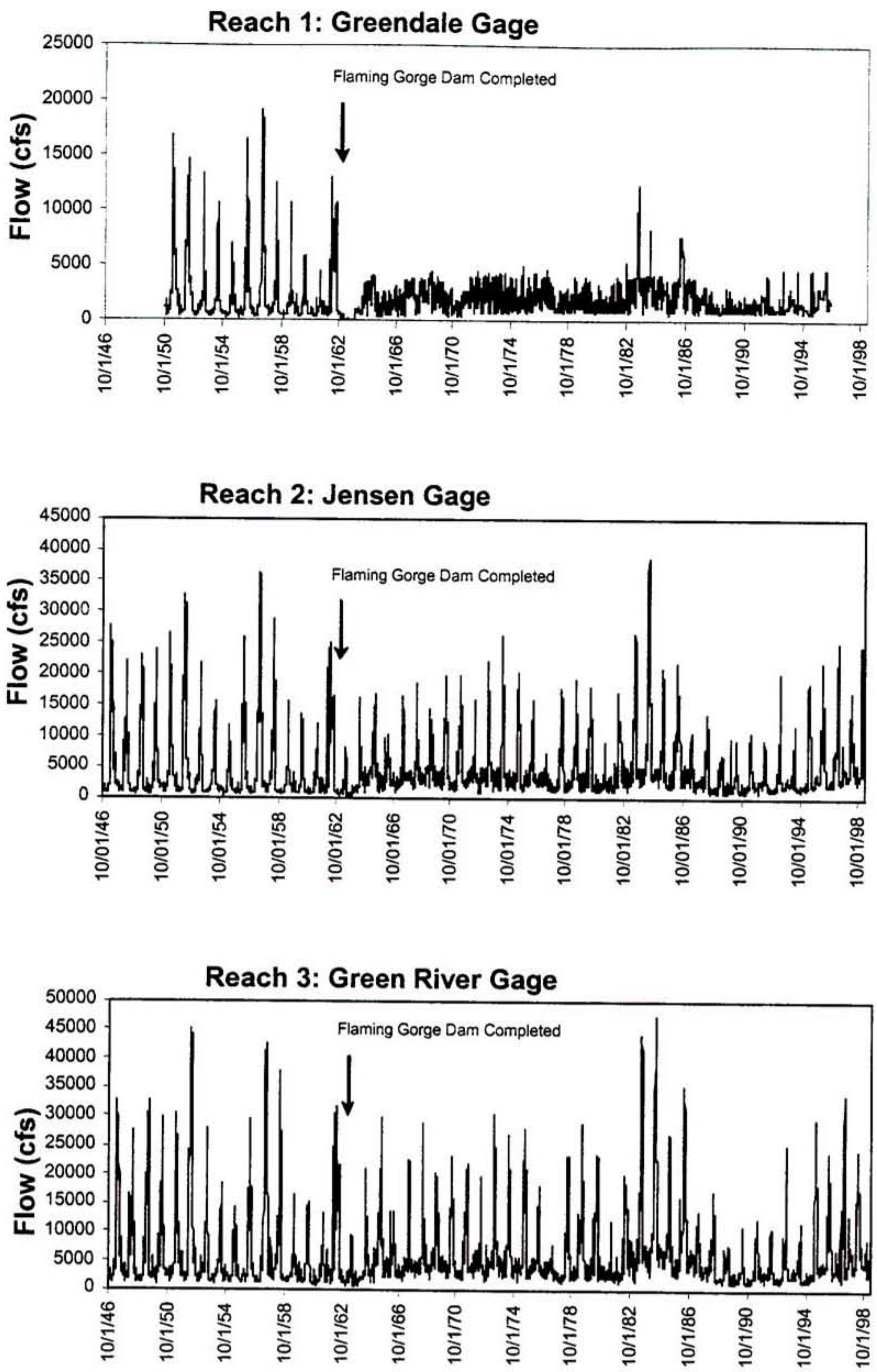

FIGURE 2 Mean Daily Flows in Reaches 1, 2, and 3 of the Green River

Although unregulated base flows in the Green River are generally considered stable, variability in flows occurs during the base-flow period even without hydropower-induced fluctuations. Variability can occur at a number of different time scales, including between years, within years, between days, and within days. Between-year variability in base flows is largely related to annual hydrologic conditions, with higher base flow in wetter years than in drier years. Within-year variability in base flow as measured at the Jensen gage in Reach 2 was higher during the pre-dam period (48% coefficient of variation [CV]) than during the post-dam period (25% CV). Variability during both pre-dam and post-dam periods was less in the winter (December through February) than in the summer and autumn (August through November). During the pre-dam period there was less within-year variability in drier years than in wetter years. Between-day differences in base flows were about 3% (range, 0 to 68%) pre-dam and 5% (range, 0 to 139%) post-dam.

Water-surface elevation (stage) is dependent on flow, but the nature of that relationship varies along the river and is strongly influenced by channel morphology. Stage-flow relationships at the Greendale, Jensen, and Green River gages are presented in Figure 3. This figure illustrates the differences in the relationship at these different locations and the asymptotic nature of each relationship (i.e., as flow increases, the relative incremental increase in stage lessens). Differences in channel width and floodplain characteristics at each location are reflected in the shape of the curves depicted in Figure 3. The river is considerably wider at the Jensen and Green River gages than at Greendale; consequently, as flow increases, the rate of stage change at Jensen and Green River gages is less than the rate at the Greendale gage.

Variations in channel morphology along the river and tributary inputs serve to dampen flow and stage fluctuations that result from hydropower operations at Flaming Gorge Dam. The degree of attenuation of operations-induced fluctuations also depends on specific release parameters, including the ramp rate (the rate of change from minimum and maximum flow expressed as $m^3/s/h$ or cfs/h), minimum and maximum flow levels, and duration of peak releases. This dampening, or attenuation, becomes greater at increasing distances from the dam.

Immediately downstream of Flaming Gorge Dam, flows can change from 23 m^3/s to 130 m^3/s (800 to 4,600 cfs) within a 24-hour period during maximum power-plant-capacity operations. This daily fluctuation would become attenuated downstream, and, under the same operational regime, flows would vary from 62.3 to 141.6 m^3/s (2,200 to 5,000 cfs) at the Jensen gage. These releases would produce daily stage changes of 1.5 m (5 ft) at Greendale and 0.6 m (2 ft) at Jensen (Yin et al. 1995). During August and September, operations that comply with the 1992 FGBO produce flows within a day that vary from 28 to 85 m^3/s (1,000 to 3,000 cfs) at Greendale and 38 to 48 m^3/s (1,300 to 1,700 cfs) at Jensen. These daily flow changes produced stage changes of 90 cm (36 in.) at Greendale and 10 cm (4 in.) at Jensen (Yin et al. 1995). Further attenuation occurs between Jensen and Ouray in Reach 2, and hydropower-related fluctuation effects are difficult to detect by Green River, Utah, in Reach 3.

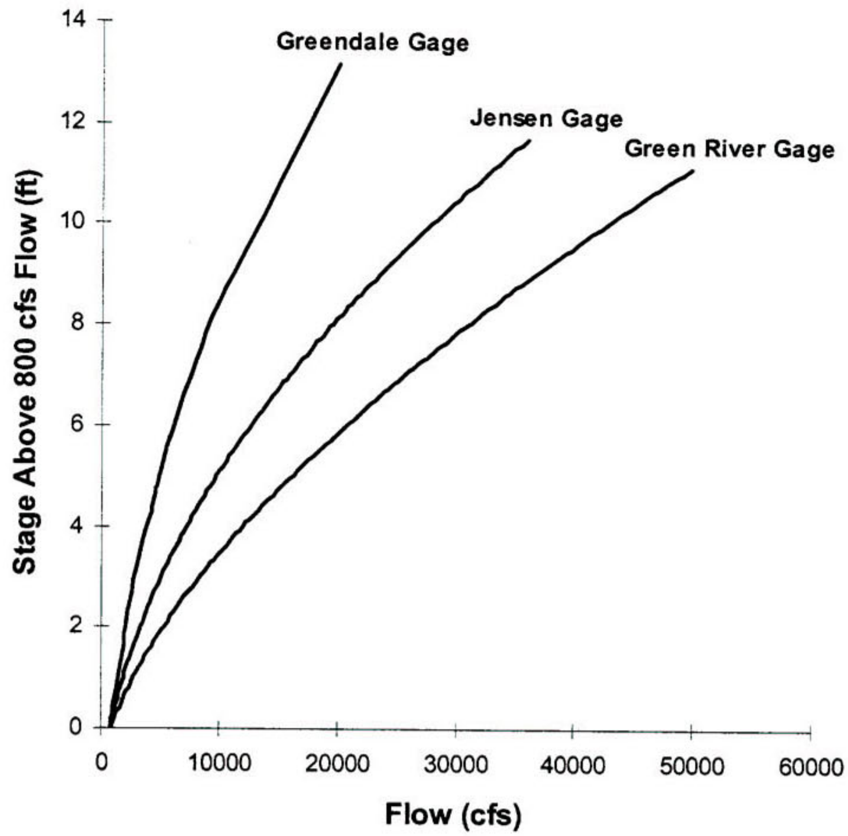

FIGURE 3 Relationships between Stage and Flow in the Green River at the USGS Stream Gages near Greendale, Jensen, and Green River, Utah

Green River Water Temperatures

Winter snows accumulate in the Green River subbasin from October through mid-April. When air temperatures in the basin begin to rise in March and April, snowmelt and runoff begin. As flow increases, the cold water gets warmer as a result of interactions with the channel bed, the atmosphere, and direct solar radiation.

Summer water temperature is important to the endangered fishes because temperature affects the productivity of the aquatic food base, growth and survival of larval fish, and conditioning of adult fish. Summer water temperature is a function of specific weather conditions and the volume and temperature of releases from Flaming Gorge Dam during this period.

As a general rule, in water years[2] with more snowmelt and runoff, the water temperatures remain colder into summer. Water years in which snowmelt and runoff occur early (such as in water

2 A "water year" begins on October 1 and extends through September 30 of the next calendar year.

year 1962, when the peak flow occurred from mid-April to mid-May) are exceptions. During water year 1995, which had a high volume of water with long peak-flow duration, water temperatures stayed low well into July. During water years with less water, water temperatures get warmer earlier in the season because base flows are low and are reached earlier in the year.

The dominant factor influencing water temperature in Reach 1 is the temperature of water released from Flaming Gorge Dam. Release temperature is adjusted through the use of a selective withdrawal structure. During typical winter operations, water is drawn from deep within the reservoir. Released water is 4°C (39°F) and is the warmest available at this time of year. During spring (beginning in late May), warmer water from nearer the surface is released. Reservoir operators adjust the withdrawal system to find a layer of water with a temperature of 13°C (55°F) throughout the summer, so that a constant temperature of release water is maintained until mid-October, when the released water is colder. Because temperatures of water that can be released through the selective withdrawal structure are affected by the rate at which the reservoir stratifies and warms, releases through the selective withdrawal structure are cooler from June through August than pre-dam water temperatures in the Green River, but are warmer during September and October. During the autumn, warmer release temperatures persist later than would have occurred in the river before the dam was constructed.

Air temperature strongly affects water temperature, but this effect is influenced by flow volume (Bestgen and Crist 2000). At higher flows, the water is slower to respond to air temperatures than it is at lower flows. Thus, in summer, higher flows tend to be colder and slower to warm than lower flows. The influence of ambient air temperature increases in importance in a downstream direction. Because ambient air temperature has such a large effect, annual variations in regional weather patterns play an important role in determining the thermal regime of the Green River downstream of Flaming Gorge Dam.

As the river flows through Browns Park, it widens and water temperature increases. From Browns Park, the river enters Lodore Canyon, which has a north-south orientation that limits exposure to direct solar radiation. Summer water temperature in the Green River from the Gates of Lodore to the confluence with the Yampa River typically increases about 2°C (4°F) as the rock mass of the canyon radiates heat to the air and water.

Thermal mixing at the confluence of the Green and Yampa Rivers is seasonally dynamic and has an important effect on Green River water temperatures. During winter, water released from Flaming Gorge Dam is warmer than Yampa River water. Although the Yampa River begins to get warmer in spring, temperature in the Green River remains low and stable as a result of cool Flaming Gorge Dam releases. From the beginning of spring runoff through mid-summer, the temperature of the Green River downstream of the confluence is strongly influenced by the temperature of the relatively large spring flows from the Yampa River. During late summer, the situation reverses as the temperature is controlled by the cooler, higher-volume releases from Flaming Gorge Dam.

From the Yampa River confluence, the Green River flows west into Whirlpool Canyon and then into Island and Rainbow Parks. Water temperature increases in Island and Rainbow Parks during the summer because the river slows down and spreads out, exposing the water to a large channel and radiant solar energy. From Rainbow Park, the river drops into Split Mountain Canyon, where it is shaded by canyon walls and where its water velocity increases. Consequently, the water temperature changes little through this canyon. The Green River enters the Uinta Basin near Jensen, Utah. Through this broad alluvial area, the river spreads out into a wide meandering channel, and, during summer, the water temperature further increases.

The Duchesne and White Rivers join the Green River near Ouray, Utah, but do not appreciably change the temperature of the Green River. Several miles downstream from the confluence of the Green River with the White and Duchesne Rivers, the Green River enters Desolation and Gray Canyons, where diel fluctuations in water temperature are moderated by warmth from the canyon walls radiating to the air and water at night.

Downstream from Gray Canyon, the Green River enters a second large alluvial plain, where the city of Green River, Utah, is located. The river channel widens in this area, water velocity decreases, and water temperature increases slightly. Below Green River, the increase in solar radiation is significant; day and night temperatures are higher and the river is warmer here than upstream.

Flaming Gorge flow and temperature recommendations (Muth et al. 2000) state that temperatures in upper Lodore Canyon should reach at least 18 C (64 F) for two to five weeks at the beginning of the base flow period and that Green River water temperatures should not be more than 5 C (9 F) colder than water from the Yampa River at the confluence of the Green and Yampa Rivers during the summer base flow period. Maximum daily water temperatures in Browns Park have occasionally met or exceeded the 18 C (64 F) target during June, July, and August, but only in July was the temperature target met or exceeded on more than 10% of days. Water measurements made in the Green and Yampa Rivers near the confluence since 1998 indicate that the mean difference between water temperatures of the two streams at the confluence was less than 5 C (9°F) during the months of June through July. However, maximum differences during all months exceeded 5 C (9 F).

Geomorphic Processes in the Green River

Channel Morphology

The Green River downstream of Flaming Gorge Dam consists of a series of linked segments of three channel planform types without a systematic downstream change from one planform to the next. The channel planform types are restricted meanders, fixed meanders, and canyons with abundant debris fans.

Restricted meanders occur in broad alluvial terraces that are bounded by relatively more resistant geology. Valleys in which restricted meanders occur are relatively wide (greater than 1.5 km [1 mi]), and only the outside bends are in contact with bedrock. Restricted meanders occur in Reach 1 (Browns Park) and much of Reach 2.

Fixed meanders are confined by resistant geology on both outside and inside bends and result from symmetrical incision associated with rapid down cutting through the geologic formation. Labyrinth Canyon in Reach 3 is characterized by fixed meanders.

Typical elements of fixed and restricted meanders include the channel, vegetated islands, unvegetated bank-attached compound bars, unvegetated island-attached compound bars, and unvegetated mid-channel compound bars. Permanent islands are less common in fixed meanders than in restricted meanders. In-channel deposits are typically sand, although gravel bars sometimes occur. Typically, bank-attached compound bars occur on alternating sides of the river. Shoreward from these bars is the vegetated floodplain at the edge of the "bankfull" channel (i.e., the channel that can accommodate stream flow without overtopping the banks), and streamward from the bars is the meandering thalweg.

At low discharge, exposed compound bars have an irregular topography caused by chute channels that dissect the bar platform. Chute channels are oriented in a downstream direction, crossing from the streamward to shoreward side at the upstream end of the bar and from the shoreward to streamward side at the downstream end of the bar. The topography of a bar is more complex where there are more chute channels. At some sites and in some years, secondary bars become attached to the shoreward margins of these compound bars. At the downstream end of most compound bars, chute channels may converge into one persistent and deep secondary channel that separates the downstream end of the compound bar from the floodplain. The remainder of the bars consists of broad, level platforms and linear ridges that may be partly vegetated.

As flow recedes from the annual peak discharge, higher-elevation portions of the bar platform are exposed, and small areas of separated flow develop in the lee of these islands. At these discharges, chute channels actively transport sediment. Upon further recession of flow, chute channels at the upstream end of the compound bar become exposed, and flow in the secondary channel ceases. Thereafter, the secondary channel becomes an area of mostly stagnant water. These low-velocity areas (backwaters) provide important nursery habitats for larval fish, especially the Colorado pikeminnow.

Canyons consist of relatively straight sections of river with resistant geology on both sides of the river. Debris fans are areas of coarse sediment deposits at the mouths of tributaries; these sediments are delivered to the main channel during high-flow events in tributaries. In canyons, debris fans form a sequence of conditions that includes (1) a slack-water area upstream from the debris fan, (2) a channel constriction at the debris fan, (3) an eddy or eddies and associated bars in the expansion area downstream from the fan, and (4) a downstream gravel bar (Schmidt and Rubin 1995). These debris fan-eddy complexes exist at the mouths of nearly all tributaries. Downstream of Flaming Gorge Dam, canyons with abundant debris fans include Lodore Canyon (Reach 1), Whirlpool and Split Mountain Canyons (Reach 2), and Desolation and Gray Canyons (Reach 3).

Many debris fans in Desolation Canyon (Reach 3) are large. Only the small, active portion of the fan delivers sediment that restricts flow and causes rapids and eddies in the modern channel, whereas the main portion of the debris fan is so large that it acts more like a meander bend as the river flows around the fan (Orchard and Schmidt 2000).

Within a particular reach, shoreline complexity is affected by sediment-deposition processes and geologic conditions. Consequently, shoreline complexity varies considerably among different planform types. An understanding of shoreline complexity is important because it affects the distribution and suitability of habitats, including backwaters and other low-velocity habitats used as nursery areas by the endangered fishes, especially Colorado pikeminnow and humpback chub.

Shoreline complexity is greatest at those discharges when the bar surface is partly inundated and where chute channels are inactive. At a very low river stage, complexity is determined by the topography of the bar margins, which are typically simpler in shape than are the upper-bar surfaces. When higher discharges inundate the bar surface, complexity is determined by the planform of the floodplain edge. Olsson and Schmidt (1993) showed that the elevation of greatest shoreline complexity changes from year to year because the elevation and topographic complexity of bars change depending on the hydrologic regime during spring runoff.

Restricted meanders have considerable shoreline complexity at bankfull discharge because of the presence of vegetated mid-channel islands. In contrast, fixed meanders have relatively little available habitat at bankfull discharge because the banks are relatively smooth and there are few permanent mid-channel islands. At intermediate stages, complexity increases dramatically, and some segments have significantly more complexity than other segments. At a very low stage, there is little difference in habitat complexity between fixed and restricted meanders, but these segments have higher habitat complexity than canyons (Schmidt 1996).

Except at very low flow, shoreline-complexity indices can be relatively high in canyons with abundant debris fans. In contrast to alluvial reaches, whose banks typically have smooth transitions from one orientation to another, debris-fan segments have banks that are composed of coarse, angular deposits where bank orientations have sharp angles. These divergences give rise to low-velocity habitats even at high river stage.

An important component of shoreline complexity is backwater habitat, which comprises areas of low or no velocity that serve as important nursery habitats for young fishes. After the 1987 spring peak, Pucherelli et al. (1990) found that the total area of backwater habitat in Reach 2 was maximized at flows between 37 and 55 m^3/s (1,300 and 1,900 cfs). The relationship to flow at two study areas within Reach 3 was less clear. Later measurements made by Bell (undated) indicated that flows that optimized habitat availability varied from year to year, and that annual peak flows had an important influence on the relationship between habitat availability and flow. Rakowski and Schmidt (1999) supported Bell's findings and concluded that establishing a single target flow intended to maximize habitat availability every year is inappropriate because bar topography, and therefore habitat availability, changes annually in response to the passage of peak flows.

