United States Department of the Interior

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February 26, 2009

Cons. # 2-22-01-F-532

Memorandum

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

From: Field Supervisor, U.S. Fish and Wildlife Service, New Mexico Ecological Services Field Office, Albuquerque, New Mexico

Subject: Final Biological Opinion for the Navajo-Gallup Water Supply Project, U.S. Bureau of Reclamation, Durango, Colorado

This document transmits the U.S. Fish and Wildlife Service's (Service) biological opinion (BO) regarding effects of actions associated with the Bureau of Reclamation's (Reclamation) proposed Navajo-Gallup Water Supply Project (NGWSP) on federally listed species and their designated critical habitats, as defined below. This BO will remain in effect until consultation is reinitiated. Species affected by the proposed project are the endangered Colorado pikeminnow (*Ptychocheilus lucius*) (pikeminnow) and its designated critical habitat; the endangered razorback sucker (*Xyrauchen texanus*) and its designated critical habitat; the endangered southwestern willow flycatcher *(Empidonax traillii extimus*) (flycatcher); and the threatened Mesa Verde cactus (*Sclerocactus mesae-verdae*). After we received your biological assessment in 2005, the bald eagle was delisted (72 FR 37345) and will not be considered further in this consultation. You determined that effects from the proposed project may affect and are likely to adversely affect the pikeminnow, the razorback sucker, and the Mesa Verde cactus and that the proposed project "may affect is not likely to adversely affect" critical habitat for pikeminnow and razorback sucker. You also determined that the proposed project "may affect is not likely to adversely affect" the flycatcher. In accordance with our new section 7 regulations effective January 15, 2009 (50 C.F.R. §402.13) we are declining to provide concurrence on the flycatcher.

This BO does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02; instead, we have relied upon the statute and the August 6, 2004, Ninth Circuit Court of Appeals decision in Gifford Pinchot Task Force v. USDI Fish and Wildlife Service (CIV No. 03-35279) to complete the following analysis with respect to critical habitat. This consultation analyzes the effects of the action and its relationship to the function and conservation role of razorback sucker and pikeminnow critical habitat to determine whether the current proposal destroys or adversely modifies critical habitat. This document represents our final BO for the razorback sucker and pikeminnow and their designated critical habitat in accordance with section 7 of the Act, as amended (16 U.S.C. 1531 et seq.).

In accordance with section 7 of the Act, as amended (16 U.S.C. 1531 et seq.) and the Interagency Cooperation Regulations published in the Federal Register (50 CFR 402), this document transmits our final BO regarding effects from the proposed project to listed species and their associated designated critical habitats. A complete administrative record of this consultation is on file at the Service's New Mexico Ecological Services Field Office.

If you have questions regarding this consultation, please contact David Campbell, at (505) 761-4745.

Wally Murphy

Attachment

cc:
Field Supervisor, U.S. Fish and Wildlife Service, Grand Junction Ecological Services Field Office, Grand Junction, Colorado
Assistant Regional Director (ES), U.S. Fish and Wildlife Service, Region 2, Albuquerque, New Mexico
Regional Section 7 Coordinator, U.S. Fish and Wildlife Service, Albuquerque, New Mexico
Assistant Regional Director (ES), U.S. Fish and Wildlife Service, Region 6, Denver, Colorado
Regional Section 7 Coordinator, U.S. Fish and Wildlife Service, Denver, Colorado

Endangered Species Act – Section 7 Consultation
Final Biological Opinion

Navajo-Gallup Water Supply Project
New Mexico

Agency:	U.S. Bureau of Reclamation
Consultation Conducted By:	U.S. Fish and Wildlife Service, New Mexico Ecological Services Field Office
Date Issued:	
Approved by:	Wally Murphy Field Supervisor
Biological Opinion Number:	2-22-01-F-532

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INTRODUCTION

This document transmits the U.S. Fish and Wildlife Service's (Service) biological opinion (BO) based on our review of the proposed Navajo-Gallup Water Supply Project located in San Juan County, New Mexico, and its effects on the Colorado pikeminnow (*Ptychocheilus lucius*) (pikeminnow) and its designated critical habitat, razorback sucker (*Xyrauchen texanus*) and its designated critical habitat, southwestern willow flycatcher *(Empidonax traillii extimus*) (flycatcher), and Mesa Verde cactus (*Sclerocactus mesae-verdae*) in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.), and implementing regulations at 50 CFR 402.

This BO is based on information provided in the biological assessment (BA); electronic mail and telephone conversations between our staffs; data in our files; literature review; and other sources of information. A notice of intent to prepare an environmental impact statement (EIS) and project scoping under the National Environmental Policy Act of 1969, as amended (NEPA) began in March 2000 (59 FR 16219). A draft EIS has been completed and released for public comment (Reclamation 2007). A complete administrative record of this consultation is on file at the New Mexico Ecological Services Field Office, Albuquerque, New Mexico. We received all the information necessary for formal consultation on December 1, 2006.