Eddies are another important component of low-velocity habitat in the Green River, but these habitats form behind geomorphic features (e.g., debris fans, large rocks) that are more resistant than sediment bars to annual peak flows. In Desolation and Gray Canyons, increases in flow change the distribution and type of eddy habitat present, but the total area of eddy habitat changes little (Orchard and Schmidt 2000). At any given flow, approximately 25% of the shorelines occur within eddies.

Although the availability of low-velocity shoreline habitat apparently changes little in Desolation and Gray Canyons with changes in flow, habitat conditions as determined by substrate characteristics in those habitats may change considerably (Orchard and Schmidt 2000). Low flows produce highly complex shoreline habitats with mostly bare sand and gravel substrates. Higher flows submerge these bars and substantially increase the amount of inundated vegetation along shorelines. The amount of talus shorelines in eddies peaked near 198 m^3/s (7,000 cfs) and declined at higher flows.

Flooded side canyons also provide low-velocity habitats used by fish; the relationship between the area of flooded side-canyon habitat and flow in Reach 3 was examined by FLO Engineering, Inc. (1996). Flooding of side canyons begins at a discharge of about 198 m^3/s (7,000 cfs). At greater flows, the area of flooded side-canyon habitat increases linearly until bankfull discharge of 1,104 m^3/s (39,000 cfs) is reached; at this flow, only 2 ha (5 acres) of flooded side-canyon area is available.

Sediment Dynamics

Sediment characteristics and dynamics are important factors that affect the availability and quality of habitat for listed species. Flow patterns have an important influence on sediment dynamics. Flow regulation reduces the dynamics of sediment deposition and erosion patterns. Each year, sediment deposits exposed during base flows are colonized by vegetation, and if subsequent floods do not scour these areas, a process of channel narrowing and increasing bank elevation can occur. At some point, this process becomes difficult to reverse because older, deeper-rooted vegetation is difficult to remove by all but the most extreme flood events.

Andrews (1986) described a sequence of degradation, equilibrium, and aggradation downstream from Flaming Gorge Dam that has developed in response to flow and sediment regulation by the dam. The degrading portion of the Green River channel, where sediment outflow exceeds sediment inflow, occurs just below Flaming Gorge Dam in Reach 1. Equilibrium conditions, where sediment inflow equals sediment outflow, occur in Reach 2. Aggradation, where sediment inflow is greater than sediment outflow, occurs in Reach 3, especially just downstream of the confluences with the White River and Duchesne River.

Andrews (1986) described channel narrowing in Reach 2 as a response to changes in sediment load and flooding caused by Flaming Gorge Dam operations. He determined that, on average, the channel had narrowed by 13% from 213 to 186 m (700 to 610 ft) since dam closure and that further narrowing would continue for another 30 years. Lyons et al. (1992) conducted additional analyses and arrived at somewhat different conclusions. Their results indicated that, in Reach 2, channel narrowing in response to construction of the dam had stopped by 1974 and that a 6% reduction from 217 to 204 m (712 to 670 ft) had occurred. The large floods from 1983 to 1986 reversed some of this narrowing and produced an average channel width of 208 m (680 ft), a 4% reduction from pre-dam width.

Merritt and Cooper (1998) examined channel changes in Browns Park in Reach 1. Three stages of channel change were identified. Stage 1 (channel narrowing and development of banks) occurred initially after closure of the dam. Stage 2 (channel widening, subaqueous bar formation, braided channel) was observed from 1977 to 1994. Stage 3 (bar stabilization, fluvial marsh development, and continued channel widening) has been observed since 1994. Merritt and Cooper (1998) projected that channel widening in Browns Park could continue for several decades but that coalescence of islands will lead to formation of a smaller meandering channel over a longer time span.

High releases in 1997 resulted in significant redistribution of sand in Lodore Canyon in Reach 1 and at least some reversal of the long-term trend of channel narrowing and vegetation encroachment (Martin et al. 1998). Measurements indicated that sediment transport at 244 m^3/s (8,600 cfs) was more than 3 times higher than sediment transport at 130 m^3/s (4,600 cfs).

Orchard and Schmidt (2000) determined that the active channel through Desolation and Gray Canyons decreased an average of 19% since the beginning of the century. They identified two episodes of channel narrowing as evidenced by two new surfaces along the channel. The cottonwood terrace is an abandoned floodplain that began to stabilize between 1922 and 1936 as a result of drier weather conditions. After closure of Flaming Gorge Dam, a second lower surface has become densely colonized by riparian vegetation and is accumulating sediment through vertical accretion. This process is continuing and appears to be contributing to a loss of in-channel fish habitat.

Allred (1997) studied channel narrowing and vertical accretion at the Green River gage in Utah and described the process by which in-channel deposits become stabilized. The stabilization process includes the following steps: (1) emplacement and accretion of a lateral bar as large amounts of sediment are moved through the system; (2) low flood magnitude in years following bar emplacement; (3) rapid encroachment of riparian vegetation onto the exposed bar surface; (4) stabilization of the bar through extensive root system development; and (5) continued vertical accretion of the bar surface during periods of inundation when existing vegetation captures additional sediment.

Channel narrowing occurred at the Green River gage from 1930 to 1938; rapid accretion occurred from 1957 to 1962; and further narrowing occurred after 1962 (Allred 1997; Allred and Schmidt 1999). That research indicates that channel narrowing occurred in response to weather changes and as vegetation (primarily tamarisk) invaded and stabilized newly formed inset floodplain deposits. The large floods of 1983 and 1984 did not reverse the narrowing trend at this site but instead resulted in the deposition of sediments at higher elevations.

Cobble and gravel deposits free of silt and sand are preferred spawning areas of the endangered fishes, and the suitability of these areas for spawning is affected by sediment-transport and depositional patterns. Two spawning areas have been studied to date: a bar used by razorback suckers upstream of Jensen, Utah, in Reach 2, and a bar used by Colorado pikeminnow at the head of Gray Canyon in Reach 3. High flows are responsible for forming both bars, and recessional flows clean the bars of fine sediment, thus making them suitable for spawning by these species (Wick 1997; Harvey and Mussetter 1994)

Floodplain Inundation

Floodplains develop along rivers where the valley floor is extensively covered with alluvium. The normal-flow channel, carved in the alluvium, is flanked by this low-relief surface that becomes part of the riverbed during high-flow periods. The natural integrity of large-river ecosystems is dependent on this interaction (Welcomme 1995, Junk et al. 1989 and Wydoski and Wick 1998). Interrelations between overbank flows and the floodplain provide a conduit for the exchange of nutrients and maintain physical habitat components of the system (Annear et al. 2004). Restricting river-floodplain interaction reduces the ecological integrity of the system and limits the growth, conditions and abundance of fishes dependent on that environment. The frequency and extent of floodplain inundation vary considerably along the Green River, largely in response to site-specific channel morphology (including the presence or absence of natural or manmade levees).

Irving and Burdick (1995) conducted an inventory, largely on the basis of aerial photography, of potential flooded bottomland habitats in the Green River. They determined that approximately 644, 3,500, and 3,300 ha (1,590, 8,650, and 8,150 acres) were present in Reaches 1, 2, and 3, respectively. In Reach 3, about 1,100 ha (2,700 acres) was present between the White River confluence and Pariette Draw, and about 760 ha (1,880 acres) was present in Canyonlands National Park in the lower portion of the reach. The highest priority bottomlands for endangered fishes are in Reach 2 and the upper portion of Reach 3 (Escalante Ranch to Pariette Draw).

In the Ouray portion of Reach 2, significant inundation of floodplain areas occurs at about 527 m^3/s (18,600 cfs). At this flow, and with artificial levees in place, a total of 514 ha (1,270 acres) of floodplain area is inundated. The area of inundated habitat increases greatly as flow exceeds 527 m^3/s (18,600 cfs): 1,457 ha (3,600 acres) is inundated at 575 m^3/s (20,300 cfs); 3,238 ha (8,000 ac) at 643 m^3/s (22,700 cfs); and 3,561 ha (8,800 acres) at 748 m^3/s (26,400 cfs) (FLO Engineering, Inc. 1996). Recently, removal or modification of artificial levees in important habitat areas has allowed flooding to be initiated at flows of 368 m^3/s (13,000 cfs).

Most of the floodplain habitat in Reach 3 is located in the upper portion of the reach just downstream of the confluences with the White and Duchesne Rivers, and this habitat is contiguous with the floodplain habitats of Reach 2. In the upper portion of Reach 3 examined by Bell et al. (1998), the total areas of floodplain inundation were 265, 425, and 767 ha (655, 1,050, and 1,895 ac) at 623, 680, and 920 m^3/s (22,000, 24,000, and 32,500 cfs), respectively, as measured at the USGS gage near Green River, Utah.

Floodplain habitats in Reaches 2 and 3 of the Green River can be classified as depression floodplains or terrace floodplains. Depression floodplains are usually separated from the main channel by an elevated levee (natural or constructed) and typically retain water for a relatively long time after river flows recede. Terrace floodplains are sloping features that fill and drain with changes in river stage (Valdez and Nelson 2004). Both of these floodplain habitat types may become inundated during annual spring peak flows and provide a variety of direct biological benefits to the endangered fishes. Colorado pikeminnow and razorback sucker utilize both types of floodplain habitats for growth resting and conditioning, particularly for adult fish preparing to migrate In addition both types of floodplain habitats but in particular depression floodplains appear to provide nursery habitat for the razorback sucker (Birchell et al. 2002). Overbank flows that inundate depression and terrace floodplain habitats also provide allochthonus energy input to the river system in the form of terrestrial organic matter and insects that are utilized directly and indirectly by the endangered fishes in the river.

As peak flows recede, depression floodplain habitats retain water at an elevation determined by the elevation of associated levee features. During the base-flow period, the amount of water in depression floodplains will usually decrease due to evaporation and percolation losses. The length of time that water is retained in depression floodplains is often site-specific, and some depression floodplains can hold water through one or more years. For these habitats, subsequent spring peak flows of sufficient magnitude will reconnect the floodplain to the main channel before the water in the wetland has been depleted. In contrast, terrace floodplains drain as flows recede; and therefore do not serve as nursery habitat for razorback suckers once peak flows recede.

Valdez and Nelson (2004) identified 16 priority floodplain sites (Figure 4) in the Split Mountain to Desolation Canyon reach of the Green River (Reach 2 and upper Reach 3) and evaluated the potential importance of each of these sites as razorback sucker nursery areas. Important floodplain characteristics considered by Valdez and Nelson (2004) included the type of floodplain (e.g., depression or terrace), the flow at which the floodplain becomes inundated, the potential area of inundation, and the distance from the known razorback sucker spawning bar in the Green River, which is located upstream in Dinosaur National Monument. Characteristics of these priority floodplains for razorback sucker are summarized in Table 6.

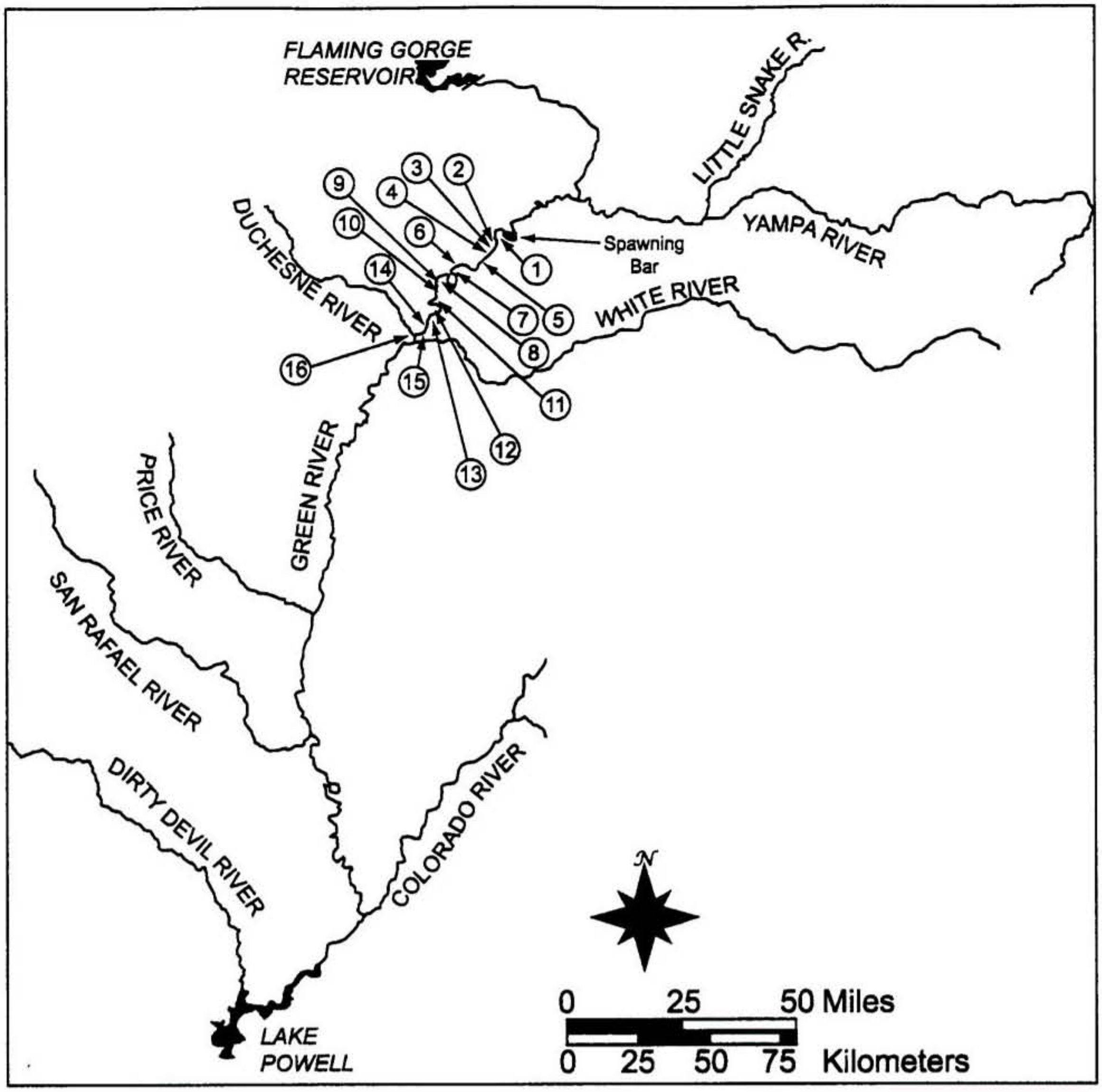

FIGURE 4 Priority Floodplain Areas in the Middle Green River. Refer to Table 6 for a key that matches numbered locations to names for individual floodplain areas. (Source: Valdez and Nelson 2004).

TABLE 6 Floodplain Type, Connecting Flow, Inundated Area, and Distance from the Razorback Spawning Bar for Sixteen Priority Wetlands

Site No.[a]	Floodplain Site	Type[b]	Connecting Flow (cfs)	Inundated Area at Connecting Flow (ac)	Distance from Spawning Bar (river mi)
1	Thunder Ranch	D	13,000[c]	330	5
2	IMC	T	18,600	4	8
3	Stewart Lake	D	7,500	570	11
4	Sportsman's Lake	D	20,000	132	14
5	Bonanza Bridge	D	13,000	23	21
6	Richens/Slaugh	T	18,600	45	25
7	Horseshoe Bend	D	13,000	17	27
8	The Stirrup	D	13,000	20	36
9	Baeser Bend	D	13,000	38	38
10	Above Brennan	D	13,000	41	45
11	Johnson Bottom	D	13,000	146	47
12	Leota Ponds	D	13,000	1,016	52
13	Wyasket Lake	T/D[d]	18,600	850	55
14	Sheppard Bottom	D[e]	25,300	1,[illegible]50	58
15a	Old Charley Wash (Main)	D	14,000	336	60
15b	Old Charley Wash (Diked)	T	13,000	56	60
16	Lamb Property	T	18,600	463	70

[a] Corresponds to numbered locations on Figure 4

[b] D = depression, T = terrace

[c] Inundation flows with notched levees as identified in Muth (2000). Valdez and Nelson (2004) reported that levee removal would allow inundation of the Thunder Ranch floodplain at 16,900 cfs.

[d] Wyasket Lake has little potential to hold water throughout the year and, except for a deep trench and a small depression, acts largely as a terrace floodplain (Valdez and Nelson 2004).

[e] Although much of the area within Sheppard Bottom acts as terrace floodplain (Valdez and Nelson 2004), the entire area identified as floodable has been considered a depression floodplain in this table.

Native and Nonnative Fishes of Flaming Gorge Reservoir

The fish community of Flaming Gorge Reservoir consists of the following nonnative species: lake trout (*Salvelinus namaycush*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), cutthroat trout (*Oncorhynchus clarki*), kokanee salmon (*Oncorhynchus nerka*), white sucker (*Catostomus commersoni*), smallmouth bass (*Micropterus dolomieu*), channel catfish (*Ictalurus punctatus*), common carp (*Cyprinus carpio*),Utah chub (*Gila atraria*), redside shiner (*Richardsonius balteatus*), and the Bear Lake sculpin (*Cottus extensus*). It also supports small numbers of some native fish species, including flannelmouth sucker (*Catostomus latipinnis*), mountain whitefish (*Prosopium williamsoni*), and the mottled sculpin (*Cottus bairdi*).

Since the reservoir was filled, rainbow trout have been stocked annually, are the most sought-after species by anglers, and provide the bulk of the harvest. Kokanee salmon and smallmouth bass were stocked during the mid 1960s and have since developed naturally reproducing fisheries. After rainbow trout, kokanee salmon are typically second in harvest and popularity with anglers. Other sport fish occasionally stocked in the reservoir include brown trout and channel catfish.

Lake trout, which drifted into Flaming Gorge from the upper Green River drainage, have also become established as a wild population. Lake trout are managed as a trophy fishery in Flaming Gorge Reservoir. Regulations are designed to keep lake trout numbers in balance with populations of kokanee salmon and Utah chubs, their primary prey.

Smallmouth bass are found in rocky shoreline habitat throughout Flaming Gorge Reservoir. A dense population dominated by smaller fish exists from the dam north to Linwood Bay. From the Antelope Flats area north, fewer but larger bass are found. Smallmouth bass in Flaming Gorge Reservoir feed almost exclusively on crayfish. They spawn from late May through early July, and during this period, mature fish move into shallow water. Smallmouth bass were introduced into Flaming Gorge Reservoir to promote growth of kokanee salmon by reducing the Utah chub population (Tuescher and Luecke 1996).

Native and Nonnative Fishes of the Green River

Twelve native fish species have been reported from reaches of the mainstem of the Green River between Flaming Gorge Dam and the Colorado River confluence and from lower portions of the river's tributaries. This assemblage of fishes includes warm-water species that prefer or require large-river habitats (e.g., razorback sucker and Colorado pikeminnow), species that prefer cool- or cold-water streams or smaller river channels (e.g., Colorado River cutthroat trout [*Oncorhynchus clarki pleuriticus*], mountain whitefish, and mottled sculpin), and species with more generalized habitat requirements (e.g., roundtail chub [*Gila robusta*], speckled dace [*Rhinichthys osculus*], and bluehead sucker [*Catostomus discobolus*]).

Twenty-five nonnative fish species have been reported from the Green River between Flaming Gorge Dam and the Colorado River confluence. The red shiner (*Cyprinella lutrensis*), common carp, sand shiner (*Notropis stramineus*), fathead minnow (*Pimephales promelas*), channel catfish, and smallmouth bass are widespread and common to abundant (Tyus et al. 1982; Jackson and Badame 2002). Salmonids are generally restricted to Reach 1 and are most abundant in the tailwaters of Flaming Gorge Dam.

Nonnative fishes dominate the ichthyofauna of the Colorado River Basin and have been implicated as contributing to reductions in the distribution and abundance of native fishes as a result of competition and predation (Carlson and Muth 1989; Lentsch et al 1996; Tyus and Saunders 1996). Behnke and Benson (1983) attributed the dominance of nonnative fishes to dramatic changes in flow regimes, water quality, and habitat characteristics. They reported that water development has converted a turbulent, highly variable river system into a relatively stable system, with flow and temperature patterns that allowed for the proliferation of nonnative fish species. Hawkins and Nesler (1991) identified red shiner, common carp, fathead minnow, channel catfish, northern pike (*Esox lucius*), and green sunfish (*Lepomis cyanellus*) as the nonnatives considered to be of greatest concern because of their suspected or documented negative interactions with native fishes. White sucker may affect populations of some species of native suckers, including the endangered razorback sucker, through hybridization.

Recently, considerable concern has been expressed regarding the potential for smallmouth bass to adversely affect native fish populations, and the Recovery Program is currently evaluating methods to control this species in the Green River. Smallmouth bass prey on native species, especially young, and also compete with native fish for food and cover. They occur in Lodore Canyon in small numbers (Bestgen and Crist 2000), and increase in abundance further downstream.

Riparian Communities

Riparian vegetation occurs along most of the Green River below Flaming Gorge Dam. Riparian vegetation is found along all portions of the river except in those areas where sheer rock walls abut the river. Before construction of Flaming Gorge Dam, the vegetation along the river occupied two distinct zones (Fischer et al. 1983). Nearest the river, flooding occurred each year during the spring, and plants in this flood zone were predominantly annuals or scour-tolerant perennials such as wild licorice (*Glycyrrhiza lepidota*), common dogbane (*Apocynum cannibinum*), and sedges (*Carex* spp.). Dominant species above the flood zone included box elder (*Acer negundo*), squawbush (*Rhus trilobata*), Fremont cottonwood (*Populus deltoides. wislizenii*), and coyote willow (*Salix exigua*) (Holmgren 1962). After construction of the dam and the elimination of annual floods, riparian vegetation from adjacent riparian and upland areas colonized much of the old flood zone. Species that spread by underground stems (such as wild licorice, common reed [*Phragmites australis*], and scouring rush [*Equisetum* spp.]) formed dense stands along the shoreline in some areas. These plants stabilize sediment deposits, and this process appears to be gradually making the channel narrower and deeper with steep banks.

Below Flaming Gorge Dam, the Green River alternately flows through narrow canyons and broad valleys that support different riparian communities. The moderate to steep slopes of canyons are vegetated with pinyon pine (*Pinus edulis*), Utah juniper (*Juniperus osteosperma*), Douglas-fir (*Pseudotsuga menziesii*), or ponderosa pine (*Pinus ponderosa*). The riparian zone occurs on a predominantly rocky substrate (mostly cobble and boulder, with sand and gravel becoming more common farther downstream). Vegetation at the summer water level to about 2 m above consists of wild licorice, redtop (*Agrostis stolonifera*), marsh paintbrush (*Castilleja exilis*), sea milkwort (*Glaux maritima*), western evening primrose (*Oenothera elata*), and silverweed cinquefoil (*Potentilla anserina*). Ute ladies'-tresses occurs in this zone. Above the normal high-water line, grasses; scouring rush; giant whitetop (*Cardaria draba*); wild licorice; and a variety of woody species, including box elder, coyote willow, tamarisk (*Tamarix ramosissima, T. chinensis,* or a hybrid of the two), and Fremont cottonwood, are common.

Through the wide valley areas (e.g., Browns Park), the river meanders within a broad, open floodplain of mostly sand and silt (and gravel in upstream areas). Steep cutbanks are common, and in some areas almost all banks are cut and severely eroded. The surrounding uplands support sagebrush (*Artemisia* spp.), desert shrubs, and, in some areas, pinyon pine and Utah juniper. Islands and backwaters are frequent throughout these sections of the river. The riparian zone is relatively broad (up to 60 m [200 ft] wide) and extends to 5 to 6 m (15 to 20 ft) above the low-water level. In the higher elevation portions of the riparian zone, grasses, coyote willow, wild licorice, giant whitetop, and scouring rush are common. Large stands of mature Fremont cottonwood occur on high terraces. These stands became established under pre-dam conditions. Mature cottonwoods are now prone to premature decay, which is likely a result of the reduction in inundation frequency that has occurred since dam construction (Williams 2000). Maintenance of these elevated riparian woodlands is a concern, especially in Reach 1, because reproduction requires occasional high flows for seedling establishment, but normal dam operations reduce the frequency of such flows.

Summary

The Service has consistently concluded in previous consultations that water depletions and the operation of infrastructure associated with those depletions are a major factor contributing to the reductions in the populations of the Colorado pikeminnow, humpback chub, bonytail, and razorback sucker. Impacts of depletions and associated storage infrastructure such as dams and reservoirs have resulted in changes in flow and temperature regimes which in turn affect endangered species and their habitat. Removing water from the river and stabilizing the system through regulation reduces the ability of the river to create and maintain important habitats and reduce the frequency and duration of availability of these habitats. Food supply, predation, and competition are important elements of the biological environment. Food supply is a function of nutrient supply and productivity. High spring flows inundate bottomland habitats and increase the nutrient supply and productivity of the river environment. Reduction of high spring flows by water storage reservoirs that store water during spring peak flows may reduce food supply. Other major factors impacting the endangered fishes include competition from and predation by nonnative fishes. These reductions in populations and loss of habitat caused the Service to list these species as endangered and to implement programs to conserve the species. Implementation of the proposed action in conjunction with other activities by the Recovery Program is designed to offset various depletion impacts to the Green and Colorado River and to provide a suitable flow and temperature regime for the endangered fishes in the Green River downstream of Flaming Gorge Dam.

EFFECTS OF THE ACTION

The proposed action would have beneficial effects on the four listed Colorado River fishes and their critical habitats within the action area. These benefits include: Increased frequency and duration of relatively high spring flows will inundate floodplain habitats, which will help maintain the ecological integrity of the river system and provide warm, food-rich environments for subadult and adult Colorado pikeminnow, bonytail and Razorback sucker as well as for young razorback sucker. Increased peak flows and proposed variability in peak flows is expected to maintain spawning areas for the endangered fishes and lead to increased in-channel habitat complexity through formation and reworking of in-channel sediment deposits. Scaling of baseflows to the hydrologic conditions will help favor the formation of low velocity shoreline nursery habitats in Reach 2 and 3. In general, implementation of a flow regime that more closely resembles the natural flow regime of the river will provide benefits to all the endangered fishes and the habitats on which they depend.

Analyses for Effects of the Action

The flow recommendations on which the proposed action is based are intended to meet the habitat requirements of the four endangered fishes by providing adequate flows. Flow regimes that would be produced under the proposed action differ from those of the environmental baseline in several important ways. The most important differences between the new flow recommendations and flows called for under the 1992 FGBO or No Action Alternative are (1) the magnitude and duration of spring peak flows, (2) the level of variability in peak and base flows between and within years, and (3) recommended winter base flows (Muth et al. 2000).

The Flaming Gorge hydrology model (Clayton and Gilmore 2002) was developed to evaluate the long-range effects of operating Flaming Gorge Dam to achieve the Green River flow objectives of the proposed action. Model results (especially predicted flow exceedance values) serve as the basis for much of the effects analysis in this biological opinion. The model includes all relevant river features (reservoirs, river reaches, confluences, diversions, etc.) from Fontenelle Reservoir, upstream of Flaming Gorge Reservoir, to the confluence of the Green and Colorado Rivers. In developing the model, emphasis was placed on details of river features directly below Flaming Gorge Reservoir and on the Yampa River. The model simulates the year-round operation of Flaming Gorge Dam to meet flow recommendations and predicts flows at the USGS streamflow gage on the Green River at Jensen, Utah approximately 150 km (93 mi) downstream of Flaming Gorge Dam. Flows are predicted that would occur over a 39-yr period, beginning in January of 2002.

A model ruleset was developed for the proposed action which incorporated the logic and decision-making processes for achieving the flow objectives. The ruleset was used primarily to calculate the volume of water to be released from Flaming Gorge Dam so that the flow objectives are achieved in Reaches 1 and 2. The ruleset controlled the reservoir elevation for safe operation of the dam, maximized reservoir storage, and minimized bypass releases, while attempting to meet the flow objectives during the spring peak release as well as during the base-flow period. For Reaches 1 and 2, the model indicates that the minimum target recommendations could be met for all flows, durations, and frequencies. The model predicted that more frequent use of the bypass tubes and spillway at Flaming Gorge Dam would occur under the proposed action than under the baseline. The model predicted that the bypass tubes would be used in 50% of all years, under the proposed action, and the spillway would be used in 29% of all years. In comparison, under baseline conditions, the bypass tubes would be used in 23% of all years, and the spillway would be used in 5% of all years. The predicted increased use of the bypass tubes and spillway under the proposed action is primarily attributable to meeting the recommendation to achieve flows of 18,600 cfs for at least 2 weeks in 40% of years. Additional information regarding the model results can be found in Clayton and Gilmore (2002).

The predicted future flows in Reach 3 were estimated (Clayton and Gilmore 2003) by combining the Reach 2 flows predicted by the Flaming Gorge Model with estimated inflows corresponding to the historic input from all Reach 2 and 3 tributaries, as well as losses occurring along the channel due to evaporation, infiltration, and depletions. This estimate was obtained by subtracting the historic flows recorded at the Greendale, Utah, gage (in Reach 1) from the flows recorded at the Green River, Utah, gage (in Reach 3), with an estimated lag period of 5 days. The recommended target of 10% frequency for a single day peak flow of 1,100 m^3/s (39,000 cfs) in Reach 3 would not be achieved by predicted flows under the proposed action; however, all other recommended flows, durations, and frequencies would be met.

A review of the hydrology model by Reclamation and Argonne National Laboratory (see EIS section 2.4) found that while the model performs well in dry, moderately dry and average years, it appeared to bypass or spill more water in moderately wet and wet years. Reclamation acknowledged in the FGEIS that the hydrology model by Clayton and Gilmore (2003) may overstate bypasses necessary to meet the Proposed Action (2000 Flow and Temperature Recommendations)

Critical Habitat Response to the Proposed Action

The primary constituent elements of critical habitat for the Colorado River endangered fishes are water, physical habitat, and the biological environment (59 F.R. 13374). Water includes a quantity of water of sufficient quality delivered to a specific location in accordance with a hydrologic regime required for the particular life stage for each species. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. In addition, oxbows, backwaters, and other areas in the 100-year floodplain, when inundated, provide access to spawning, nursery, feeding, and rearing habitats. Food supply, predation, and competition are also important elements of the biological environment.

This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 C.F.R. 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.

Under the proposed action, releases from Flaming Gorge Dam in most years would be patterned to provide recommended flows in Reaches 2 and 3 rather than achieve specific targets in Reach 1, but releases would be high enough in wetter years to provide significant channel maintenance (i.e., rework and rebuild in-channel sediment deposits, increase habitat complexity, and prevent or reverse channel narrowing) in Lodore Canyon (Muth et al. 2000). Increased channel maintenance would improve in-channel habitat conditions for endangered fishes, reduce vegetation encroachment of channel-margin sediment deposits, and, thus, create a more natural, dynamic riparian corridor.

Under the proposed action, some flow fluctuation would result in Reach 1 from Flaming Gorge Dam hydropower operations. These flow fluctuations would be limited to the extent necessary to achieve recommended levels of variability in Reach 2. Target water temperatures of 18 °C (64 °F) for two to five weeks in the beginning of the base flow period in upper Lodore Canyon are expected to be achieved in most years by targeting release temperatures of 13 to 14 °C (55 to 57 °F) during the midsummer. During high runoff years it may not be possible to meet target temperatures due to the lack of warm water available for release from Flaming Gorge Reservoir (Muth et al. 2000). These temperatures are warmer, and more suitable for native fish than those of the environmental baseline. In addition, temperature modeling conducted for the EIS analysis suggests that a difference of less than 5 °C (9 °F) between waters from the Green and Yampa Rivers will be achieved more consistently under the proposed action than have occurred since implementing operations to meet the 1992 FGBO.

Peak flows in Reach 2 would be sufficient to provide significant inundation of floodplain habitat and off-channel habitats (e.g., tributary mouths and side channels) in wet and moderately wet years (30% of years) (Muth et al. 2000). This inundation would establish river-floodplain connections and provide warm, food-rich environments for growth and conditioning of fishes. In wetter years, peak flows in Reach 2 under the proposed action would also rework and rebuild in-channel sediment deposits (including spawning substrates), increase habitat complexity, form in-channel sand bars, and prevent or reverse channel narrowing.

In Reach 2, significant inundation of floodplain habitat and off-channel habitat would also occur in at least one of four average years, with some flooding of off-channel habitats occurring in all average years (Muth et al. 2000). Significant channel maintenance would occur in at least one of two average years.

Under the proposed action, no floodplain inundation would be expected in Reach 2 during moderately dry and dry years, but some flooding of off-channel habitat would still occur. In addition, some sediment transport would occur in all moderately dry and dry years because peak flows would exceed the incipient-motion threshold of the sand substrate. These flows would prevent vegetation establishment within the river channel.

Under the proposed action, base flows in Reach 2 would more closely approximate pre-dam levels of magnitude, duration, and variability than occur under current operations. Flows under the proposed action would favor the formation of low-velocity shoreline habitats that would be more stable and increase productivity of the river ecosystem. Higher water temperatures would occur at lower base flows in average and drier years (70% of all years) and would enhance ecological productivity.

Expected effects of the proposed action on physical and ecological conditions in Reach 3 would approximate those described above for Reach 2 (Muth et al. 2000). However, floodplain habitat in Reach 3 is more isolated from the river because of vertical accretion of banks and vegetation encroachment. As a result, less floodplain habitat would be inundated in Reach 3 than in Reach 2 under the proposed action. Nonetheless, the frequency and duration of floodplain inundation in Reach 3 are expected to be greater under the proposed action than under current conditions.

Species Response to the Proposed Action

Colorado Pikeminnow

It is anticipated that Colorado pikeminnow would benefit from the proposed action in several ways. The frequency and duration of relatively high spring flows is expected to increase under the proposed action. Floodplain habitats in the Uinta Basin portion of Reach 2 and 3 would be inundated for at least two weeks in four of ten years, and bankfull flows would be achieved in one of two years. These high flows would result in substantial inundation of floodplains, tributary mouths, and side channels in Reach 2 and upper Reach 3 that would provide warm, food-rich environments for growth and conditioning of subadult and adult Colorado pikeminnow prior to spawning. The increased duration of floodplain inundation would prolong the potential benefits provided by these habitats to juvenile and adult Colorado pikeminnow. High peak flows could also result in significant reworking and rebuilding of in-channel sediment deposits, leading to increased habitat complexity and formation of in-channel sandbars behind with associated backwater habitats. Although little or no floodplain inundation would occur in drier years, some off-channel habitats (e.g., side channels and tributary mouths) in Reaches 2 and 3 would be inundated and could benefit juvenile and adult Colorado pikeminnow in those years.

Habitats in Lodore Canyon that are occupied by Colorado pikeminnow could be improved and maintained by the relatively frequent high flows of the proposed action. The Flaming Gorge hydrology model (Clayton and Gilmore 2002) predicted that peak flows would exceed powerplant capacity in about 50% of all years, compared with about 23% of all years under baseline (current) operations. The model also predicted that spillway releases (flows above 244 m^3/s or 8,600 cfs) would occur in about 29% of years under the proposed action compared to about 5% of all years under current operations. The sediment reworking that would occur could improve conditions on cobble beds that could subsequently serve as spawning sites.

Larval pikeminnow drift downstream from spawning bars to occupy nursery habitats found in Reaches 2 and 3. Colorado pikeminnow use backwater nursery areas during their first year of life throughout the base-flow period. These backwaters are characteristically low velocity areas associated with main channel sand bars. Rakowski and Schmidt (1999) conducted a study in Reach 2 to describe the process by which backwaters were formed and maintained. They concluded that a single base flow target from year to year was inappropriate because the shape of sand bars varied based on magnitude of the preceding annual spring flood.

Under the proposed action, base-flow magnitudes would be based on hydrological conditions, and variability in flows around the mean base flow would be greater than under baseline conditions during the base-flow season. Scaling base flows to hydrologic condition and the antecedent peak flow should favor the formation of backwaters and other low-velocity shoreline nursery habitats in Reaches 2 and 3. Maintaining the magnitude of annual mean base flows during summer, autumn, and winter under the proposed action should promote favorable conditions for Colorado pikeminnow in low-velocity habitats. Although the level of fluctuation restriction needed to fully protect low-velocity habitats is uncertain (Muth et al. 2000), it is believed that keeping hydropower-induced changes in mean base flows at Ouray within the recommended levels of seasonal and within-day variability throughout the summer, autumn, and winter would promote favorable conditions for young Colorado pikeminnow in low-velocity nursery habitats in Reach 2. Hydropower-induced fluctuations in flow are largely attenuated by the time flows reach the Ouray portion of Reach 2.

Under the proposed action, warmer water would be released from Flaming Gorge Dam during portions of the base-flow period in most years. As a result, summer water temperatures in Lodore Canyon would typically be higher under the proposed action than under baseline conditions. These warmer summer temperatures could increase the suitability of Lodore Canyon for spawning by Colorado pikeminnow (Muth et al. 2000). In addition, the resulting decrease in the difference between water temperatures in the Green River and the Yampa River at the Echo Park confluence during July would reduce the possibility of cold shock to Colorado pikeminnow larvae drifting out of the Yampa River and into the Green River. Under the proposed action, the recommendation to reduce the temperature difference between the Yampa and Green Rivers at the confluence could be met more often than under baseline conditions. Water temperatures in the lower portions of Reach 2 and throughout Reach 3 under the proposed action would not differ substantially from those under existing baseline conditions.

In addition to the potential benefits of the proposed action to the Colorado pikeminnow described above, there is the potential for some adverse effects as well. To achieve the recommended magnitudes and durations of spring peak flows in Reach 2, water may need to be released over the spillway more than five times as often as under current operations. Increased use of the spillway increases the risk that nonnative fish would be released into the Green River from Flaming Gorge Reservoir. Of particular concern is the potential to release smallmouth bass, a warmwater predator that is thought to adversely affect native fish populations in the basin and that is currently being targeted by Recovery Program control efforts. Increased escapement of this species through spillway releases, together with the increased water temperatures during summer and early fall under the proposed action may increase the potential for smallmouth bass or other nonnative fish to survive, reproduce, and expand their distribution in the Green River, especially in areas of Reach 1 such as Lodore Canyon, where the colder summer temperatures under baseline conditions may currently reduce survival and reproduction by nonnative fish. Even if escapement from the reservoir does not result in increased numbers of nonnative fishes downstream, there is a potential for increased survival, reproduction, and expansion of nonnative fish species in Lodore Canyon due to increased water temperatures alone.

Razorback Sucker

Access to floodplain habitat is considered critical for providing larval and juvenile razorback suckers with nursery habitat. Razorback sucker spawning has occurred at several locations, but is concentrated in an area 154 to 172 km (96 to107 mi) downstream of Flaming Gorge Dam in Reach 2. This spawning area is located immediately upstream of most of the floodable habitat in the vicinity of the Ouray National Wildlife Refuge. Under the proposed action, flows in Reach 2 would reach or exceed 527 m^3/s (18,600 cfs) for at least two weeks in 41% of years, as opposed to only 16% of years under baseline conditions. Timing peak flows to coincide with peak flows in the Yampa River would result in an overlap between the inundation period and the period when drifting razorback sucker larvae are typically present in most years, and would allow larval razorback suckers to be entrained into inundated areas. Because the proposed action would result in bankfull or greater flows in one of two years, there would be sufficiently frequent reconnection of depression wetlands (that maintain water throughout the year) with the main channel that razorback suckers would be able to reenter the main channel after growing to a suitable size.

It is anticipated that peak flows under the proposed action would also regularly inundate floodplains in the upper portion of Reach 3 (e.g., between the White River confluence and the upstream end of Desolation Canyon) and would provide some in-channel habitat maintenance throughout the reach in all years. In most years, the proposed peak flows would also inundate tributary mouths and side channels that provide warm, food-rich environments for growth and conditioning by subadult and adult razorback sucker before and after spawning. Although peak flows of 527 m^3/s (18,600 cfs) or greater would inundate floodplain habitats as described above, recent modifications to existing levees allow flooding of some habitats at lower flows.