Background and Consultation History

The Bureau of Reclamation (Reclamation) is proposing to construct a water supply project that would divert water from the San Juan River and Navajo Reservoir to the Navajo Nation, Jicarilla Apache Nation, and the City of Gallup.

On August 29, 2005, the Service received a letter and draft BA from Reclamation requesting initiation of formal section 7 consultation under the ESA. The BA documented your determinations that the proposed action would "likely adversely affect" pikeminnow, razorback sucker, Mesa Verde cactus, flycatcher, and bald eagle and the critical habitat for pikeminnow. However, the letter failed to request formal section 7 consultation on the effects of the proposed project on razorback sucker critical habitat. Since receipt of your BA in 2005, the bald eagle was delisted (72 FR 37345) and therefore will not be considered further in this consultation.

On September 16, 2005, the Service requested a conference call with Reclamation to discuss and clarify information provided in the BA.

On September 22, 2005, the Service received all information necessary to begin formal consultation. The Service however requested that Reclamation's provide a letter clarifying their intent on including razorback sucker critical habitat in this formal consultation.

DESCRIPTION OF THE PROPOSED ACTION

Action Area

The action area for the proposed project includes the diversion points at the Navajo Indian Irrigation Project (NIIP) main canal at Cutter Reservoir and at the Public Service Company of New Mexico (PNM) diversion dam on the San Juan River, downstream to Lake Powell (Figure

1). The action area also includes one-half mile around the main water treatment plants located at each diversion location, the 19 forebay tanks, the 24 pumping plants, the 5 regulating tanks and approximately 25 community storage tanks; and one-half mile on either side of the 267 miles of pipeline. The action area includes most of the Navajo Nation in New Mexico and the Window Rock area of Arizona, the Jicarilla Apache Nation in New Mexico, and Gallup. Stated below.

Proposed Action

The Navajo-Gallup Water Supply Project (NGWSP) is proposed to deliver treated municipal water to selected Navajo communities, a portion of the Jicarilla Apache Nation, and the City of Gallup, New Mexico. The project is planned with adequate capacity to serve approximately 203,000 people (43 Chapters) in the Navajo Nation, 1,300 people in the Jicarilla Apache Nation, and approximately 47,000 people in Gallup, the projected populations as of year 2040. The service area for the proposed pipeline includes most of the New Mexico portion of the Navajo Nation, the Navajo Nation in the Window Rock area within Arizona, the Jicarilla Apache Nation and the City of Gallup, New Mexico (Figure 1). The water supply will be from the San Juan River with surface return flow in the San Juan basin and groundwater recharge to the San Juan, Rio San Jose and Rio Puerco basins. For water balance considerations, the groundwater recharge is not assumed to return to surface flow in any of the basins due to the distance from the surface water bodies and existing pumping within the basins that keep the water surface elevation in the aquifers from rising to levels that would allow surface discharge.

Reclamation examined 12 alternatives for the NGWSP. The proposed preferred alternative is called the San Juan River Public Service Company of New Mexico 2040 Alternative, with diversion points from the NIIP main canal at Cutter Reservoir and at the PNM diversion dam on the San Juan River. A treatment plant will be located at each diversion location, with main pumping plants supplying water to 267 miles of pipeline. The system would consist of 19 forebay tanks, 24 pumping plants, 5 regulating tanks and approximately 25 community storage tanks (Figure 1).

Cutter Lateral

The Cutter Lateral would serve Huerfano, Nageezi, Counselor, Pueblo Pentado, Ojo Encino, Torreon and Whitehorse Chapters in the eastern portion of the Navajo Nation and a portion of the western Jicarilla Apache Nation, delivering up to 4,645 acre-feet per year. The Cutter Lateral will take water from the Cutter Reservoir, a feature of the NIIP main canal (Figure 1).

The water treatment and pumping plant will have a footprint of about three to four acres located downstream of Cutter Dam, in a previously disturbed area. The plant will have a capacity of 5.39 million gallons per day (mgd) or 8.34 cubic feet per second (cfs). Facilities include mixing and flocculation tanks, three ultra-filtration units, three ultraviolet light (UV) disinfection units, a 112,000 gallon subsurface pumping plant forebay, two wastewater polishing ponds, chemical storage buildings, an operations and maintenance (O&M) building and a 4-unit pumping plant. Associated electrical control equipment necessary to power and control the electrically driven pumps and other ancillary equipment will be contained on this site.

The plant will feed about 89 miles of buried pipeline ranging in diameter from 10 to 24 inches.

Five re-lift pumps will be built along the route to maintain required delivery pressure, along with three community storage tanks and two regulating tanks. Much of the pipeline route is paralleled with an overhead electrical transmission line to power the pumping plants. A 230/69 kilovolt (KV) substation will provide power from the existing 230 KV PNM transmission line. Each re-lift pump will consist of a forebay tank, pumping plant, air chamber, chlorination building, electrical control and ancillary equipment. The typical footprint will be about one acre, enclosed in a chain link fence. Each site will be totally contained with no open water.

Storage tank locations will include the storage tank (size varies depending on location), chlorination building, pumping plant, air chamber, electrical control and ancillary equipment in an enclosed yard. The typical footprint is about one acre.

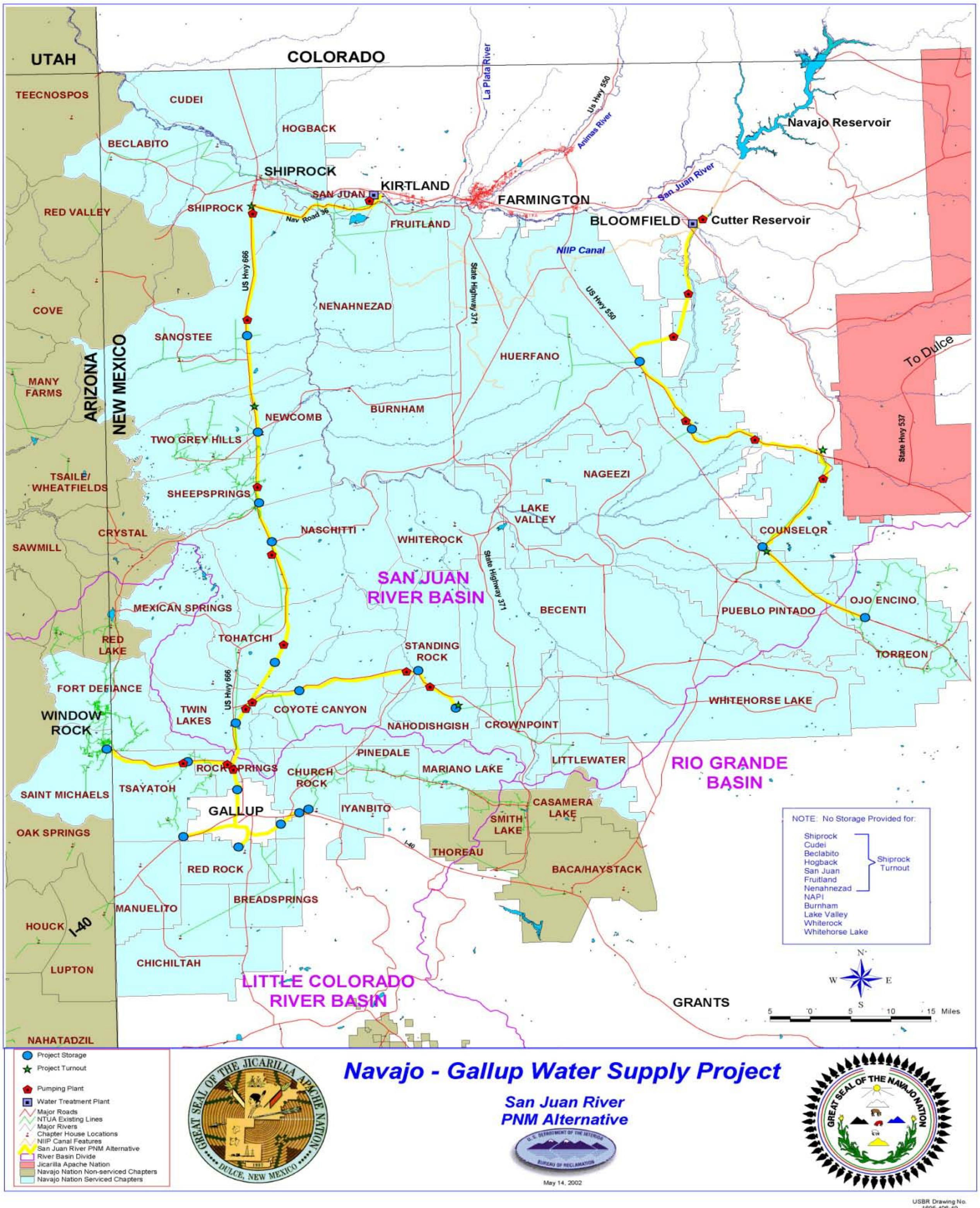
San Juan Lateral

The San Juan Lateral diversion point will occur at the existing PNM diversion dam (Figure 1). The pumping plant intake will be located just upstream of the PNM intake on the north bank of the San Juan River. It will supply the main pipeline and deliver up to 33,118 acre-feet of water per year to the 36 Navajo Nation Chapters and the City of Gallup, New Mexico.