Under the proposed action, peak flows are expected to be of sufficient frequency, magnitude, and duration to rework and rebuild in-channel sediment deposits in portions of Lodore Canyon that may be occasionally used by subadult or adult razorback suckers and would remove fine sediments from spawning bars used by razorback suckers in Reaches 2 and 3.

Base flow magnitudes would be established each year according to hydrological conditions, and variability in flows around the mean base flow would be consistent with pre-dam variability throughout the base-flow season. Scaling base flows to hydrologic condition and the antecedent peak flow would favor the development of backwaters and other low-velocity shoreline habitats in Reaches 2 and 3 that are sometimes used by young razorback suckers. Maintaining the magnitude of annual mean base flows during summer, autumn, and winter periods under the proposed action should promote favorable conditions for razorback sucker in low-velocity habitats (Muth et al. 2000).

Under the proposed action, warmer water would be released from Flaming Gorge Dam during the base-flow period. As a result, summer water temperatures in Lodore Canyon and the upper portion of Reach 2 would typically be higher under the proposed action than under current operations. These warmer temperatures could improve razorback sucker growth in those areas in most years. Water temperatures in the lower portion of Reach 2 and throughout Reach 3 would not differ substantially from those under baseline conditions.

In addition to the potential benefits of the proposed action to the razorback sucker described above, there is the potential for some adverse effects as well. To achieve the recommended magnitudes and durations of spring peak flows in Reach 2, water may need to be released over the spillway more than five times as often as under current operations. Increased use of the spillway increases the risk that nonnative fish would be released into the Green River from Flaming Gorge Reservoir. Of particular concern is the potential to release smallmouth bass, a warmwater predator that is thought to adversely affect native fish populations in the basin and that is currently being targeted by Recovery Program control efforts. In addition, there is a potential for white suckers, a species known to hybridize with the razorback sucker, to be released into the Green River. Increased escapement of these species through spillway releases, together with the increased water temperatures during summer and early fall under the proposed action may increase the potential for smallmouth bass or other nonnative fish to survive, reproduce, and expand their distribution in the Green River, especially in areas of Reach 1 such as Lodore Canyon, where the colder summer temperatures under baseline conditions may currently reduce survival and reproduction by nonnative fish. Even if escapement from the reservoir does not result in increased numbers of nonnative fishes downstream, there is a potential for increased survival, reproduction, and expansion of nonnative fish species in Lodore Canyon due to increased water temperatures alone.

Humpback Chub

Under the proposed action, the magnitude, frequency, and duration of high spring releases from Flaming Gorge Dam would increase relative to the environmental baseline. The Flaming Gorge hydrology model (Clayton and Gilmore 2002) predicted that peak flows would exceed powerplant capacity in about 50% of all years, compared with about 23% of all years under baseline (current) operations. Spillway releases would occur in about 29% of years under the proposed action compared to about 5% of years under current operations.

Humpback chub currently do not occur in Reach 1, and no direct effects of the proposed action in that reach are anticipated. If humpback chub should become established within Reach 1 as a result of implementing the proposed action, peak flows would help maintain in-channel habitat areas by reworking sediment deposits in Lodore Canyon in wetter years. The peak flows that would occur under the proposed action are also expected to mobilize in-channel sediment deposits in currently occupied portions of Reach 2 and 3 (Whirlpool, Split Mountain, Desolation, and Gray Canyons). The proposed action would benefit humpback chub in these areas by helping prepare and maintain substrates in spawning areas, increasing habitat complexity, and preventing or reversing channel narrowing. Although significant changes in channel morphology are not anticipated, peak flows of the proposed action are expected to scour and maintain the large recirculating eddies that are used as resting and feeding habitats by adults.

If humpback chub should become established within Reach 1, it is anticipated that the base flows under the proposed action would provide suitable summer, autumn, and winter conditions for humpback chub. These base flows would be appropriate for development of recirculating eddies and for promoting development of complex shoreline habitat in Whirlpool, Split Mountain, Desolation, and Gray Canyons. In addition, maintaining the seasonal, daily, and within-day variability of flows within the ranges identified in the proposed action would maintain stability of conditions in the shoreline habitats that are preferred by young fish.

Higher summer water temperatures in most years could encourage movement and establishment of humpback chub in the lower portions of Lodore Canyon and could enhance growth and survival of young humpback chub in Whirlpool Canyon. Temperature regimes in Split Mountain Canyon and further downstream will be largely unaffected by the proposed action. Water temperatures in Reach 3 under the proposed action are expected to be indistinguishable from those that occur under baseline conditions. Summer water temperatures in Desolation and Gray Canyons would continue to reach the desired humpback chub spawning temperature of at least 17°C (62.6°F) during the descending limb of the spring peak in most years.

In summary, the proposed action is expected to benefit humpback chub in the Green River by improving habitat conditions for all life stages. The proposed action would result in flows that would maintain and improve conditions in the currently occupied canyon reaches. The proposed action would increase the temperature of water released during summer months in most years. Warmer summer water temperatures would improve conditions for growth and survival of humpback chub in Whirlpool Canyon and could result in expansion of the population into Lodore Canyon.

In addition to the potential benefits of the proposed action to the humpback chub described above, there is the potential for some adverse effects as well. To achieve the recommended magnitudes and durations of spring peak flows in Reach 2, water may need to be released over the spillway more than five times as often as under current operations. Increased use of the spillway increases the risk that nonnative fish would be released into the Green River from

Flaming Gorge Reservoir. Of particular concern is the potential to release smallmouth bass, a warmwater predator that is thought to adversely affect native fish populations in the basin and that is currently being targeted by Recovery Program control efforts. Increased escapement of this species through spillway releases, together with the increased water temperatures during summer and early fall under the proposed action may increase the potential for smallmouth bass or other nonnative fish to survive, reproduce, and expand their distribution in the Green River, especially in areas of Reach 1 such as Lodore Canyon, where the colder summer temperatures under baseline conditions may currently reduce survival and reproduction by nonnative fish. Even if escapement from the reservoir does not result in increased numbers of nonnative fishes downstream, there is a potential for increased survival, reproduction, and expansion of nonnative fish species in Lodore Canyon due to increased water temperatures alone.

Bonytail

Little is known of the habitat requirements of the bonytail because it was extirpated from most of its historic range before studies were conducted. In the Green River, Vanicek (1967) generally found bonytail in pools and eddies with low velocities, although these habitat features were often located adjacent to areas of strong current. Similarly, Valdez (1990) reported that bonytail captured in Desolation and Gray Canyons were sympatric with humpback chub in shoreline eddy habitat with boulders and cobble. It has been recently hypothesized that flooded bottomlands may provide important bonytail nursery habitat. The Recovery Program has been building their stocking program to achieve a target release of 5,330 hatchery produced bonytail (target size of 200 mm) in the upper and lower Green River each year for six years. In excess of 20,000 bonytail (many < 200mm) have already been stocked in Reaches 1 and 2 since 2000.

The peak flows that would occur under the proposed action would rework and rebuild in-channel sediment deposits in potential bonytail habitat found in Echo Park, Whirlpool and Split Mountain Canyons in the upper portion of Reach 2. These peak flows would similarly rework and rebuild in-channel sediment deposits in Desolation and Gray Canyons in Reach 3, where bonytail have historically been found. These proposed peak flows could benefit reintroduced bonytail in these areas by preparing and maintaining substrates in spawning areas, promoting increased habitat complexity, and preventing or reversing channel narrowing during wetter years. The proposed peak flows would also scour and maintain eddies. The proposed peak flows would periodically inundate flooded bottomland habitats and would allow access to such areas by bonytail larvae in some years.

Base flows that would occur under the proposed action would be scaled to annual hydrologic conditions. These flows would provide eddies and complex shoreline habitat in Echo Park, Whirlpool, Split Mountain, Desolation, and Gray Canyons.

Higher summer water temperatures in most years could encourage movement and establishment of bonytail within lower portions of Lodore Canyon and could enhance growth and survival of bonytail in Whirlpool Canyon. As occurs under current baseline conditions, summer water temperatures in Desolation and Gray Canyons would reach the desired humpback chub spawning temperature of at least 17°C (62.6°F) during the descending limb of the spring peak in most years. It is assumed that such temperatures would also be suitable for reproduction and growth of bonytail.

Although a great deal of uncertainty remains regarding bonytail habitat requirements, the proposed action is expected to benefit bonytail reintroduced into the Green River and is expected to provide appropriate conditions for survival and recruitment of this species. The proposed action would result in flows that would maintain and improve substrate conditions in historically occupied canyon reaches. In addition, the proposed action would increase the temperature of water released during summer months in most years, resulting in improved potential for spawning, growth, and survival of bonytail in Whirlpool Canyon.

In addition to the potential benefits of the proposed action to the bonytail described above, there is the potential for some adverse effects as well. To achieve the recommended magnitudes and durations of spring peak flows in Reach 2, water may need to be released over the spillway more than five times as often as under current operations. Increased use of the spillway increases the risk that nonnative fish would be released into the Green River from Flaming Gorge Reservoir. Of particular concern is the potential to release smallmouth bass, a warmwater predator that is thought to adversely affect native fish populations in the basin and that is currently being targeted by Recovery Program control efforts. Increased entrainment of this species in spillway releases, together with the increased water temperatures during summer and early fall under the proposed action may increase the potential for smallmouth bass or other nonnative fish to survive, reproduce, and expand their distribution in the Green River, especially in areas of Reach 1 such as Lodore Canyon, where the colder summer temperatures under baseline conditions may currently reduce survival and reproduction by nonnative fish.

Ute Ladies'-Tresses

The distribution and abundance of Ute ladies'-tresses is affected by changes in the frequency and duration of inundation and by changes in patterns of erosion or deposition. Under the proposed action, the magnitude and duration of peak flows would generally be higher than those of the environmental baseline, especially in wet years. Higher peak flows would result in greater depth and duration of inundation in areas below the existing annual peak flow elevation, such as the post-dam floodplain, along with potential increases in flow velocity. Higher elevation surfaces, such as the intermediate bench or cottonwood-box elder terrace, could be inundated more frequently than under the existing flow regime. Depending on local geomorphic characteristics, sites supporting existing Ute ladies'-tresses colonies may experience a range of effects from increased sediment deposition to increased erosion.

Under the proposed action, annual peaks in Reach 1 would generally be higher than under existing baseline conditions, and geomorphic surfaces supporting Ute ladies'-tresses would generally be inundated more frequently. Results of the Flaming Gorge Hydrologic Model (Clayton and Gilmore 2002) indicate that, under the proposed action, the post-dam floodplain in Reach 1 (inundated at 130 m^3/s [4,600 cfs]) would be inundated in all years by the peak releases of at least one day duration, as under baseline conditions. This surface would be inundated in about 74% of years by flows of two weeks duration, up from about 46% under baseline, and in about 55% of years by flows of four weeks duration, up from about 27% under baseline. The intermediate bench (inundated at about 244 m^3/s [8,600 cfs]) would be inundated in about 30% of years by the peak releases of at least one day duration under the proposed action, and about 7% of years under baseline conditions. The intermediate bench would be inundated in about 8% of years by flows of two weeks duration, slightly up from about 7% under baseline, and in about 2% of years by flows of four weeks duration, slightly down from about 3% under baseline.

Ute ladies'-tresses are able to tolerate occasional periods of extended inundation. The post-dam floodplain surfaces in Reach 1 are sometimes inundated for a duration of up to eight weeks. All Ute ladies'-tresses colonies inventoried in Red Canyon and Browns Park in 1999 were inundated that year by peak flows of 308 m^3/s (10,900 cfs), and most were inundated for at least 32 days (Grams et al. 2002). These survived an average of 0.7 m (2.3 ft) inundation, and up to 1.2 m (3.9 ft) at some sites. On average, sites supporting Ute ladies'-tresses are inundated from a few days to 10 days per year under environmental baseline conditions (1 to 3% of the time) (Grams et al. 2002). Post-dam floodplain sites would be inundated for somewhat longer periods, with two and four week inundations occurring in more years than under baseline conditions. In Red Canyon and Browns Park, approximately 6% of the Ute ladies'-tresses colonies occur on the post-dam floodplain, while about 23% occur on an undifferentiated post-dam floodplain/intermediate bench surface. Intermediate bench sites may be inundated more frequently, with the largest difference from baseline being in the flow durations of at least one day. Approximately 71% of the Ute ladies'-tresses colonies in Red Canyon and Browns Park occur on Intermediate bench surfaces, with 23% on the undifferentiated post-dam floodplain/intermediate bench surfaces. In extreme wet years, high flows could result in some mortality on lower elevation surfaces (e.g., post-dam floodplain sites) greater than what now occurs under the environmental baseline.

Erosion and deposition that could be caused by peak flows would likely be low at many occupied sites. The amount of sediment deposited during the high flows of 1999 at occupied sites in Red Canyon and Browns Park ranged from none (most of the sites) to less than 5 cm (2 in.) of very fine sediment (Grams et al. 2002). Total post-dam deposition at these sites apparently averaged 11 cm (4.3 in.). Sediment deposition was greater on unoccupied post-dam floodplain and intermediate bench surfaces. Deposition also occurred on some post-dam floodplain and intermediate bench surfaces in Lodore Canyon, some of which were occupied. Partial and complete burial of Ute ladies'-tresses were recorded. On channel margin deposits, as well as on islands and expansion bars, in Lodore Canyon, sand deposition and/or erosion was observed on 70% of post-dam floodplain and intermediate bench surfaces examined following the 1999 peak flow (Grams et al. 2002). Intermediate bench and the downstream portions of post-dam floodplain features tended to be subject to deposition, with ranges of several centimeters to over one meter observed.

Under the proposed action, sediment deposition could increase on some occupied sites, such as in Lodore Canyon. However, occupied Ute ladies'-tresses sites in Red Canyon and Browns Park tend to be located in positions with low rates of sediment deposition. Ute ladies'-tresses are able to tolerate some sediment deposition. One colony in Lodore Canyon flowered and produced seed after partial burial in 1999. However, some mortality of buried individuals could be expected.

Erosion at sites occupied by Ute ladies'-tresses in Red Canyon and Browns Park is generally absent or minor. Erosion was observed in Lodore Canyon, however, as a result of 308 m^3/s

(10,900 cfs) flows in 1999. Scouring resulted in habitat loss on upstream portions of channel margin deposits, islands, and expansion bars, especially at the post-dam floodplain level. Ute ladies'-tresses were lost as a result. Increased peak flows under the proposed action could result in increased erosion of these Ute ladies'-tresses sites.

Post-dam floodplain or intermediate bench surfaces that experience erosion or deposition and become available for development of early seral stage vegetation could be colonized by Ute ladies'-tresses, and new reproductive colonies could become established. However, some of those new colonies might be only temporary. For example, some areas that are subject to frequent disturbance from flooding (such as some post-dam floodplain surfaces), might not be stable for the length of time required for Ute ladies'-tresses to become established and to reproduce (10 to 20 years) and might not develop beyond early seral stage communities. In addition, some new sites that are relatively stable for extended periods, (such as some intermediate bench surfaces) might become colonized by native woody species, such as coyote willow or cottonwood, or invasive species, such as tamarisk, giant whitetop, yellow sweetclover (*Melilotus officinalis*), or common reed. Such sites might eventually become unsuitable for survival of Ute ladies'-tresses because of decreased light as a result of excess shading by other species.

New colonies could become established on higher-elevation sites in Red Canyon, upper Browns Park, or Lodore Canyon. Studies indicate that Ute ladies'-tresses became established on the higher pre-dam cottonwood-box elder terrace in Island Park after high flows in 1983 or 1984 (Grams et al. 2002). Deposition of fine sediments and increased frequency of inundation at these higher elevations might increase site suitability for Ute ladies'-tresses. However, some of these areas may currently support other plants whose shade might prevent Ute ladies'-tresses establishment or survival.

Sites that support Ute ladies'-tresses typically have a shallow water table during August and are positioned 0.5 to 0.9 m (1.5 to 2.8 ft) above the normal flow elevation (Grams et al. 2002). Under the proposed action, base flows during August and the remainder of the growing season, would be higher in all but the driest years than under baseline conditions and would be expected to support colonies at existing elevations as well as at slightly higher elevations. The average monthly flow in Reach 1 during August under the proposed action would be approximately 45 m^3/s (1,600 cfs). This would be about 11 m^3/s (380 cfs) above baseline operations in August. Under the proposed action, the highest base flow in Reach 1 would be 76 m^3/s (2,700 cfs) and would occur in wet years. Because base flows may vary from targeted flows by as much as 40% during this period under the proposed action, the maximum base flow expected in Reach 1 would be 106 m^3/s (3,760 cfs), which is below the level of the post-dam floodplain and intermediate bench. Although flows in May, at the beginning of the growing season, may be somewhat lower under the proposed action than under baseline conditions, the growth or survival of Ute ladies'-tresses would not be affected as the difference would be small, and flows would be considerably higher than base flows, ascending to a peak in June. Relatively low base flows during dry years (about 1 m^3/s [25 cfs] lower than baseline August operations) would not be expected to adversely affect Ute ladies'-tresses unless an extended sequence of dry years occurred.

Effects of flow changes in Reach 2 would be similar to those described for Reach 1. Model results indicate that, under the proposed action, the post-dam floodplain in Reach 2 (inundated at approximately 455 m^3/s [16,100 cfs]) would be inundated in about 72% years by the peak releases of at least one day duration, as under baseline conditions. This surface would be inundated in about 47% of years by flows of two weeks duration, up from about 35% under baseline, and in about 19% of years by flows of four weeks duration, slightly up from about 18% under baseline. The intermediate bench (inundated at about 600 m^3/s [21,000 cfs]) would be inundated in 39% of years by the peak releases of at least one day duration under the proposed action, as under baseline conditions. This surface would be inundated in about 14% of years by flows of two weeks duration, up from about 9% under baseline, and in about 5% of years by flows of four weeks duration, as under baseline.

In Reach 2, the largest differences from baseline are in the flows of two-week duration or more during the spring-peak period. Sites occupied by Ute ladies'-tresses in Island Park and downstream of Split Mountain might be subject to extended inundation, increased deposition, or increased erosion. The magnitude of effects on occupied sites might be limited in most years, although peak flows in wet years could result in some mortality of Ute ladies'-tresses. There are far fewer colonies in Reach 2 than in Reach 1, however.

As in Reach 1, sites suitable for establishment of Ute ladies'-tresses could become available at higher elevations in Island and Rainbow Parks, if suitable sediments are deposited. However, high peak flows in Reach 2 caused by Yampa River input might decrease the potential suitability of some new sites on post-dam surfaces, such as intermediate bench surfaces. Sites that are subject to frequent disturbance from high flows may not be stable for long enough periods for Ute ladies'-tresses establishment and reproduction.

Under the proposed action, base flows in Reach 2 in August and the remainder of the growing season would be higher in most years and would be expected to support colonies at existing elevations as well as at slightly higher elevations. The average monthly flow in Reach 2 during August, under the proposed action, would be approximately 57 m^3/s (2,000 cfs). This would be about 11 m^3/s (400 cfs) above baseline operations in August. The highest target base flow in Reach 2 would be 85 m^3/s (3,000 cfs), and would occur in wet years. Because base flows may vary from targeted flows by as much as 40% during this period, the maximum base flow expected in Reach 2 would be 119 m^3/s (4,200 cfs), which is below the level of the post-dam floodplain and intermediate bench where Ute ladies'-tresses occur. Relatively low base flows during dry years under the proposed action would not be expected to adversely affect Ute ladies'-tresses in Reach 2 unless an extended sequence of dry years occurred.

It is possible that the proposed action will facilitate the spread and vigor of invasive species such as tamarisk into occupied or potentially suitable habitat of Ute ladies'-tresses orchid. However, the rate and extent of invasion and habitat change is unknown. Tamarisk is an aggressive opportunist and persists in habitats they invade (i.e., are resistant to natural vegetation succession). Invasion tamarisk would result in significant detrimental impacts to habitat and some colonies could be threatened with eventual extirpation.