Water will be diverted through a self-cleaning fish screen with 3/32 inch openings and a through-screen velocity of less than 0.5 feet per second to a sump where low-head pumps will lift the raw water into settling ponds for removal of suspended sediment. The remaining treatment and pumping plant facilities will be as described for the Cutter Lateral, except that the capacity of this lateral is greater, measured at 38.25 mgd (59.19 cfs). There are seven ultra-filtration units, seven UV disinfection units, and one 797,000 gallon clear well. There are two settling ponds and two sediment drying beds at this site that are required to handle the elevated suspended sediment concentration. Associated buildings and ancillary equipment listed for the Cutter Lateral will also be required at this site, although here they will be larger. The total footprint at this site is expected to be about 18 acres, much of which is previously disturbed in a sparsely inhabited trailer park.

The San Juan Lateral pumping plant will feed about 145 miles of buried pipeline ranging in diameter from 12 to 48 inches. The buried pipeline will cross the San Juan River just upstream from the treatment plant and ascend to the mesa on the south side of the river. From there it will proceed west following Navajo Highway 64 to U.S. Highway 491, following the highway route through the City of Gallup to connect to five Navajo chapters on the southern border of the city. The project facilities serving the Gallup area are named the Gallup Regional System; it consists of one new pumping plant and upgrades to five storage tanks and 32 miles of pipeline. There will be seven re-lift stations along the main line, with three on the Dalton Pass branch and two on the Window Rock branch. Along the route there will be 17 storage tanks (plus five community storage tanks in the Gallup Regional System), and three regulating tanks, with additional junctions to Shiprock, Burnham, and Gallup water supply systems as well as a turnout to NIIP. The electrical transmission line parallels the pipeline over much of its route.

Figure 1. Navajo Gallup Water Supply Project Service Area and Project Layout.



Impacts from Construction

Pipeline Construction Impacts

The pipeline and accompanying facilities would permanently impact 27 acres of vegetation, including 3,920 square feet of tamarisk and Russian olive habitat. Clearing and grading will temporarily impact 31,477 acres. Much of the pipeline would be adjacent to existing highways or well-traveled roads. Project construction would be phased over approximately 14 years, with only small portions of the area disturbed at any one time. The pipeline construction would occur almost exclusively in upland habitat, much of which has been previously disturbed.

San Juan River Crossing

The method of construction to be used at the San Juan River crossing (Figure 1) has not been determined. Consequently, the Service has analyzed the impacts for both potential river crossing construction methods: 1) open trench with construction of coffer dams in one-half of the river width at any one time; and 2) directional boring. Impact to aquatic resources will be minimized by the actions outlined in the "Conservation Measures" section below.

Impacts of the Open Trench Method

The open trench would include clearing and grading of 0.9 acres of degraded riparian habitat that consists of tamarisk and Russian olive and 0.10 acres of temporary impacts to an emergent wetland. Of the 0.9 acres of riparian impact, 0.65 acres will result in temporary impacts and will be replanted with native riparian species; 0.25 acres will be placed in the pipeline right-of -way and planted in grasses. The 0.10 acres of wetland area temporarily impacted will be replanted with native emergent wetland species.

Impacts of the Directional Boring Method

All the impacts associated with the directional boring method would be within the project's evaporation pond footprint which will be constructed on 4.5 acres of previously developed upland.

Water Treatment and Pumping Facilities

For either method used to cross the San Juan River, construction of water treatment and pumping facilities adjacent to the San Juan River would permanently impact 1.5 acres, temporarily impact 3.2 acres of degraded riparian habitat that consists of tamarisk and Russian olive and would include the conversion of 4.5 acres of a previously developed area to an evaporation pond.

Water Depletion Impacts

San Juan River Water Depletion

The project is designed to divert a total of 37,764 acre-feet of water per year from the San Juan River with a resulting depletion of 35,893 acre-feet to the San Juan Basin, based on 2040 projected population with a demand rate of 160 gallons per capita per day. The Cutter Diversion would require 4,645 acre-feet per year with no return flow to the San Juan River. The PNM diversion would take the remaining 33,119 acre-feet of diversion, with an average return flow of 1,871 acre-feet. The planned diversion and depletion by location is shown in Table 1.

It is assumed that the only return flow from the project to the San Juan River would enter the river at the Shiprock wastewater treatment plant. There may be some water delivery to users with individual septic systems in the Shiprock area, but the delivery is expected to be a small percentage of the total. The return flow through the treatment plant is assumed to be 50 percent for the Shiprock deliveries. All other deliveries would also have similar losses, but the system losses would be due to evaporation, or recharge local groundwater aquifers. For water balance purposes, no return flow to the San Juan River from these other locations is expected or accounted. Return flow to the Rio Grande or Little Colorado Rivers is highly unlikely, even though there will be discharge to the groundwater in these areas. Local groundwater storage space together with local pumping will limit the potential for surface discharge. Even if surface discharge does occur, the distance to the Rio Grande or Little Colorado Rivers is so great that it is unlikely that return flow would reach these rivers.