In summary, Ute ladies'-tresses is well adapted to changing conditions in riparian floodplains. It typically occurs where streams exit steep terrain, retain moderate velocity, and begin to create a meander floodplain corridor. It's occurrence in a steep-walled canyon such as Lodore is considered to be an artifact of Flaming Gorge operation where both high and low flows have been attenuated. This is corroborated by failure to find the species or suitable habitat conditions along the Yampa River. In Reach 1, Ute ladies'-tresses occurs on landforms just below debris fans, conditions which replicate emergence of streams from steep terrain into more moderate terrain. Historically, it is likely that the orchid did not occur in Lodore Canyon, but rather in various locations upstream of Flaming Gorge Dam, and possibly in Browns, Island, and Rainbow parks. While reoperation of Flaming Gorge Dam will more nearly replicate natural flow conditions than historical or baseline operation, it will be insufficient to recreate riparian habitat dynamics and complexity in areas such as Browns, Island, and Rainbow parks due to the excessive sediment buildup in those areas since the dam was built. Thus, we do not expect that suitable potential habitat will be created and sustained in those areas. In addition, it has been speculated that an increase in the frequency and duration of bypasses and spills from Flaming Gorge Dam could adversely effect populations in Reach 1 that were established under prior dam operations.

Uncertainties

In their Biological Assessment, Reclamation and Western, identified a number of uncertainties associated with the proposed action and offered a list of actions to reduce potential adverse effects to the listed species. We summarize those discussions below:

Uncertainties Associated with Hydrology

Reclamation and Western point out the limitations of the Flaming Gorge Hydrology Model (Clayton and Gilmore 2002). The Service recognizes that the Flaming Gorge Model is not an operations model, but was a tool developed to conduct comparative analyses of impacts / effects of alternatives in the environmental compliance arena. Under the proposed action, the Service, through it's involvement on the Technical Working Group and the Flaming Gorge Working Group, would work closely with Reclamation in recommending dam operations to meet the flow and temperature recommendations. In our ITS, we identify the type of information we expect to be included in Reclamation's Annual Operations Report. A thorough accounting of operations will help the Service and others evaluate the extent to which the recommendations were met in the most recent year and how that relates to previous years of operation.

Uncertainty with Selective Withdrawal Operations

Reclamation included a conservation measure in their proposed action that addressed operational uncertainty in their ability to meet the temperature recommendations. We have addressed Reclamation's concern in our ITS by requiring Reclamation to develop a selective withdrawal operations plan, which addresses their uncertainties and outlines a process to resolve them.

Uncertainties Associated With Increased Spillway Use

Based on past experiences, Reclamation foresees potential structural damages to the FGD spillway each time it is used, and therefore commit to inspecting the structure after each spill event. In the biological assessment, Reclamation states that if the amount of damage was deemed unacceptable they would limit use of the spillway to those times it was hydrologically necessary. The Service expects Reclamation to report the results of their post-spill spillway inspections in their annual operations report (see ITS Term and Condition #6). Should Reclamation determine that the increased use of the spillway under the proposed action was unacceptable the Service will consider if re-initiation of Section 7 consultation is necessary.

We encourage Reclamation to coordinate with the State of Utah's ongoing tailrace trout population monitoring to evaluate the level of nitrogen super-saturation associated with use of the spillway. If results of those ongoing efforts in a change in Reclamation's operations to meet the flow recommendations, the Service would determine if re-initiation of this Section 7 consultation was necessary.

The Service recognizes and agrees with Reclamation's concern that spills from Flaming Gorge Dam could result in unacceptable levels of entrainment of nonnative reservoir fish species. We have addressed these concerns by providing the framework for an adaptive management process that evaluates the proposed action (including entrainment) in our ITS.

Uncertainties in Fish Responses to Flow and Temperature Modifications

Reclamation and Western in their biological assessment expressed concern over how the fish community and in particular nonnative species might respond to aspects of the flow and temperature recommendations. Whereas, the action agencies and the Service recognize that the intention of the proposed action is to benefit the endangered fish in the long-term, the Service shares the concern that implementation of the proposed action could result in both temporal and spatial short-term benefits to some nonnative species. Evaluating the effects of the proposed action on the fish community will be of critical importance in determining how to best manage the system for recovery of the endangered fish species. In our ITS (RPM #1 and T&C #1) we identify the need for the action agencies and the Service to work with the Recovery Program to develop a Study Plan that evaluates this proposed action. We recommend that the Recovery Program consider uncertainties, identified by the authors of Muth et al (2000) and as identified by Reclamation through their NEPA process, in the development of that study plan. The Service agrees with the action agencies that the Recovery Program is the appropriate science body to take the lead in developing and implementing that plan. It is the Service's opinion that implementation of that study plan within the context of the Recovery Program and full communication of that plan with interested parties via the Flaming Gorge Working Group represents an appropriate adaptive management solution to these fish community uncertainties.

Uncertainties Associated With Floodplain Inundation

In their biological assessment, Reclamation and Western have brought into question the need for some of the dam releases (based on results of hydrologic modeling presented in Reclamation'

EIS) to meet Reach 2 floodplain magnitude and duration targets as identified in Muth et al (2000) to benefit larval razorback suckers. Reclamation and Western's position on this issue is based primarily on information that was presented in the Recovery Program sponsored Floodplain Management Plan for the Green River Subbasin (Valdez and Nelson 2004). It is the Service's opinion that based on the best available information Muth et al (2000) should be implemented, however the specific questions raised by the action agencies in their biological assessment regarding floodplain inundation should be considered through the adaptive management process outlined in RPM #1, T&C #1 of the ITS.

Uncertainties Associated with Riparian Vegetation

There are uncertainties associated with the response of invasive plant species to the proposed action. Recent research suggests that the flood flows may prevent additional tamarisk establishment on post-dam floodplain surfaces in Lodore Canyon, but may push establishment to higher elevations. Information is lacking on the degree to which these responses would occur.

Uncertainties related to the response of certain native plant communities to the proposed action include duration and magnitude of flood flows necessary to stimulate a positive response in mature cottonwoods and response of wetland species to higher base flows of late summer and lower base flows of winter and early spring.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Endangered Species Act. In the action area, the Green River flows mostly through federal land. No future state or private actions are known to be in the planning stage in the action area that would not require Section 7 consultation. For this reason, no cumulative effects are anticipated on the endangered species or designated critical habitat in the action area.

CONCLUSION

After reviewing the current status of the endangered fishes and the Ute ladies'-tresses, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the Service's biological opinion that the proposed action is not likely to jeopardize the continued existence of the Colorado pikeminnow, humpback chub, bonytail, razorback sucker or Ute ladies'-tresses and will not result in the destruction or adverse modification of critical habitat of these species. The implementation of the proposed action is expected to result in overall beneficial effects to the species and critical habitat in the Green River downstream from Flaming Gorge Dam and induce a positive species response, particularly with the endangered fishes due to a more natural hydrologic regime. The basis for the determination of no jeopardy and no adverse modification of critical habitat for each listed species is summarized below.

Colorado Pikeminnow

The Service concludes that although some aspects of operations to meet the flow and temperature recommendations may result in increased interactions between endangered and nonnative fish species, the proposed action will result in long-term positive benefits for the Colorado pikeminnow and critical habitat. Positive effects of the proposed action include; increased inundation and access to floodplains which would provide warm, food rich environments for adult and subadult Colorado pikeminnow, peak flows of sufficient magnitude to maintain main channel habitats for adult fish including spawning bars, base flows that would encourage development and maintenance of backwaters and other low velocity shoreline habitats favorable for young fish and a temperature regime that would reduce temperature shock to drifting Colorado pikeminnow larvae at the confluence of the Green and Yampa rivers and potentially improve growth of adult fish in lower Reach 1 and the upper portion of Reach 2.

Razorback Sucker

The Service concludes that although some aspects of operations to meet the flow and temperature recommendations may result in increased interactions between endangered and nonnative fish species, the proposed action will result in long-term positive benefits for the razorback sucker and critical habitat. Positive effects of the proposed action include; increased inundation and access to floodplains for young razorback suckers, peak flows of sufficient magnitude to maintain main channel habitats for adult fish, base flows that would encourage backwater development and other low velocity shoreline habitats favorable for razorback suckers and a temperature regime that could improve razorback sucker growth in lower Reach 1 and the upper portion of Reach 2.

Humpback Chub

The Service concludes that although some aspects of operations to meet the flow and temperature recommendations may result in increased interactions between endangered and nonnative fish species, the proposed action will result in long-term positive benefits for the humpback chub. Positive effects of the proposed action include; peak flows of sufficient magnitude to maintain main channel habitats for adult fish, base flows that would encourage development of complex low velocity shoreline habitats and a temperature regime that could enhance growth and survivability of young humpback chub in Whirlpool Canyon in Reach 2.

Bonytail

Although there is uncertainty about some aspects of bonytail life history and some aspects of operations to meet the flow and temperature recommendations may result in increased interactions between endangered and nonnative fish species, the Service concludes that the proposed action will result in long-term positive benefits for the bonytail and critical habitat by providing conditions appropriate for survival and recruitment. Positive effects of the proposed action include; increased inundation and access to floodplains for young bonytail, peak flows of sufficient magnitude to maintain main channel habitats for adult fish, base flows that would encourage backwater development and other low velocity shoreline habitats and a temperature regime that could improve the potential for spawning and growth of bonytail in the Whirlpool Canyon portion of Reach 2.

Ute Ladies'-tresses

The Service concludes that the proposed action is not likely to jeopardize the Ute ladies'-tresses or result in the destruction or adverse modification of critical habitat since no critical habitat has been designated for this species. Along the Green River, Ute ladies'-tresses occur on surfaces that formed in response to construction and past operations of Flaming Gorge Dam. Most colonies are located in Reach 1, but several have also been found in Reach 2. Most individuals occur on post-dam floodplain surfaces, near the annual peak-flow elevation, or on the intermediate bench, which is at a slightly higher elevation. These sites are located within a zone that is inundated between 1% and 3% of the time. Under the proposed action, mean annual peak flows would increase, and the frequency of larger peak flows would increase. While occupied sites might be subject to some erosion, deposition, or extended inundation, direct effects on Ute ladies'-tresses colonies as a result of these flow changes are expected to be small because of site characteristics that often are protective, such as landscape position and substrate composition. The 1 to 3% inundation zone may shift to a slightly higher position along the river margin, potentially resulting in reductions in the number of individuals at lower elevations, such as on some post-dam floodplain surfaces. Locations at elevations slightly above the existing zone of 1 to 3% inundation may become more suitable for Ute ladies'-tresses establishment. The indirect effects of the proposed action include potential changes in location, distribution, vigor, and competitive ability of both native and non-native invasive species, which may in turn adversely affect the ability of Ute ladies'-tresses to occupy suitable habitat.

Ute ladies'-tresses is adapted to and requires occasional disturbance to maintain its preferred seral stage; proposed-action flows would provide this occasional disturbance while maintaining appropriate soil-moisture conditions during the growing season. Implementation of the proposed action may result in some losses of individual plants at currently occupied sites due to erosion or deposition during high flow events. New colonies of Ute ladies'-tresses may become established at higher elevations and offset these losses. However, increased vigor or competitiveness of native and non-native invasive species may preclude or impede orchid establishment and long term sustainability in occupied and potentially suitable habitat.

There are several large populations of Ute ladies'-tresses throughout it 7 state range, and many small populations. Although the population in Reach 1 and 2 is considered significant, anticipated adverse impacts are unlikely to result in extirpation either of this population or of the species throughout its range.

INCIDENTAL TAKE

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent act or omission that creates the likelihood of injury to listed wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are nondiscretionary, and must be undertaken so that they become binding conditions of any Federal discretionary activity, for the exemption in section 7(o)(2) to apply. The following reasonable and prudent measures and terms and conditions are intended to be largely consistent with the 2004 Recovery Implementation Program Recovery Action Plan (RIPRAP) of the Upper Colorado River Endangered Fish Recovery Program[3] (Recovery Program) and will be implemented according to the RIPRAP schedule. This incidental take statement, however, also contains several terms and conditions not included in the 2004 RIPRAP. For these terms and conditions Reclamation and Western will either work with the Recovery Program to include them in future RIPRAP revisions or may assume responsibility for their implementation. The participating Federal Agencies have a continuing duty to monitor the activity covered by this incidental take statement. If Reclamation and Western through the Recovery Program or as individual agencies 1) fail to assume and implement the terms and conditions or 2) fail to retain oversight to ensure compliance with the terms and conditions, the protective coverage of section 7(o)(2) may lapse for the projects covered by this incidental take statement. In order to monitor the impact of incidental take, Reclamation and Western must report to the Service as specified in the incidental take statement [50 CFR 402.14(i)(3)] (see TC#5-annual report).

AMOUNT OR EXTENT OF TAKE

The Service believes that managing reservoir releases to be consistent with the flow recommendations is necessary for the survival and recovery of the endangered fish. The Proposed Action is fully intended to benefit the endangered Colorado River fish, and the Service expects an overall, long-term beneficial effect to result from implementation. However, the Proposed Action also has the potential to cause increases in nonnative fish within the action area. Increases in nonnative fish may result in incidental take in the form of harm through predation on and competition with the endangered fish (Hawkins and Nesler 1991; Lentsch et al. 1996; Tyus and Saunders 1996). Incidents of predation by northern pike on endangered fishes have been

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[3] The Recovery Program was established in 1988 when the Secretary of Interior; Governors of Wyoming, Colorado and Utah; and the Administrator of the Western Area Power Administration signed a cooperative agreement to implement the program. The purpose of the Recovery Program is to recover the endangered fishes in the Colorado River system while providing for existing and new water development in the Upper Basin. The Recovery Program is also intended to serve as a reasonable and prudent alternative to avoid the likelihood of jeopardy to the continued existence of the endangered fishes and to avoid the likely destruction or adverse modification of critical habitat in Section 7 consultations on depletion impacts related to new projects and all impacts (except contaminants) associated with historic water projects in the Upper Basin.

observed in both the Yampa and Green rivers. Other nonnative predators, such as smallmouth bass and channel catfish, also present a threat to endangered fishes due to both predation and competition for food and space. A rapidly expanding population of smallmouth bass in the Yampa River during the recent drought years was blamed for precipitous declines in the abundance of juvenile native fish (Anderson 2002). Smallmouth bass have also recently expanded into the Green River above its confluence with the Yampa River (Bestgen pers. comm.). Small-bodied nonnative species such as red shiner, sand shiner, and fathead minnow may also negatively interact (competition and predation) with early life stages of native species.

Mechanisms by which populations of nonnative fish may be increased as a result of the Proposed Action include:

1. Release of water through the spillway as identified in the Proposed Action may result in the entrainment of nonnative fish. Use of the spillway and/or bypass tubes and the resulting high flows during the spring may inhibit some nonnative fish populations in the Green River in Reach 1. However, spillway releases will also likely result in the entrainment of nonnative fish, particularly smallmouth bass from Flaming Gorge Reservoir into the Green River during high water years.
2. Increased inundation of the floodplain (duration and magnitude) in Reach 2 and 3 provides important habitats preferred by both native and nonnative species
3. Increased release temperatures from Flaming Gorge Dam create habitat conditions in Reach 1 that could benefit nonnative fish species as well as the native endangered fishes.

The Service is unable to determine the exact level of incidental take that would result from increases in nonnative fish populations due to implementation of the Proposed Action. Estimating the incidental take of individual listed fish associated with a possible increase in nonnative fish populations due to spills, temperature modification and increased floodplain inundation is difficult to quantify for the following reasons: 1) quantifying the amount of predation is extremely difficult due to large extent of the action area and the difficulty of estimating fish populations and predation rates, 2) estimates of nonnative predators in Flaming Gorge Reservoir that are potentially subject to entrainment during a spill are unknown as well as survival rates of fish that are entrained, 3) much of the floodplain inundation that will occur in the future is dependent on the uncontrolled Yampa River spring flows, i.e., the incremental amount of take that could be attributed to Reclamation's operations to fully meet the spring flow recommendations is unquantifiable, and 4) the amount of take directly attributable to the proposed action is confused by a Lodore Canyon fish community that is rapidly changing in response to drought conditions and nonnative species invading from the Yampa River.

In addition to take associated with nonnative fish, the Service expects that an unquantifiable level of take may occur as a result of drifting Colorado pikeminnow larvae in the Yampa River being exposed to thermal shock of differing water temperature in the Green River at their confluence. As larvae drift out of the Yampa River into the Green River they are exposed to cold water released from Flaming Gorge Dam. Take is difficult to quantify since effects of cooler water temperatures on the survival of Colorado pikeminnow larvae are largely unknown. However, Berry (1988) and Tyus (1991) suggested that higher recruitment of Colorado pikeminnow occurred in years when the temperature differences between the two rivers was 2°C or less and Muth et al. (2000) stated that temperature differences of 5-10°C are common and may cause indirect mortality. The Proposed Action is to meet the temperature recommendation of 5°C difference or less at the confluence of the Green and Yampa River during the time when pikeminnow larvae are present. Temperature monitoring, however, at the Yampa / Green Rivers confluence has not been conducted long enough to assess Reclamation's ability to achieve the recommendation.

According to Service policy, as stated in the Endangered Species Consultation Handbook (USFWS 1998b) (Handbook), some detectable measure of effect should be provided, such as the relative occurrence of the species or a surrogate species in the local community, or amount of habitat used by the species, to serve as a measure for take. Take also may be expressed as a change in habitat characteristics affecting the species, such as water quality or flow (USFWS 1998b). Because estimating the number of individuals of the four listed fishes that could be taken by nonnative fishes and by thermal shock of Colorado pikeminnow larvae in this biological opinion is difficult, we have developed a surrogate measure to estimate the amount of anticipated take to listed fish in the form of harm. The surrogate we are using is flows in the Green River below Flaming Gorge Dam. Flows of a magnitude, timing and duration consistent with the Proposed Action and the Flow Recommendations (Muth et al. 2000) provide the short and long-term habitat conditions in the Green River suitable for the survival and recovery of the endangered fish. Take would be exceeded if the Service, after consultation with the action agencies, determined that flows in the Green River below Flaming Gorge Dam were not consistent with the flow recommendations as identified in the Proposed Action and there was evidence of harm to listed species. This would include significant habitat modification or degradation when it kills or injures wildlife by significantly impairing essential behavioral patterns including breeding, feeding or sheltering from failure to meet the flow recommendations. We exempt all take in the form of harm that would occur from normal operations including spills and modified temperature releases from Flaming Gorge Dam operations that are consistent with the Proposed Action to meet the flow recommendations provided the action agencies, working in cooperation with the Recovery Program, comply with the reasonable and prudent measures and the implementing terms and conditions of this Incidental Take Statement.

EFFECT OF THE TAKE

In the accompanying biological opinion, the Service determined that the anticipated level of incidental take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

REASONABLE AND PRUDENT MEASURES

The Service, in cooperation with the Recovery Program, developed the flow and temperature recommendations (Muth et al. 2000) with the although the proposed flows would improve endangered fish habitat that there will be times and situations where warm water nonnative species could benefit and drifting larval Colorado pikeminnow may be impacted at the confluence. Therefore, the Service believes that the reasonable and prudent measures to minimize incidental take associated with the propose action need to be focused on evaluating the effects of implementation of the flow and temperature recommendations (Proposed Action) and understanding and managing negative interactions between native and nonnative fish.

Through implementation of the proposed action, Reclamation and Western intend to protect and assist in the recovery of the populations and designated critical habitat of the four endangered fishes, while maintaining all purposes of the Flaming Gorge Unit of the CRSP, particularly those related to the development of water resources. As part of their proposed action, Reclamation and Western included a list of environmental commitments in their biological assessment (identified as conservation measures in this biological opinion). Some of those conservation measures stemmed from uncertainties associated with the proposed action that Reclamation identified in their NEPA process and as were identified by Muth et al. (2000). As some of those uncertainties are linked to potential take of the endangered fish, they serve as the basis for the following Reasonable and Prudent Measures. The Service believes the following reasonable and prudent measures are necessary and appropriate to avoid and minimize the impacts of incidental take of the listed Colorado River fishes:

1. Implementation and refinement of the proposed action will occur through an adaptive management process. Reclamation, Western and the Service will work through the Recovery Program to implement appropriate monitoring and research studies to test the result of implementing the proposed action and identify the potential for modifying or refining flows and temperatures from Flaming Gorge Dam. The Service considers the Recovery Program the appropriate science body to develop and implement monitoring and research studies that would address uncertainties associated with the proposed action. In accordance with the Section 7 agreement, Reclamation, the Service, and Western will work with the Recovery Program to revise the RIPRAP as necessary to incorporate the approved studies deemed necessary to evaluate the proposed action.

2. The Recovery Program will assess the need for and implement as necessary nonnative fish control programs in the Green and Yampa River systems in accordance with the RIPRAP and scopes of work approved by the Recovery Program.

3. Reclamation has committed to develop a process for operating the selective withdrawal structure consistent with the objectives of improving temperature conditions for the endangered fish (see Description of the Proposed Action).

4. Reclamation and the Recovery Program should determine if temperature gaging in Reach 1 and Reach 2 is adequate to ensure temperature recommendations are met

5. Reclamation will produce a summary report each year to document annual operations and the information used to develop those operations. Over time, it is expected that these data would be of benefit in determining if flow recommendations are being met and correlating and analyzing conditions for the endangered fish species and their habitat downstream from Flaming Gorge Dam.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the following terms and conditions, which implement the reasonable and prudent measures described above, must be satisfied. These terms and conditions are nondiscretionary.

In order to implement RPM #1 Reclamation will:

A.) Establish the Technical Working Group, as detailed in Section 2.5.3 of the EIS, consisting of biologists and hydrologists involved with endangered fish recovery issues. The Technical Working Group will meet at various times throughout the year to provide input and feedback concerning current and past operations on endangered fish needs and provided recommendations to Reclamation on its operational plan for Flaming Gorge Dam. A representative from the Service's Utah Field Office will participate on the Technical Working Group.

B.) Consistent with the Recovery Program RIPRAP Item No. I.D. in the Green River Mainstem Action Plan which states: *Evaluate and revise as needed, flow regimes to benefit endangered fish populations* - Reclamation, Western and the Service will work through the Recovery Program technical committees to develop a Study Plan to evaluate the Flaming Gorge Flow and Temperatures Recommendations. The Study Plan should be completed within one year of the finalization of this biological opinion and should focus on previously identified uncertainties related to floodplain inundation, nonnative impacts, effects of elevated temperatures and geomorphic processes. Whereas the intent of this Study Plan is to guide future evaluation of the Flaming Gorge Flow and Temperature Recommendations, it should draw heavily on the direction provided in section 7 consultation documents including the biological assessment and biological opinion, Recovery Program guiding documents:

- Strategic Plan for Geomorphic Research and Monitoring (LaGory et al. 2003)
- Green River Sub-basin Floodplain Management Plan (Valdez and Nelson 2004)

and ongoing field studies:

- Gunnison and Green River Sediment Monitoring: Project # 85F
- Cumulative Effects of Flaming Gorge Dam Releases since 1996 on the Fish Community in Lodore and Whirlpool Canyons: Project 115
- Floodplain Habitat Surveys: Project Cap-6 HYD
- Razorback sucker migration / recruitment from floodplain habitat: Cap-6 RZ
- Larval bonytail and razorback sucker survival in floodplain habitats: Cap-6 bt/rz
- Larval razorback and bonytail survival in Baeser; Cap-6 rz/bt
- Entrainment of larval razorback sucker cap6-rz/entr
- Native fish response to nonnative control efforts in Utah: new study
- Yampa and Middle Green River razorback sucker and Colorado pikeminnow larval survey for Flaming Gorge operations: Project 22f
- Population Estimation for Colorado pikeminnow in the Green River (Project 128) and for humpback chub in the Green River (Project 129)

- Annual Fall Monitoring for CPM YOY: Project 138).
- Nonnative Control in the Yampa and Green Rivers (Projects 109; 110; 98a-c; 123)

The study Plan will be structured to provide a framework that demonstrates how past, ongoing and future Recovery Program efforts can be used to test objectives of the flow and temperature recommendations and to address uncertainties identified in the Flaming Gorge EIS and by Muth et al. (2000). These uncertainties include the potential impacts related to the escapement of nonnative fishes from Flaming Gorge Reservoir from the increased frequency of spillway use. Reclamation and Western working through the Recovery Program and within the context of the study plan should also assess and prioritize the possibility of improving connectivity of floodplain habitats and identifying ways to improve entrainment of larval razorback suckers into floodplain habitats at lower peak flow levels. A timeline for producing periodic evaluations (e.g. 5-yr assessments) of the Flaming Gorge Flow and Temperature Recommendations will be provided. In accordance with the Section 7 agreement, Western, Reclamation, and the Service will request the Recovery Program to modify the RIPRAP to incorporate approved studies following standard Recovery Program procedures.

In order to implement RPM #2 Reclamation, Western, and the Service will support the Recovery Program in active implementation of the following RIPRAP items:

From the Green River Action Plan: Mainstem

- III.A.4. Develop and implement control programs for nonnative fishes in river reaches occupied by the endangered fishes to identify required levels of control. Each control activity will be evaluated for effectiveness, and then continued as needed.
- III.A.4.a. Northern pike in the middle Green River.
- III.A.4.c. Channel catfish (e.g. Deso./Gray Canyons) to protect humpback chub populations, and in the middle Green River to protect razorback sucker and Colorado pikeminnow.

From the Green River Action Plan: Yampa and Little Snake Rivers

- III.A.1.b. Control northern pike
- III.A.1.b.(1) Remove and translocate northern pike and other sportfishes from Yampa River.
- III.A.1.b.(2) Reduce northern pike reproduction in the Yampa River.
- III.A.1.b.(2)(a)
- Identify and evaluate natural and artificial spawning/nursery habitats for northern pike in the Yampa River for exclusion devices.
- III.A.1.b.(2)(b) Implement remedial measures to reduce pike reproduction in Yampa River.
- III.A.1.c. Control channel catfish
- III.A.1.d. Remove and translocate smallmouth bass.

The Recovery Program is actively pursuing both nonnative control and native fish response studies in the Green and Yampa Rivers. The Yampa River is outside the action area, but is a primary source of smallmouth bass and northern pike supplying Reaches 1,2, and 3 of the Green River and is therefore referenced here.

In order to implement RPM #3 Reclamation will:

A.) Draft a selective withdrawal operation plan within one year of finalization of this biological opinion. This plan will describe operations to meet the temperature recommendations, describe limitations of meeting the temperature recommendations (physical, budgetary, manpower) and propose experimental solutions to these limitations as needed.

B.) Reclamation's accumulated thermal unit analysis in the EIS indicated that dam releases of 16°C during average and wetter hydrologies increased the potential to benefit adult Colorado pikeminnow in Lodore Canyon and minimized the potential impacts of cold shock to drifting Colorado pikeminnow larvae at the Yampa/Green River confluence. Through development and implementation of an operations plan (T&C #3A) to meet the temperature recommendations, Reclamation should experiment with releases of 16°C during appropriate hydrologies. Such experimentation would not require structural modification of equipment of operation changes affecting hydropower generation.

In order to implement RPM #4:

Reclamation, Western and the Service will work with the Recovery Program to determine the need for real-time temperature gages at the downstream terminus of Lodore Canyon and on the lower Yampa River to assist in their operation of the selective withdrawal device to meet the temperature recommendations. This activity is consistent with tasks in Recovery Program Project No. 19B (Hydrology Support for Biological Research). If a need for real-time temperature gages is determined to exist, the Service will approach the Recovery Program in accordance with the Section 7 agreement to propose installation of such gage(s).

In order to implement RPM #5:

Reclamation will provide to the Service and Recovery Program a concise annual operations report. A primary purpose of the annual report is to provide an assessment of how well operations at Flaming Gorge Dam contributed to meeting flow targets. In addition, the annual report will provide a record of operations as identified under the incidental take statement. Basic information that should be summarized includes the following:

a. A review of the April-July unregulated inflow forecasts provided by the National Weather Service via the River Forecast Center that were used to classify Green River hydrology.
b. Additional factors that were used to determine which flow recommendation hydrologic category was targeted (e.g. Flaming Gorge Reservoir elevation, Yampa hydrology, past operations, power needs, Technical Working Group conversations, etc.),

c. An accounting of actual flows and operations: spring flows and baseflows (reference USGS gages at Yampa River at Deerlodge, Green River at Greendale, Ut at Jensen, Ut, and near Green River, Ut),
d. Results from Reclamation's spillway inspections,
e. A summary of daily and seasonal fluctuations at Jensen, Utah,
f. An overview of Reclamation's operations to meet thermal targets,
g. An accounting of the actual thermal regime in upper and lower Lodore Canyon and the lower Yampa River based on available information.
h. Recommendations to refine operations

The Service recognizes that the Recovery Program may adjust dates and time frames for RIPRAP activities referenced in the terms and conditions in this biological opinion. These changes are made through revisions to the RIPRAP and are subject to Service approval as part of the Recovery Program process. To the extent that such revisions affect dates in this biological opinion, these adjustments are recognized by the Service as modifying dates for those activities in the biological opinion.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The Service is recommending the following conservation actions:

1. Install additional SNOTEL sites in the headwater reaches of the Yampa River, Upper Green River and Little Snake River. Additional sites will increase the accuracy and precision of runoff forecasts and increase Reclamation's capability to time releases to meet the flow recommendations.

2. Based on implementation of the flow recommendations, reanalyze economic feasibility of retrofitting the bypass tubes with turbines and implement if viable.

3. Participate with members of the Ute ladies'-tresses/riparian vegetation work group and other entities to identify means, devise strategies, and help implement remediation or mitigation measures for Ute ladies'-tresses recommended by the work group as a result of information gathered through research and monitoring.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION NOTICE

This concludes formal consultation on the subject action. As provided in 50 CFR sec. 402.16, reinitiation of formal consultation is required for projects where discretionary Federal Agency involvement or control over the action has been retained (or is authorized by law) and under the following conditions:

1. The amount or extent of take specified in the incidental take statement for this opinion is exceeded.

2. New information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion. In preparing this opinion, the Service describes the positive and negative effects of the action it anticipates and considered in the section of the opinion entitled "EFFECTS OF THE ACTION." New information would include, but is not limited to, not achieving significant portions of the flow and temperature recommendations or unanticipated effects of implementing the proposed action.

3. The section 7 regulations (50 CFR 402.16 (c)) state that reinitiation of consultation is required if the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion.

4. The Service lists new species or designates new or additional critical habitat, where the level or pattern of depletions covered under this opinion may have an adverse impact on the newly listed species or habitat. If the species or habitat may be adversely affected by depletions, the Service will reinitiate consultation on the biological opinion as required by its section 7 regulations.

If the Service reinitiates consultation, it will first provide information on the status of the species and recommendations for improving population numbers to the Recovery Program. Only if the Recovery Program does not implement recovery actions to improve the status of the species, will the Service reinitiate consultation with individual projects.

□

LITERATURE CITED

Allred, T.M. 1997. Channel narrowing of the Green River near Green River, Utah: history, rates, and processes of narrowing. Master's Thesis. Utah State University, Logan, Utah.

Allred, T.M., and J.C. Schmidt. 1999. Channel narrowing of the Green River near Green River, Utah: history, rates and processes of narrowing. Final Report of Utah State University Department of Geography and Earth Resources to Upper Colorado River Endangered Fish Recovery Program, Denver, Colo.

Anderson, R.A. 2002. Riverine fish flow investigations, Federal Aid Project F-289-R5 Job Progress Report, Colorado Division of Wildlife, Fish Research Section, Fort Collins, Colorado.

Annear, T., Chisolm, I., Beecher, H., Locke, A., Aarestad, P., Coomer, C., Estes, C., Hunt, J., Jacobson, R., Jobsis, G., Kauffman, J., Marshall, J., Mayes, K., Smith, G., Wentworth, R., and Stalnaker, C. 2004. Instream Flows for Riverine Resource Stewardship, Revised Edition. Instream Flow Council, Cheyenne, WY. 268 pages.

Andrews, E.D. 1986. Downstream effects of Flaming Gorge Reservoir on the Green River, Colorado and Utah. Geological Society of America Bulletin 9:1012–1023.

Archer, D.L., L.R. Kaeding, B.D. Burdick, and C.W. McAda. 1985. A study of the endangered fishes of the Upper Colorado River. Final Report - Cooperative Agreement 14-16-0006-82-959. U.S. Department of the Interior, Fish and Wildlife Service, Grand Junction, Colorado. 134 pp.

Arft, A. 1993. Demographics, ecology, and management needs of the threatened orchid *Spiranthes diluvialis* (Sheviak). Report for Colorado Natural Areas Program, December 1993. 36 pp.

Arft, A. 1995. Genetics, demography, and conservation management of the rare orchid *Spiranthes dilivialis*. Ph.D. Dissertation, University of Colorado, Boulder.

Behnke, R.J. 1980. The impacts of habitat alterations on the endangered and threatened fishes of the Upper Colorado River Basin: A discussion. In Energy Development in the Southwest: Problems of water, fish, and wildlife in the Upper Colorado River Basin. vol. 2, ed. W.O. Spofford. Jr., A.L. Parker, and A.V. Kneese, pp. 182-192. Research Paper R-18. Washington, D.C.: Resources for the Future.

Behnke, R.J., and D.E. Benson. 1983. Endangered and threatened fishes of the Upper Colorado River Basin. Ext. Serv. Bull. 503A, Colorado State University, Fort Collins. 38 pp.

Bell, A., D. Berk, and P. Wright. 1998. Green River flooded bottomlands mapping for two water flows in May 1996 and one water flow in June 1997. Technical Memorandum No. 8260-98-07. U.S. Bureau of Reclamation, Technical Service Center, Denver, Colorado.

Berry, C.R., Jr. 1988. Effects of cold shock on Colorado squawfish larvae. The Southwestern Naturalist 33:193-197.

Bestgen, K.R. 1990. Status Review of the Razorback Sucker, Xyrauchen texanus. Larval Fish Laboratory #44. Colorado State University, Ft. Collins.

Bestgen, K.R., and L.W. Crist. 2000. Response of the Green River fish community to construction and re-regulation of Flaming Gorge Dam, 1962–1996. Final Report of Colorado State University Larval Fish Laboratory to Upper Colorado River Endangered Fish Recovery Program, Denver, Colo.

Bestgen, K.R., R.T. Muth, and M.A. Trammell. 1998. Downstream transport of Colorado squawfish larvae in the Green River drainage: temporal and spatial variation in abundance and relationships with juvenile recruitment. Colorado State University, Ft. Collins. Recovery Program Project Number 32.

Bestgen, K.R., D.W. Beyers, G.B. Haines, and J.A. Rice. 1997. Recruitment models for Colorado squawfish: tools for evaluating relative importance of natural and managed processes. Final Report of Colorado State University Larval Fish Laboratory to U.S. National Park Service Cooperative Parks Unit and U.S. Geological Survey Midcontinent Ecological Science Center, Fort Collins, Colorado.

Bestgen, K.R., G.B. Haines, R. Brunson, T. Chart, M. Trammell, R.T. Muth, G. Birchell, K. Christopherson, and J.M. Bundy. 2002. Status of wild razorback sucker in the Green River basin, Utah and Colorado, determined from basinwide monitoring and other sampling programs. Final Report of Larval Fish Laboratory, Colorado State University, Fort Collins, Colo., to Upper Colorado River Endangered Fish Recovery Program, Denver, Colo.

Bestgen, K.R., J.A. Hawkins, G.C. White, K. Christopherson, M. Hudson, M. Fuller, D.C.Kitcheyan, R. Brunson, P. Badame, G.B.Haines, J. Jackson, C.D. Walford, and T.A. Sorensen. 2004. Status of Colorado pikeminnow in the Green River basin, Utah and Colorado. Draft Final Report to the Recovery Program for the Endangered Fishes of the Upper Colorado River, Project Number 22i and 22j. Colorado State University, Fort Collins, Colorado.

Birchell, G.J., K. Christopherson, C. Crosby, T.A. Crowl, J. Gourley, M. Townsend, S. Goeking, T. Modde, M. Fuller, and P. Nelson. 2002. The levee removal project: Assessment of floodplain habitat restoration in the middle Green River. Final report for project CAP-6-LR to the Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado. (June).

Black, R. 1998. Diamond Fork Canyon Ute ladies'-tresses (*Spiranthes diluvialis*) year end monitoring report - 1997. Prepared for Central Utah Water Conservancy District by ecological plannind and toxicology, inc. 19 pp. plus appendices.

Bosley, C.E. 1960. Pre-impoundment study of the Flaming Gorge Reservoir. Wyoming Game and Fish Commission, Fisheries Technical Report 9:1–81.

Bulkley, R.V., and R. Pimentel. 1983. Temperature preference and avoidance by adult razorback suckers. Transactions of the American Fisheries Society 112:601–607

Burdick, B D., and R.B. Bonar. 1997. Experimental stocking of adult razorback sucker in the upper Colorado and Gunnison Rivers. Final Report to the Recovery Program for the Endangered Fishes of the Upper Colorado River, Project Number 50. U.S. Fish and Wildlife Service, Grand Junction, Colorado.

Burdick, B.D. and L.R. Kaeding. 1985. Reproductive ecology of the humpback chub and the roundtail chub in the Upper Colorado River. Proceedings of the Annual Conference of Western Association of Game and Fish Agencies. 65:163 (abstract).

Burke, T. 1994. Lake Mohave native fish rearing program. U.S. Bureau of Reclamation, Boulder City, Nevada.

Carlson, C.A., and R.T. Muth. 1989. The Colorado River: lifeline of the American Southwest. Pages 220-239 in D.P. Dodge, ed. Proceedings of the International Large River Symposium. Canadian Special Publication of Fisheries and Aquatic Sciences 106, Ottawa.

Central Utah Water Conservancy District. 1998. Draft special-status species technical report. Spanish Fork Canyon-Nephi irrigation system draft environmental impact statement.

Chart, T.E., and L. D. Lentsch. 1999a. Flow effects on humpback chub (*Gila cypha*) in Westwater Canyon. Final Report of Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Chart, T.E., and L.D. Lentsch. 1999b. Reproduction and recruitment of *Gila* spp. and Colorado pikeminnow (*Ptychocheilus lucius*) in the middle Green River 1992–1996. Final Report to the Recovery Program for the Endangered Fishes in the Upper Colorado River Basin, Project Number 39. Utah Division of Wildlife Resources, Moab and Salt Lake City.

Chart, T. E., and L. D. Lentsch. 2000. Reproduction and recruitment of *Gila* spp. and Colorado pikeminnow (*Ptychocheilus lucius*) in the middle Green River 1992- 1996. Report C *in* Flaming Gorge Studies: reproduction and recruitment of *Gila* spp. and Colorado pikeminnow (*Ptychocheilus lucius*) in the middle Green River. Final Report of Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Chart, T.E., D.P. Svendson, and L.D. Lentsch. 1999. Investigation of potential razorback sucker (*Xyrauchen texanus*) and Colorado squawfish (*Ptychocheilus lucius*) spawning in the lower Green River, 1994 and 1995. Final Report to the Recovery Program for the

Endangered Fishes in the Upper Colorado River Basin, Project Number 38. Report Number 99-32, Utah Division of Wildlife Resources, Salt Lake City.

Clarkson, R.W., E.D. Creef, and D.K. McGuinn-Robbins. 1993. Movements and habitat utilization of reintroduced razorback suckers (*Xyrauchen texanus*) and Colorado squawfish (*Ptychocheilus lucius*) in the Verde River, Arizona. Special Report. Nongame and Endangered Wildlife Program, Arizona Game and Fish Department, Phoenix.

Clayton, R., and A. Gilmore. 2002. Flaming Gorge Draft Environmental Impact Statement Hydrologic Modeling Report. On file, Bureau of Reclamation, Upper Colorado Region, Provo Area Office, Provo, Utah.

Clayton, R., and A. Gilmore. 2003. Flaming Gorge Draft Environmental Impact Statement Amendment to Hydrologic Modeling Report. On file, Bureau of Reclamation, Upper Colorado Region, Provo Area Office, Provo, Utah.

Coyner, J. 1989. Status check on reported historic populations of *Spiranthes diluvialis*. Memorandum, U.S. Fish and Wildlife Service, Salt Lake City, Utah. 9 pp.