Deliveries typically vary depending on changes in demand with the largest demand in summer months. The Shiprock water delivery pattern for March 1992 through February 1993, shown in Table 2, was used to determine average monthly deliveries. Return flows were assumed to follow the same distribution.

The system design capacity to handle a 7-day peak demand for pumping plants and pipelines is computed as 1.3 times the peak average monthly demand. Daily and diurnal demand peaking are handled by the community storage tanks.

Table 1. Forecast 2040 Demand and Design Capacity by Service Area

Location	SJR Diversion ac-ft/yr	SJR Depletion ac-ft/yr
City of Gallup, NM	7,500	7,500
Jicarilla Apache Nation	1,200	1,200
Navajo Nation, New Mexico		
Central Area	834	834
Crownpoint	2,473	2,473
Gallup Area	4,316	4,316
Huerfano	864	864
Rock Springs	2,118	2,118
Route 491	5,366	5,366
Torreon	2,240	2,240
San Juan River	3,742	1,871
NAPI industrial uses	700	700
Navajo Nation, Arizona (Window Rock area)	6,411	6,411
Total Navajo Nation	**29,064**	**27,193**
Project Total	**37,764**	**35,893**

Table 2. Monthly Demand Pattern for All Deliveries

Month	% Demand	Month	% Demand
January	7	July	10
February	6	August	10
March	9	September	10
April	7	October	8
May	9	November	7
June	10	December	7

Water Supply

Three water supply scenarios have been proposed and are discussed below. Table 1 summarizes the annual depletion demands from the San Juan River by the NGWSP participants. Of the total NGWSP depletion of 35,893 acre-feet per year, the Navajo Nation will consumptively use up to 27,193 acre-feet per year for its project uses in New Mexico and Arizona, the Jicarilla Apache Nation will consumptively use up to 1,200 acre-feet per year for its project uses in New Mexico, and the City of Gallup, New Mexico, will consumptively use up to 7,500 acre-feet per year.

Table 3 – Summary of Depletions in Acre-Feet for Full NGWSP Development under Water Supply Scenario 1.

Water Provider	Change in Use of Baseline Depletion	Return Flows	New Depletion	Met Within Threshold Depletion[1]	Total
Jicarilla Apache Nation	**(6,740)**[2]		**(1,960)**[3]	**0**	**(8,700)**
Navajo Nation	**0**		**(6,411)**	**(20,782)**	**(27,193)**
NGWSP Sub-totals	**(6,740)**	**+3,100**	**(8,371)**	**(20,782)**	**(35,893)**
Total NGWP	**(6,740)**		**(5,271)**[4]	**(20,782)**	**(32,793)**[4]

[1] See Depletion Guarantee description.

[2] Includes forbearance by the Jicarilla Apache Nation of 6,570 ac-ft per year of consumptive use on the Jicarilla Apache Nation Navajo River Water Supply Project (JANNRWSP) and 170 ac-ft of consumptive use under Jicarilla water rights for historic uses. This planning assumption does not preclude the alternative of the Navajo Nation forbearing an equivalent amount or more of consumptive use on the Navajo Indian Irrigation Project or other projects for which depletions are included the baseline, and changing the use of the amount forborne to the NGWSP. The City of Gallup may subcontract with either the Jicarilla Apache Nation or the Navajo Nation, or both in combination, for the diversion of up to 7,500 ac-ft of water per year total from the Navajo Reservoir supply for its NGWSP uses.

[3] This Biological Opinion shall not establish any right in the Jicarilla Apache Nation to retain approval for 1,960 ac-ft per year of new depletions in excess of the baseline depletions listed in Table 5 should this amount of Jicarilla water rights, over and above the change in use of 6,740 ac-ft of baseline depletion, not be required for NGWSP purposes due to the City of Gallup subcontracting with the Navajo Nation, rather than subcontracting solely with the Jicarilla Apache Nation, for water for the City's NGWSP uses (see note 2).

[4] By the time the Navajo Nation's water demands under the NGWSP reach the full 27,193 ac-ft per year of depletion, the return flows from the Navajo Indian Irrigation Project (NIIP) to the San Juan River are anticipated to have increased by approximately 3,100 ac-ft per year, on average, over and above the current rate of return flows from the NIIP. This increase in return flows from the NIIP offsets an equivalent amount of new depletion by the NGWSP, and reduces the net new depletion from the river in this Biological Opinion from 8,371 ac-ft per year to 5,271 ac-ft per year.

One water supply scenario is that the City of Gallup, to supply its NGWSP uses, enters into a subcontract with the Jicarilla Apache Nation for the delivery of up to 7,500 acre-feet of water per year from the Navajo Reservoir supply under the Jicarilla's Settlement Contract approved by Congress in 1992. The plans for the Jicarilla Apache Nation Navajo River Water Supply Project (JANNRWSP) include the allowance to deliver all or part of the water allocated to the JANNRWSP to other uses, including the NGWSP, at a time that it should be needed. Under this scenario, the NGWSP would consumptively use 6,570 acre-feet per year of Navajo Reservoir supply water previously committed to the JANNRWSP, plus 170 acre-feet of water associated with forbearance of Jicarilla historic use water rights. Thus, of the 8,700 acre-feet per year of NGWSP depletion that would be sourced by the Jicarilla Apache Nation, 6,740 acre-feet per year would be provided through changes in use of depletions already in the baseline, and 1,960 acre-feet per year would be provided through new depletions that are in excess of the baseline and are approved by this BO (Table 3). Of the Navajo Nation's 27,193 acre-feet per year depletion from the NGWSP, 6,411 acre-feet per year would be provided through new depletions that are in excess of the baseline and are approved by this BO, and 20,782 acre-feet per year would be met within the total threshold depletions for the San Juan River Basin described by the Depletion Guarantee (Table 3). The City of Gallup's NGWSP depletion would be included in the Jicarilla depletions shown in Table 3.

A second water supply scenario is that the City of Gallup enters into a subcontract with the Navajo Nation for the delivery of up to 7,500 acre-feet of water per year from the Navajo Nation's Navajo Reservoir water supply contract to meet the City's NGWSP demands. The Navajo Nation would be able to subcontract the delivery and use of its Navajo Reservoir supply contract water if Congress approves the San Juan River Basin in New Mexico Navajo Nation Water Rights Settlement Agreement signed by the State of New Mexico and the Navajo Nation in April 2005. In this event, the Navajo Nation may agree to forbear portions of its consumptive uses under the Navajo Indian Irrigation Project or other Navajo projects for which depletions are in the baseline in order to offset the depletions made under a subcontract with the City of Gallup for uses by the City under the NGWSP. Under this scenario, a total of 34,693 acre-feet per year of depletion by the NGWSP would be supplied from the Navajo Nation's Navajo Reservoir water supply contract. Of this amount, 5,540 acre-feet per year would be provided through changes in use of Navajo Nation depletions that are already in the baseline, 8,371 acre-feet per year would be provided through new depletions that are in excess of the baseline and are approved by this BO, and 20,782 acre-feet per year would be met within the total threshold depletions for the San Juan River Basin described by the Depletion Guarantee (Table 4). The City of Gallup's NGWSP depletion would be included in the Navajo depletions shown in Table 4.

Table 4 – Summary of Depletions for Full NGWSP Development under Water Supply Scenario 2

Water Provider	Change in Use of Baseline Depletion	Return Flows	New Depletion	Met Within Threshold Depletion[1]	Total
Jicarilla Apache Nation	**(1,200)**[2]			**0**	**(1,200)**
Navajo Nation	**(5,540)**[3]		**(8,371)**	**(20,782)**	**(34,693)**
NGWSP Sub-totals	**(6,740)**	**+3,100**	**(8,371)**	**(20,782)**	**(35,893)**
Total NGWP	**(6,740)**		**(5,271)**[4]	**(20,782)**	**(32,793)**[4]

[1] See Depletion Guarantee description.

[2] Includes forbearance by the Jicarilla Apache Nation of 1,200 ac-ft per year of consumptive use on the Jicarilla Apache Nation Navajo River Water Supply Project (JANNRWSP). This planning assumption does not preclude the alternative of the Jicarilla Apache Nation forbearing an additional amount of consumptive use on the JANNRWSP or other projects for which depletions are included the baseline, and changing the use of the amount forborne to the NGWSP. The City of Gallup may subcontract with either the Jicarilla Apache Nation or the Navajo Nation, or both in combination, for the diversion of up to 7,500 ac-ft of water per year total from the Navajo Reservoir supply for its NGWSP uses.

[3] Includes forbearance by the Navajo Nation of 5,540 ac-ft per year of consumptive use on the Navajo Indian Irrigation Project or other Navajo projects for which depletions are in the baseline.

[4] By the time the Navajo Nation's water demands under the NGWSP reach the full 27,193 ac-ft per year of depletion, the return flows from the Navajo Indian Irrigation Project (NIIP) to the San Juan River are anticipated to have increased by approximately 3,100 ac-ft per year, on average, over and above the current rate of return flows from the NIIP. This increase in return flows from the NIIP offsets an equivalent amount of new depletion by the NGWSP, and reduces the net new depletion from the river in this Biological Opinion from 8,371 ac-ft per year to 5,271 ac-ft per year.