Day, K.S., and C. Crosby. 1997. An assessment of young-of-the-year Colorado squawfish (*Ptychocheilus lucius*) use of backwater habitats in the Green River, Utah. Utah Division of Wildlife Resources, Vernal, Utah.

Day, K.S., K.D. Christopherson, and C. Crosby. 1999a. An assessment of young-of-the-year Colorado pikeminnow (*Ptychocheilus lucius*) use of backwater habitats in the Green River, Utah. Report B *in* Flaming Gorge Studies: assessment of Colorado pikeminnow nursery habitat in the Green River. Final Report of Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Day, K.S., K.D. Christopherson, and C. Crosby. 1999b. Backwater use by young-of-year chub (*Gila* spp.) and Colorado pikeminnow in Desolation and Gray canyons of the Green River, Utah. Report B *in* Flaming Gorge Studies: reproduction and recruitment of *Gila* spp. and Colorado pikeminnow (*Ptychocheilus lucius*) in the middle Green River. Final

Dill, W.A. 1944. The fishery of the lower Colorado River. California Fish and Game 30:109-211.

Douglas, M.E., W.L. Minckley, and H.M. Tyus. 1989. Quantitative characters, identification of Colorado River chubs (Cyprinidae: genus *Gila*) and the art of seeing well. Copeia 1993:334343.

Douglas, M.E., W.L. Minckley, and H.M. Tyus. 1998. Multivariate discrimination of Colorado Plateau *Gila* spp.: the art of seeing well revisited. Transactions of the American Fisheries Society 127:163173.

Ellis, N.M. 1914. Fishes of Colorado. University of Colorado Studies. Vol. 11(1).

Fischer, N.T., et al. 1983. Vegetation along Green and Yampa Rivers and response to fluctuating water levels, Dinosaur National Monument. Biology Department, University of New Mexico, Albuquerque, N.M.

FLO Engineering, Inc. 1996. Green River flooded bottomlands investigation, Ouray Wildlife Refuge and Canyonlands National Park, Utah. Final Report of FLO Engineering, Inc., to Upper Colorado River Endangered Fish Recovery Program, Denver, Colo.

Gaufin, A.R., G.R. Smith, and P. Dotson. 1960. Aquatic survey of the Green River and tributaries within the Flaming Gorge Reservoir basin, Appendix A. Pages 139–162 *in* A.M. Woodbury (ed.) Ecological studies of the flora and fauna of Flaming Gorge Reservoir basin, Utah and Wyoming. University of Utah Anthropological Papers 48.

Grams, P., J. Schmidt, and T. Naumann. 2002. Geomorphic adjustment of the Green River and habitat distribution of the Ute ladies'-tresses orchid in Red Canyon and Browns Park, Colorado and Utah. Draft Final Report. Jan. 9.

Gorman, O.T., and D.M. Stone. 1999. Ecology of spawning humpback chub, *Gila cypha*, in the Little Colorado River near Grand Canyon, Arizona. Environmental Biology of Fishes 55:115–133.

Gutermuth, F.B., L.D. Lentsch, and K. . Bestgen. 1994. Collection of Age-0 Razorback Suckers (*Xyrauchen texanus*) in the Lower Green River, Utah. Southwestern Nat., 39 (4).

Haines, G.B., and H.M. Tyus. 1990. Fish associations and environmental variables in age-0 Colorado squawfish habitats, Green River, Utah. Journal of Freshwater Ecology 5:427–435.

Hamilton, S.J., and B. Waddell. 1994. Selenium in eggs and milt of razorback sucker (*Xyrauchen texanus*) in the middle Green River, Utah. Archives of Environmental Contamination and Toxicology 27:195-201.

Hamilton, S.J., and R.H. Wiedmeyer. 1990. Bioaccumulation of a mixture of boron, molybdenum, and selenium in chinook salmon. Transactions of the American Fisheries Society 119:500–510.

Hamilton, S.J., K.J. Buhl, F.A. Bullard, and S.F. McDonald. 1996. Evaluation of toxicity to larval razorback sucker of selenium-laden food organisms from Ouray NWR on the Green River, Utah. Final Report to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Hamman, R.L. 1981. Spawning and culture of Colorado squawfish Ptychocheilus lucius in a raceway. In Miller et al. Colorado River Fishery Project Final Report.

Hamman, R.L. 1982. Spawning and culture of humpback chub. Progressive Fish-Culturist 44:213-216.

Harvey, M.D., and R.A. Mussetter. 1994. Green River endangered species habitat investigations. RCE Ref. No. 93-166.02. Resource Consultants & Engineers, Fort Collins, Colo.

Harvey, M.D., R.A. Mussetter, and E.J. Wick. 1993. Physical process-biological response model for spawning habitat formation for the endangered Colorado squawfish. Rivers 4:114-131.

Hawkins, J.A., and J. O'Brien. 2001. Research plan for developing flow recommendations in the Little Snake River, Colorado and Wyoming, for endangered fishes of the Colorado River Basin. Colorado State University, Larval Fish Laboratory, final report to the Upper Colorado River Endangered Fish Recovery Program. Denver.

Hawkins, J.A., and T.P. Nesler. 1991. Nonnative fishes of the Upper Colorado River Basin: an issue paper. Final Report of Colorado State University Larval Fish Laboratory and Colorado Division of Wildlife to Upper Colorado River Endangered Fish Recovery Program, Denver, Colo.

Hawkins, J.A., E.J. Wick, and D.E. Jennings. 1996. Fish composition of the Little Snake River, Colorado, 1994. Final Report of Colorado State University Larval Fish Laboratory to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Holden, P.B. 1973. Distribution, abundance, and life history of the fishes of the upper Colorado River basin. Doctoral Dissertation. Utah State University, Logan.

Holden, P.B. 1977. Habitat requirements of juvenile Colorado River squawfish. Western Energy and Land Use Team, U.S. Fish and Wildlife Service, Fort Collins, Colorado.

Holden, P.B. 1991. Ghosts of the Green River: impacts of Green River poisoning on management of native fishes. Pages 43□54 *in* W.L. Minckley and J.E. Deacon (eds.). Battle against extinction: native fish management in the American Southwest. University of Arizona Press, Tucson.

Holden, P.B. 1994. Razorback sucker investigations in Lake Mead, 1994. Report of Bio/West, Inc., Logan, Utah, to Southern Nevada Water Authority.

Holden, P.B., and L.W. Crist. 1981. Documentation of changes in the macroinvertebrate and fish populations in the Green River due to inlet modification of Flaming Gorge Dam. Final Report PR-16-5 of Bio/West, Inc., Logan, Utah, to U.S. Fish and Wildlife Service, Salt Lake City, Utah.

Holden, P.B., and C.B. Stalnaker. 1970. Systematic studies of the cyprinid genus Gila in the Upper Colorado River Basin. Copeia 1970(3):409-420.

Holden, P.B., and C.B. Stalnaker. 1975. Distribution and abundance of fishes in the middle and upper Colorado River basins, 1967–1973. Transactions of the American Fisheries Society 104:217–231.

Holden, P.B., and C.B. Stalnaker. 1975a. Distribution and abundance of mainstream fishes of the middle and Upper Colorado River Basins, 1967-1973. Transactions of the American Fisheries Society 104(2):217-231.

Holden, P.B. and C.B. Stalnaker. 1975b. Distribution of fishes in the Dolores and Yampa River systems of the Upper Colorado Basin. Southwestern Naturalist 19:403-412.

Holmgren, A.H. 1962. The vascular plants of the Dinosaur National Monument. Utah State University, Logan, Utah.

Hreha, A. and J. Wallace. 1994. Preliminary soil analysis of *Spiranthes diluvialis* (Sheviak) sites in northeastern, central, and southeastern Utah. Red Butte Garden and Arboretum. 15pp.

Hubbs, C.L., and R.R. Miller. 1953. Hybridization in nature between the fish genera *Catostomus* and *Xyrauchen.* Papers of the Michigan Academy of Arts, Science and Letters 38:207□233.

Irving, D., and B.D. Burdick. 1995. Reconnaissance inventory and prioritization of existing and potential bottomlands in the upper Colorado River basin, 1993–1994. Final Report to the Recovery Program for the Endangered Fishes of the Upper Colorado River. U.S. Fish and Wildlife Service, Vernal, Utah and Grand Junction, Colorado.

Irving, D., and T. Modde. 2000. Home-range fidelity and use of historical habitat by adult Colorado squawfish (*Ptychocheilus lucius*) in the White River, Colorado and Utah. Western North American Naturalist 60:16□25.

Jackson, J.A., and P.V. Badame. 2002. Centrarchid and channel catfish control in the middle and lower Green River; 1997 and 1998. Publication 02-24. Utah Division of Wildlife Resources report to to Upper Colorado River Endangered Fish Recovery Program, Denver, Colo.

Jennings, W.F. 1989. Final report. Species studied: *Eustoma grandiflorum*, *Spiranthes diluvialis*, *Malaxis brachypoda*, *Hypoxis hirsuta*, *Physaria bellii*, *Aletes humilis*. Report for The Nature Conservancy under the Colorado Natural History Small Grants Program. The Nature Conservancy, Boulder, Colorado. 48 pp.

Jennings, W.F. 1990. Final Report. Species studied: *Spiranthes diluvialis*, *Sisyrinchium pallidum*. Report for The Nature Conservancy under the Colorado Natural History Small Grants Program. The Nature Conservancy, Boulder, Colorado. 29 pp.

Johnson, B.L., W.B. Richardson, and T. J. Naimo. 1995. Past, present, and future concepts in large river ecology. BioScience 45:134–141.

Jonez, A., and R.C. Sumner. 1954. Lakes Mead and Mohave investigations: a comparative study of an established reservoir as related to a newly created impoundment. Final Report. Federal Aid Wildlife Restoration (Dingell-Johnson) Project F-l-R, Nevada Game and Fish Commission, Carson City.

Jordan, D.S. 1891. Report of explorations in Colorado and Utah during the summer of 1889 with an account of the fishes found in each of the river basins examined. Bulletin of the United States Fish Commission 9:24.

Jordan, D.S., and B.W. Evermann. 1896. The fishes of North and Middle America. Bulletin U.S. National Museum 47 (1):1240.

Joseph, T.W., J.A. Sinning, R.J. Behnke, and P.B. Holden. 1977. An evaluation of the status, life history, and habitat requirements of endangered and threatened fishes of the Upper Colorado River system. U.S. Fish and Wildlife Service, Office of Biological Services, Fort Collins, Colorado, FWS/OBS 24, Part 2:183.

Junk, W.J., P.B. Bailey, and R.E. Sparks. 1989. The flood pulse concept in river-floodplain systems. Canadian Special Publication of Fisheries and Aquatic Sciences 106:110–127.

Kaeding, L.R., and M.A. Zimmerman. 1983. Life history and ecology of the humpback chub in the Little Colorado and Colorado Rivers of the Grand Canyon. Transactions of the American Fisheries Society 112:577–594.

Kaeding, L.R., B.D. Burdick, P.A. Schrader, and C.W. McAda. 1990. Temporal and spatial relations between the spawning of humpback chub and roundtail chub in the upper Colorado River. Trans. Am. Fish Soc. 119:135-144.

Kaeding, L.R., B.D. Burdick, P.A. Schrader, and W.R. Noonan. 1986. Recent capture of a bonytail chub (Gila elegans) and observations on this nearly extinct cyprinid from the Colorado River. Copeia 1986(4):1021-1023.

Karp, C.A., and Tyus, H.M. 1990. Humpback chub (*Gila cypha*) in the Yampa and Green Rivers, Dinosaur National Monument, with observations on roundtail chub (*G. robusta*) and other sympatric fishes. Great Basin Naturalist 50:257–264.

LaGory K. E., Hayse J.W. and D. Tomasko. 2003. Recommended priorities for geomorphology research in endangered fish habitats of the upper Colorado River basin. Environmental Assessment Division, Argonne National Laboratory, Illinois, 106 pages.

Lanigan, S.H., and C.R. Berry, Jr. 1979. Distribution and abundance of endemic fishes in the White River in Utah, final report. Contract #14-16-006-78-0925. U.S. Bureau of Land Management, Salt Lake City, Utah. 84 pp.

Lanigan, S.H., and C.R. Berry. 1981. Distribution of fishes in the White River, Utah. Southwestern Naturalist 26:389-393.

Lanigan, S.H., and H.M. Tyus. 1989. Population size and status of the razorback sucker in the Green River basin, Utah and Colorado. North American Journal of Fisheries Management 9:1.

Lentsch, L.D., R.T. Muth, P.D. Thompson, B.G. Hoskins, and T.A. Crowl. 1996. Options for selective control of nonnative fishes in the upper Colorado River Basin. Final report. Utah Division of Wildlife Resources, Salt Lake City, Utah.

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 and Management 7:219–232.

Mabey, L. W., and D. K. Shiozawa. 1993. Planktonic and benthic microcrustaceans from floodplain and river habitats of the Ouray Refuge on the Green River, Utah. Department of Zoology, Brigham Young University, Provo, Utah.

Marsh, P.C. 1985. Effect of Incubation Temperature on Survival of Embryos of Native Colorado River Fishes. Southwestern Naturalist 30(1):129-140.

Marsh, P.C. 1987. Food of adult razorback sucker in Lake Mohave, Arizona-Nevada. Transactions of the American Fisheries Society 116:117□119.

Marsh, P.C. 1993. Draft biological assessment on the impact of the Basin and Range Geoscientific Experiment (BARGE) on federally listed fish species in Lake Mead, Arizona and Nevada. Arizona State University, Center for Environmental Studies, Tempe, Arizona.

Martin, L. and J. Wagner. 1992. Hydrologic conditions related to the Hog Canyon riparian restoration project, Dinosaur National Monument. National Park Service Technical Report NPS/NRWRD/NRTR-92/13, Fort Collins, Colorado. 32 pp.

Martin, J.A., P.E. Grams, M.T. Kammerer, and J.C. Schmidt. 1998. Sediment transport and channel response of the Green River in the Canyon of Lodore between 1995–1997, including measurements during high flows, Dinosaur National Monument, Colorado. Draft Final Report, Utah State University, Logan, Utah.

McAda, C.W. 2000. Flow recommendations to benefit endangered fishes in the Colorado and Gunnison Rivers. Final Report of U.S. Fish and Wildlife Service, Grand Junction, Colorado, to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

McAda, C.W., and R.S. Wydoski. 1980. The razorback sucker, Xyrauchen texanus, in the Upper Colorado River Basin, 1974-76. U.S. Fish and Wildlife Service Technical Paper 99. 50 pp.

McAda, C.W., W.R. Elmblad, K.S. Day, M.A. Trammel, and T.E. Chart. 1997. Interagency Standardized Monitoring Program: summary of results, 1996. Annual Report to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

McAda, C.W., J.W. Bates, J.S. Cranney, T.E. Chart, W.R. Elmblad, and T.P. Nesler. 1994a. Interagency Standardized Monitoring Program: summary of results, 1986□1992. Final Report to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

McAda, C.W., J.W. Bates, J.S. Cranney, T.E. Chart, M.A. Trammel, and W.R. Elmblad. 1994b. Interagency Standardized Monitoring Program: summary of results, 1993. Annual Report to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

McDonald, D.B., and P.A. Dotson. 1960. Pre-impoundment investigation of the Green River and Colorado River developments. *In* Federal aid in fish restoration investigations of specific problems in Utah's fishery. Federal Aid Project No. F-4-R-6, Departmental Information Bulletin No. 60-3. State of Utah, Department of Fish and Game, Salt Lake City.

Meffe, G.K. 1985. Predation and species replacement on American southwestern fishes: a case study. Southwestern Naturalist 30(2):173-187.

Merritt, D.M., and D.J. Cooper. 1998. Processes of vegetation and channel adjustment to river regulation along the upper Green River, Colorado. Draft Manuscript, Department of Earth Resources, Colorado State University, Fort Collins, Colo.

Miller, A. S., and W. A. Hubert. 1990. Compendium of existing knowledge for use in making habitat management recommendations for the upper Colorado River basin. Final Report of U.S. Fish and Wildlife Service Wyoming Cooperative Fish and Wildlife Research Unit to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Miller, R.R. 1946. Gila cypha, a remarkable new species of cyprinid fish from the Colorado River in Grand Canyon, Arizona. Journal of the Washington Academy of Science 36(12):409-415.

Miller, R.R. 1961. Man and the changing fish fauna of the American Southwest. Papers of the Michigan Academy of Science, Arts, and Letters 46:365-404.

Miller, W.H., D.L. Archer, H.M.Tyus, and R.M. McNatt. 1982b. Yampa River fishes study. Final- Report of U.S. Fish and Wildlife Service and National Park Service, Salt Lake City, Utah.

Miller, W.H., L.R. Kaeding, H.M. Tyus, C.W. McAda, and B.D. Burdick. 1984. Windy Gap Fishes Study. U.S. Department of the Interior, Fish and Wildlife Service, Salt Lake City, Utah. 37 pp.

Miller, W.H., J.J. Valentine, D.L. Archer, H.M. Tyus, R.A. Valdez, and L.R. Kaeding. 1982a. Colorado River Fishery Project Final Report Summary. U.S. Fish and Wildlife Service, Salt Lake City, Utah. 42 pp.

Minckley, W. L. 1973. Fishes of Arizona. Arizona Game and Fish Department, Phoenix. 293 pages.

Minckley, W. L. 1982. Trophic Interrelations Among Introduced Fishes in the Lower Colorado River, Southwestern United States. California Fish and Game 68: 78-89.

Minckley, W.L. 1983. Status of the razorback sucker, Xyrauchen texanus (Abbott), in the lower Colorado River Basin. Southwestern Naturalist 28(2):165-187.

Minckley, W.L., and J.E. Deacon. 1968. Southwest fishes and the enigma of "endangered species". Science, 159:1424-1432.

Minckley, W.L., D.A. Hendrickson, and C.E. Bond. 1986. Geography of Western North America Freshwater Fishes: Description and Relationships to Intracontinental Tectonism. pp 519-613 In: C.H. Hocutt and E.O. Wiley (eds.). The Zoogeography of North American Freshwater Fishes. Wiley-Interscience, New York, New York.

Minckley, W.L., P.C. Marsh, J.E. Brooks, J E. Johnson, and B.L. Jensen. 1991. Management toward recovery of razorback sucker (Xyrauchen texanus). in W.L. Minckley and J.E. Deacon, Eds. Battle Against Extinction. University of Arizona Press, Tucson.

Modde, T. 1996. Juvenile razorback sucker (Xyrauchen texanus) in a managed wetland adjacent to the Green River. Great Basin Naturalist 56:375-376.

Modde, T. 1997. Fish use of Old Charlie Wash: an assessment of floodplain wetland importance to razorback sucker management and recovery. Final report of U.S. Fish and Wildlife Service, Vernal, Utah, to Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Modde, T., and D.B. Irving. 1998. Use of multiple spawning sites and seasonal movement by razorback sucker in the middle Green River, Utah. North American Journal of Fisheries Management 18:318□326.

Modde, T., and G. Smith. 1995. Flow recommendations for endangered fishes in the Yampa River. Final Report of U.S. Fish and Wildlife Service, Vernal, Utah, to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Modde, T., and E.J. Wick. 1997. Investigations of razorback sucker distribution movements and habitats used during spring in the Green River, Utah. Final Report of U.S. Fish and Wildlife Service, Vernal, Utah, to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Modde, T., K.P. Burnham, and E.J. Wick. 1996. Population status of the razorback sucker in the middle Green River. Conservation Biology 10:110–119.

Moyle, P.B. 1976. Inland fishes of California. University of California Press, Berkeley.

Muth, R.T. 1990. Ontogeny and taxonomy of humpback chub, bonytail, and roundtail chub larvae and early juveniles. Doctoral Dissertation. Colorado State University, Fort Collins.

Muth, R.T. 1995. Conceptual-framework document for development of a standardized monitoring program for basin-wide evaluation of restoration activities for razorback sucker in the Green and Upper Colorado River systems. Colorado State University Larval Fish Laboratory final report to the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin, Denver, Colorado.