A third water supply scenario is that the City of Gallup enters into a Navajo Reservoir water supply subcontract with the Navajo Nation for the delivery of water to meet a portion of the City's NGWSP demands, and enters into a Navajo Reservoir water supply subcontract with the Jicarilla Apache Nation for the delivery of water to meet the remainder of the City's NGWSP demands, with the total delivery under both subcontracts not to exceed 7,500 acre-feet of water per year. Under this scenario, the total amount of annual NGWSP uses that would be provided through changes in use of baseline depletions would remain at 6,740 acre-feet, of which the Jicarilla Apache Nation would be required to provide 1,200 acre-feet plus the amount of water delivered to the City of Gallup under a subcontract with the Jicarillas, up to a maximum of 6,740 acre-feet, and the Navajo Nation would be required to provide the remainder (Tables 3 and 4). The amount of annual NGWSP uses that would be provided through new depletions that are in excess of the baseline and are approved by this BO would remain at 8,371 acre-feet, and the amount of annual NGWSP uses that would be met within the total threshold depletions for the San Juan River Basin described by the Depletion Guarantee would remain at 20,782 acre-feet (Tables 3 and 4).

Under the second and third water supply scenarios, the Navajo Nation will identify consumptive use limits on its projects or uses that are listed in the baseline to achieve the forbearance and change in use of baseline depletions needed to offset up to 5,540 acre-feet per year of NGWSP uses under its Navajo Reservoir water supply contract. The amount of forbearance and change in use required of the Navajo Nation will be consistent with the description of water supply scenarios 2 and 3, and will not exceed 5,540 acre-feet.

Depletion Guarantee

This section clarifies the conditions of the Depletion Guarantee and describes the commitments necessary to monitor depletions in the San Juan River Basin and maintain compliance with the ESA. The Depletion Guarantee is a commitment by the Navajo Nation that ensures that the depletions for its uses under the NGWSP will be offset by unused Navajo Nation depletions in the San Juan Basin, including forbearance of its uses on the Navajo Indian Irrigation Project as necessary, if and when required to keep the total of the depletions in the basin from exceeding the threshold described herein. So long as the sum of actual annual depletions from all uses listed in the hydrologic baseline shown in Table 5, excluding San Juan-Chama Project exportation, plus all NGWSP uses does not reach a total depletion amount of 752,127 acre-feet per year (854,370 acre-feet per year for all depletions in the baseline, less 107,514 acre-feet per year average depletion by the San Juan-Chama Project, plus 5,271 acre-feet of new depletions approved by this BO), the full NGWSP depletion of 35,893 acre-feet per year will be allowed to be made without requiring any forbearance of uses in excess of the 6,740 acre-feet of changes in use of baseline depletions described in the above subsection on water supply. The depletions by the San Juan-Chama Project and for projects that may be added to the hydrologic baseline at a date later than the date of this BO for the NGWSP will not be counted in this analysis comparing actual future depletions for the San Juan River Basin against the total threshold depletion for the basin. This average depletion of 752,127 acre-feet is termed the Depletion Guarantee threshold depletion for ease of reference. By subtracting the San Juan-Chama Project exportation from the threshold and the total depletion calculation, the large annual variation in exportation included in the model analysis for flow recommendation determination is preserved and no offset of the variation is unnecessarily required through the depletion guarantee.

If at some point in the future the threshold depletion condition for the San Juan River Basin described in the paragraph above is reached, the Navajo Nation will reduce its total depletion in the basin so that its consumptive uses under the NGWSP do not cause the total of the actual depletions in the basin, excluding San Juan-Chama Project exports and depletions by projects added to the hydrologic baseline after issuance of this BO, to exceed the threshold depletion allowed. The Navajo Nation could accomplish the required reductions in use by changes in the operations of any of the Navajo projects that deplete water from the San Juan River. The maximum depletion guarantee requirement in any year is a reduction in Navajo Nation depletions of 20,782 acre–feet (Tables 3 and 4). At the time that the depletion threshold condition for the basin is reached and the Depletion Guarantee must be implemented, the quantification of the threshold depletion amount (currently 752,127 acre-feet per year based on the baseline depletions identified in Table 5 and as described above) will be recomputed using the baseline depletion amounts for the same identified baseline uses listed in Table 5 that are estimated in the version of the San Juan River Basin Hydrology Model (SJRBHM) that is most recently available at that time so as to reflect any revisions or improvements in modeling that might be made in the future. Changes in the San Juan River Basin Recovery Implementation Program's (SJRRIP) flow recommendations for the San Juan River or in the status of listed species may result in reduction or removal of this Depletion Guarantee in the future, based upon reconsultation.