Muth, R.T., and D.E. Snyder. 1995. Diets of young Colorado squawfish and other small fish in backwaters of the Green River, Colorado and Utah. Great Basin Naturalist 55:95–104.

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 to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Muth, R.T., G.B. Haines, S.M. Meismer, E.J. Wick, T.E. Chart, D.E. Chart, D.E. Snyder, and J.M. Bundy. 1998. Reproduction and early life history of razorback sucker in the Green River, Utah and Colorado, 1992¥1996. Final Report of Colorado State University Larval Fish Laboratory to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Nesler, T.P., R.T. Muth, and A.F.Wasowicz. 1988. Evidence for baseline flow spikes as spawning cues for Colorado Squawfish in the Yampa River, Colorado. American Fisheries Society Symposium. 5:68-79.

Nesler, T.P., K. Christopherson, J.M. Hudson, C.W. McAda, F. Pfeifer, and T.E. Czapla. 2003. An integrated stocking plan for razorback sucker, bonytail, and Colorado pikeminnow for the Upper Colorado River Endangered Fish Recovery Program. Addendum to State Stocking Plans.

O'Brien, J.S. 1984. 1983 Yampa River cobble reach morphology investigation. Final Report. U.S. Fish and Wildlife Service, Denver, Colorado. 79 pp.

Olsson, C.L., and J.C. Schmidt. 1993. Response of a sand-bedded river to high discharge and resulting changes in availability of Colorado squawfish nursery habitat (Abstract). American Geophysical Union 1993 Fall Meeting Program and Abstracts: 221.

Orchard, K.L., and J.C. Schmidt. 2000. A geomorphic assessment of the availability of potential humpback chub habitat in the Green River in Desolation and Gray Canyons, Utah. Report A *in* Flaming Gorge studies: reproduction and recruitment of *Gila* spp. and Colorado pikeminnow (*Ptychocheilus lucius*) in the middle Green River. Final Report of Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program, Denver, Colo.

Osmundson, D. B. 2002. Verification of stocked razorback sucker reproduction in the Gunnison River via annual collections of larvae. Annual report to the Recovery Program for the Endangered Fishes of the Upper Colorado River, Project Number 121. U.S. Fish and Wildlife Service, Grand Junction, Colorado.

Osmundson, D.B., and K.P. Burnham. 1998. Status and trends of the endangered Colorado squawfish in the upper Colorado River. Transactions of the American Fisheries Society 127:957□970.

Osmundson, D.B., and L.R. Kaeding. 1989. Studies of Colorado squawfish and razorback sucker use of the "15-mile reach" of the Upper Colorado River as part of conservation measures for the Green Mountain and Ruedi Reservoir water sales. Final Report. U.S. Fish and Wildlife Service, Grand Junction, Colorado.

Osmundson, D.B., and L.R. Kaeding. 1991. Flow recommendations for maintenance and enhancement of rare fish habitat in the 15-mile reach during October-June. Final Report. U.S. Fish and Wildlife Service, Grand Junction, Colorado.

Osmundson, B.C., T.W. May, and D.B. Osmundson. 2000. Selenium concentrations in the Colorado pikeminnow (*Ptychocheilus lucius*): relationship with flows in the upper Colorado River. Archives of Environmental Contamination and Toxicology 38:479–485.

Osmundson, D.B., P. Nelson, K. Fenton, and D.W. Ryden. 1995. Relationships between flow and rare fish habitat in the 15-mile reach of the Upper Colorado River. Final Report. U.S. Fish and Wildlife Service, Grand Junction, Colorado.

Osmundson, D.B., M.E. Tucker, B.D. Burdick, W.R. Elmblad and T.E. Chart. 1997. Non-spawning Movements of Subadult and Adult Colorado Squawfish in the Upper Colorado River. Final Report. U.S. Fish and Wildlife Service, Grand Junction, CO.

Platania, S.P. 1990. Biological summary of the 1987 to 1989 New Mexico-Utah ichthyofaunal study of the San Juan River. Unpublished report to the New Mexico Department of Game and Fish, Santa Fe, and the U.S. Bureau of Reclamation, Salt Lake City, Utah, Cooperative Agreement 7-FC-40-05060.

Platania, S.P., and D.A. Young. 1989. A survey of the ichthyofauna of the San Juan and Animas Rivers from Archuleta and Cedar Hill (respectively) to their confluence at Farmington, New Mexico. Department of Biology, University of New Mexico, Albuquerque.

Propst, D.L., and K.R. Bestgen. 1991. Habitat and biology of the loach minnow, Tiaroga cobitis, in New Mexico. Copeia 1991(1):29-30.

Pucherelli, M.J., R.C. Clark, and R.D. Williams. 1990. Mapping backwater habitat on the Green River as related to the operation of Flaming Forge Dam using remote sensing and GIS. U.S. Bureau of Reclamation 90 (18):1-11.

Rakowski, C.L., and J.C. Schmidt. 1999. The geomorphic basis of Colorado pikeminnow nursery habitat in the Green River near Ouray, Utah. Report A *in* Flaming Gorge Studies: Assessment of Colorado pikeminnow nursery habitat in the Green River. Final Report of Utah Division of Wildlife Resources to Upper Colorado River Endangered Fisl Recovery Program, Denver, Colorado.

Rinne, J.N. 1991. Habitat use by spikedace, Meda fulgida (Pisces:Cyprinidae) in southwestern streams with reference to probable habitat competition by red shiner (Pisces:Cyprinidae). Southwestern Naturalist 36(1):7-13.

Robinson, A.T., R.W. Clarkson, and R.E. Forrest. 1998. Dispersal of larval fishes in a regulatec river tributary. Transactions of the American Fisheries Society 127:722□786.

Ruppert, J.B., R.T. Muth, and T.P. Nesler. 1993. Predation on fish larvae by adult red shiner, Yampa and Green Rivers, Colorado. Southwestern Naturalist 38:397□399.

Schmidt, J.C. 1996. Geomorphic control of the distribution of age-0 Colorado squawfish in the Green River in Colorado and Utah. Draft Manuscript. Department of Geography and Earth Resources, Utah State University, Logan, Utah.

Schmidt, J.C., and D.M. Rubin. 1995. Regulated streamflow, fine-grained deposits, and effective discharge in canyons with abundant debris fans. Pages 177–195 in J.E. Costa, A.J. Miller K.W. Potter, and P.R. Wilcock, editors. Natural and anthropogenic influences in fluvial geomorphology. AGU Geophysical Monograph 89.

Seethaler, K. 1978. Life History and Ecology of the Colorado squawfish (Ptychocheilus lucius) in the Upper Colorado River Basin. Thesis, Utah State University, Logan.

Sigler, W.F., and R.R. Miller. 1963. Fishes of Utah. Utah Department of Fish and Game, Salt Lake City. 203 pp.

Sipes, S.D. and F.J. Tepedino. 1995a. Reproductive biology of the rare orchid, *Spiranthes diluvialis*: breeding system, pollination, and implications for conservation. Conservation Biology 9(4):929-938.

Sipes, S.D. and F.J. Tepedino. 1995b. The pollination and reproduction of *Spiranthes diluvialis*: Implications for conservation of four populations. Report prepared for USDA Forest Service Challenge Cost Share program, uinta National Forest, Provo, Utah, and U.S. Fish and Wildlife Service, Salt Lake City, Utah. 36pp.

Smith, G.R. 1960. Annotated list of fish of the Flaming Gorge Reservoir Basin, 1959. Pages 163-268 in R.M. Woodbury, ed. Ecological Studies of the Flora and Fauna of Flaming Gorge Reservoir Basin, Utah and Wyoming. Department of Anthropology, University of Utah, Salt Lake City. Anthropological Paper Number 48, Series Number 3.

Snyder, D.E. 1981. Contributions to a guide to the cypriniform fish larvae of the upper Colorado River system in Colorado. U.S. Bureau of Land Management Biological Science Series 3:1-81.

Stephens, D.W., B. Waddell. 1998. Selenium sources and effects on biota in the Green River Basin of Wyoming, Colorado, Utah, *in* Frankenberger, W.T., Jr., and Engberg. R.A., eds., Environmental chemistry of selenium: New York, Marcel Dekker, p. 183-204.

Stephens, D.W., B. Waddell, and J.B. Miller. 1992. Detailed study of selenium and selected elements in water, bottom sediment, and biota associated with irrigation drainage in the middle Green River Basin, Utah, 1988-90. U.S. Geological Survey Water Resources Invest. Report No. 92-4084.

Stone, R.D. 1993. Final report for the 1992 challenge cost share project, Uinta and Wasatch-Cache National Forests, target species: Ute ladies'-tresses orchid (*Spiranthes diluvialis* Sheviak). Utah Natural Heritage Program, Salt Lake City, Utah. 27 pp. plus appendices.

Sublette, J.S., M.D. Hatch, and M. Sublette. 1990. The fishes of New Mexico. University of New Mexico Press, Albuquerque, New Mexico.

Suttkus, R.D., and G.H. Clemmer. 1977. The humpback chub, *Gila cypha*, in the Grand Canyon area of the Colorado River. Occasional Papers of the Tulane University Museum of Natural History, New Orleans, Louisiana 1:1–30.

Taba, S.S., J.R. Murphy, and H.H. Frost. 1965. Notes on the fishes of the Colorado River near Moab, Utah. Proceedings of the Utah Academy of Sciences, Arts, and Letters 42(2):280-283.

Teuscher, D. and C. Luecke. 1996. Competition Between Kokanees and Utah Chub in Flaming Gorge Reservoir. Transactions of the American Fisheries Society 125:505-511.

Trammell, M. A., and T. E. Chart. 1999. Colorado pikeminnow young-of-the-year habitat use, Green River, Utah, 1992□1996. Report C *in* Flaming Gorge Studies: Assessment of Colorado pikeminnow nursery habitat in the Green River. Final Report of Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Tyus, H.M. 1985. Homing behavior noted for Colorado squawfish. Copeia 1985: 213-215.

Tyus, H.M. 1987. Distribution, reproduction, and habitat use of the razorback sucker in the Green River, Utah, 1979-1986. Transactions of the American Fisheries Society 116:111-116.

Tyus, H.M. 1990. Potamodromy and reproduction of Colorado squawfish Ptyochocheilus lucius. Transactions of the American Fisheries Society 119:1,035-1,047.

Tyus, H.M. 1991. Movement and Habitat Use of Young Colorado Squawfish in the Green River, Utah. Journal of Freshwater Ecology. 6(1):43-51.

Tyus, H.M. 1998. Early records of the endangered fish *Gila cypha*, Miller, from the Yampa River of Colorado with notes on its decline. Copeia 1998:190-193.

Tyus, H.M., and G.B. Haines. 1991. Distribution, habitat use, and growth of age-0 Colorado squawfish in the Green River basin, Colorado and Utah. Transactions of the American Fisheries Society 119:1035-1047.

Tyus, H.M., and C.A. Karp. 1989. Habitat Use and Streamflow Needs of Rare and Endangered Fishes, Yampa River, Colorado. U.S. Fish and Wildlife Service, Biology Report 89(14). 27 pp.

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. Southwestern Naturalist 35:427□433.

Tyus, H.M., and C.A. Karp. 1991. Habitat use and streamflow needs of rare and endangered fishes in the Green River, Utah. Final Report. Flaming Gorge Studies Program. U.S. Fish and Wildlife Service, Colorado River Fish Project, Vernal Utah.

Tyus, H.M., and C.W. McAda. 1984. Migration, movements and habitat preferences of Colorado squawfish, Ptychocheilus lucius, in the Green, White, and Yampa Rivers, Colorado and Utah. Southwestern Naturalist 29:289-299.

Tyus, H M, and J.F. Saunders. 1996. Nonnative fishes in the upper Colorado River basin and a strategic plan for their control. Final Report of University of Colorado Center for Limnology to Upper Colorado River Endangered Fish Recovery Program. Denver.

Tyus, H.M., B.D. Burdick, R.A. Valdez, C.M. Haynes, T.A. Lytle, and C.R. Berry. 1982. Fishes of the Upper Colorado River Basin: Distribution, abundance and status. Pages 12-70 in Miller, W. H., H. M. Tyus and C. A. Carlson, eds. Fishes of the Upper Colorado

River System: Present and Future. Western Division, American Fisheries Society, Bethesda, Maryland.

U.S. Fish and Wildlife Service. 1980. Biological Opinion for the Strawberry Aqueduct and Collection System, Bonneville Unit, Central Utah Project, Utah. Fish and Wildlife Service, Region 6, Denver, Colorado.

U.S. Fish and Wildlife Service. 1987. Final Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. United States Department of Interior, Fish and Wildlife Service, Region 6, Denver, Colorado.

U.S. Fish and Wildlife Service. 1990. Humpback chub recovery plan, 2nd revision. Report of Colorado River Fishes Recovery Team to U.S. Fish and Wildlife Service, Region 6, Denver, Colorado.

U.S. Fish and Wildlife Service. 1992a. Final Biological Opinion on Operation of Flaming Gorge Dam. Fish and Wildlife Service, Mountain-Prairie Region, Denver, Colorado.

U.S. Fish and Wildlife Service. 1992b. Endangered and threatened wildlife and plants; final rule to list the plant *Spiranthes diluvialis* (Ute lady's-tresses) as a threatened species. Federal Register 57(12):2048-2054.

U.S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants: Determination of critical habitat for four Colorado River endangered fishes; final rule. Federal Register 59(54):13374-13400.

U.S. Fish and Wildlife Service. 1998a. Razorback sucker recovery plan. U.S. Fish and Wildlife Service, Region 6, Denver, Colorado.

U.S. Fish and Wildlife Service. 1998b. Endangered species consultation handbook, procedures for conducting consultation and conference activities under section 7 of the Endangered Species Act. U.S. Fish and Wildlife Service, National Marine Fisheries Service. U.S. Government Printing Office ISBN 0-16-049596-2.

U.S. Fish and Wildlife Service. 2002a. Colorado pikeminnow (Ptychocheilus lucius) Recovery Goals: amendment and supplement to the Colorado Pikeminnow Recovery Plan. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

U.S. Fish and Wildlife Service. 2002b. Razoback sucker (Xyrauchen texanus) Recovery Goals: amendment and supplement to the Razorback Sucker Recovery Plan. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

U.S. Fish and Wildlife Service. 2002c. Humpback chub (Gila Cypha) Recovery Goals: amendment and supplement to the Humpback Chub Recovery Plan. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

U.S. Fish and Wildlife Service. 2002d. Bonytail (Gila elegans) Recovery Goals: amendment and supplement to the Bonytail Recovery Plan. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

U.S. Fish and Wildlife Service. 2003. Section 7 Consultation, Sufficient Progress and Historic Projects Agreement and Recovery Action Plan (RIPRAP). Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. United States Department of Interior, Fish and Wildlife Service, Region 6, Denver, Colorado.

Valdez, R.A. 1990. The endangered fish of Cataract Canyon. Final Report of Bio/West, Inc., Logan, Utah, to U.S. Bureau of Reclamation, Salt Lake City, Utah.

Valdez, R.A., and G.H. Clemmer. 1982. Life History and prospects for recovery of the humpback and bonytail chub. Pages 109-119 in W.M. Miller, H.M. Tyus and C.A. Carlson, eds. Proceedings of a Symposium on Fishes of the Upper Colorado River System: Present and Future. American Fisheries Society, Bethesda, Maryland.

Valdez, R.A., and W. Masslich. 1989. Winter habitat study of endangered fish-Green River. Wintertime movement and habitat of adult Colorado squawfish and razorback suckers. Report No. 136.2. BIO/WEST, Inc., Logan, Utah. 178 pp.

Valdez, R.A. and P. Nelson. 2004. Green River Subbasin Floodplain Management Plan. Final Report to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado, Project No. C-6.

Valdez, R.A., and R.J. Ryel. 1995. Life History and Ecology of the Humpback Chub (*Gila cypha)* in the Colorado River, Grand Canyon, Arizona. BIO/WEST, Inc. for the Bureau of Reclamation.

Valdez, R.A., and R.J. Ryel. 1997. Life history and ecology of the humpback chub in the Colorado River in Grand Canyon, Arizona. Pages 3□31 *in* C. van Riper, III and E.T. Deshler (eds.). Proceedings of the Third Biennial Conference of Research on the Colorado Plateau. National Park Service Transactions and Proceedings Series 97/12.

Valdez, R.A., P.B. Holden, and T.B. Hardy. 1990. Habitat suitability index curves for humpback chub of the Upper Colorado River Basin. Rivers 1:31□42.

Valdez, R.A., P. Mangan, R.Smith, and B. Nilson. 1982. Upper Colorado River investigations (Rifle, Colorado to Lake Powell, Utah). Pages 100-279 *in* U.S. Fish and Wildlife Service, Colorado River Fishery Project, Final Report, Part 2: Field Investigations. U.S. Fish and Wildlife Service, Salt Lake City, Utah.

Valdez, R.A., M. Moretti, and R.J. Ryel. 1994. Records of bonytail captures in the Upper Colorado River Basin. Unpublished Report. Utah Division of Wildlife Resources, Salt Lake City, Utah.

Valdez, R.A., P.G. Mangan, R. Smith, and B. Nilson. 1982a. Upper Colorado River fisheries investigations (Rifle, Colorado to Lake Powell, Utah). Pages 100-279 in W.H. Miller, J.J. Valentine, D.L. Archer, H.M. Tyus, R.A. Valdez, and L. Kaeding, eds. Part 2-Field investigations. Colorado River Fishery Project. U.S. Bureau of Reclamation, Salt Lake City, Utah.

Vanicek, C.D. 1967. Ecological studies of native Green River fishes below Flaming Gorge dam, 1964-1966. Ph.D. Dissertation. Utah State University. 124 pp.

Vanicek, C.D., and R.H. Kramer. 1969. Life history of the Colorado squawfish Ptychocheilus lucius and the Colorado chub Gila robusta in the Green River in Dinosaur National Monument, 1964-1966. Transactions of the American Fisheries Society 98(2):193.

Vanicek, C.D., R.H. Kramer, and D.R. Franklin. 1970. Distribution of Green River fishes in Utah and Colorado following closure of Flaming Gorge dam. Southwestern Naturalist 14:297-315.

Ward, J., and T. Naumann. 1998. Ute ladies'-tresses orchid (Spiranthes diluvialis Sheviak) inventory, Dinosaur National Monument and Browns Park National Wildlife Refuge.

Welcomme, R.L. 1995. Relationships between fisheries and the integrity of river systems. Regulated Rivers 11:121-136.

Wick, E.J. 1997. Physical processes and habitat critical to the endangered razorback sucker on the Green River, Utah. Doctoral Dissertation. Colorado State University, Fort Collins, Colo.

Wick, E.J., T.A. Lytle, and C.M. Haynes. 1981. Colorado squawfish and humpback chub population and habitat monitoring, 1979-1980. Progress Report, Endangered Wildlife Investigations. SE-3-3. Colorado Division of Wildlife, Denver. 156 pp.

Wick, E.J., D.E. Snyder, D. Langlois, and T. Lytle. 1979. Colorado squawfish and humpback chub population and habitat monitoring. Federal Aid to Endangered Wildlife Job Progress Report. SE-3-2. Colorado Division of Wildlife, Denver, Colorado. 56 pp. + appendices.

Williams, C.A. 2000. A comparison of floodplain hydrology and cottonwood water relations on a regulated and unregulated river in northwestern Colorado. M.S. Thesis, Colorado State Univ., Ft. Collins. 183 pp.

Wolz, E.R., and D.K. Shiozawa. 1995. Soft sediment benthic macroinvertebrate communities of the Green River at the Ouray National Wildlife Refuge, Uintah County, Utah. Great Basin Naturalist 55:213-224.

Wydoski, R.S. and E.J. Wick. 1998. Ecological Value of Floodplain Habitats to Razorback Suckers in the Upper Colorado River Basin. Upper Colorado River Basin Recovery Program, Denver, Colorado.

Yin, S.C.L., J.J. McCoy, S.C. Palmer, and H.E. Cho. 1995. Effects of Flaming Gorge Dam hydropower operations on flow and stage in the Green River, Utah and Colorado. Environmental Assessment Division, Argonne National Laboratory, Argonne, Ill.