Monitoring Requirements

No specific, detailed accounting of depletions will be required unless the sum of NIIP and Animas LaPlata Project (ALP) depletions reaches 290,000 acre-feet (Table 5). Since these projects are more easily tracked than depletions in the entire basin, it will limit monitoring requirements. If this condition is met, all the depletions listed in the baseline for NGWSP will be monitored and reported on a 5-year cycle to coincide with Reclamation's Consumptive Use and Loss report. Depletions will be reported by the categories listed in the hydrologic baseline shown in Table 5 and the total computed. As discussed above, San Juan-Chama project depletions will be removed for comparison to the depletion guarantee threshold depletion.

If the sum of these depletions reaches the depletion guarantee threshold, the elements of the depletion guarantee will be implemented. At that point, modeling will be completed for the limits the Navajo Nation proposes putting in place to meet flow conditions specified in your BA.

Responsibilities

U.S. Fish and Wildlife Service

The Service, in coordination with the SJRRIP, will be responsible for reviewing the accounting of depletions.

Bureau of Reclamation

Reclamation, in coordination with the Service, will be responsible to ensure that the San Juan River Basin Hydrology Model (SJRBHM) is implemented in order to assure compliance with the flow recommendations and as specified in the NGWSP BA for limits identified by the Navajo Nation at the time the depletion guarantee is implemented. Reclamation will identify the point at which ALP and NIIP annual depletions reach 290,000 acre-feet collectively. If that target depletion is reached, Reclamation will initiate reporting of depletions for the categories listed in the hydrologic baseline for NGWSP (Table 5) on a 5-year cycle as a part of the consumptive use and loss reporting procedure. As a result of the monitoring, Reclamation will identify the point at which the sum of actual uses reaches the depletion guarantee threshold. If this level of depletion is reached, Reclamation will limit deliveries to Navajo projects as identified by the Navajo Nation, to levels required by implementation of the depletion guarantee. In the event that the SJRRIP terminates, Reclamation will assume the responsibilities listed above for the SJRRIP.

Navajo Nation

The Navajo Nation will limit uses as specified in the depletion guarantee if the conditions stated above are reached and provide to the SJRIP and Reclamation the projects it wishes limited.

Conditions

None of the actions and conditions listed herein shall limit the ability of Reclamation to reinitiate consultation on the NGWSP to increase its baseline depletion or alter the requirements of the depletion guarantee.

Reclamation will notify the SJRRIP and the States of New Mexico and Colorado of any such requests to reinitiate consultation on the NGWSP. Reinitiation of consultation on the NGWSP will be performed in conformance with the SJRRIP's Principles for Conducting Endangered Species Act Section 7 Consultations on Water Development and Water Management Activities Affecting Endangered Fish Species in the San Juan River Basin (Principles) that is described in the SJRRIP's Program Document, Appendix C, dated September 7, 2006, as may be modified by the SJRRIP and the Service.

The depletion levels discussed are conditioned upon current estimates of natural flow and baseline depletions for 1929-1993 and are subject to change as hydrology or models are updated. If such updates occur, a newly computed depletion guarantee shall be computed and utilized based upon the same depletion categories as described herein.

Limitations

This BO, including the description of water supply scenarios in the San Juan River Basin and the Navajo Nation's depletion guarantee commitment, is not binding on the use of water by any person or entity other than the Navajo Nation, and shall not affect the ability of any person or entity to fully develop and utilize their water rights. The fact that the total amount of baseline depletions in the basin may not be used for some period of time in the future shall not be construed to diminish in any way the rights of persons or entities other than the Navajo Nation to develop their water uses in accordance with interstate compact apportionments and state water rights. Also, this BO and the Navajo Nation's depletion guarantee described herein do not constitute a precedent or otherwise affect the applicability of the Principles for other section 7 consultations on projects in the San Juan River Basin.

Table 5. Baseline and Current Depletion Summary in the San Juan River Basin[1]

Depletion Category	Riverware Baseline (ac-ft)	Estimated Current (ac-ft)	Presently Unused (ac-ft)
New Mexico Depletions			
Navajo Lands Irrigation Depletion			
Navajo Indian Irrigation Project	280,600[2]	160,330	120,270
Hogback	12,100	9,535	2,565
Fruitland	7,898	6,147	1,751
Cudei	900	715	185
Subtotal	**301,498**	**176,727**	**124,771**
Non-Navajo Lands Irrigation Depletion			
Above Navajo Dam - Private	738	575	163
Above Navajo Dam - Jicarilla	2,190	350	1,840
Animas River	36,711	24,878	11,833
La Plata River	9,808	8,470	1,338
Upper San Juan	9,137	6,680	2,457
Hammond Area	10,268	7,507	2,761
Farmers Mutual Ditch	9,532	7,457	2,075
Jewett Valley	3,088	2,379	709
Westwater	110	110	0
Subtotal	**81,582**	**58,406**	**23,176**
Total NM Irrigation Depletion	**383,080**	**235,133**	**147,949**
Non-Irrigation Depletions			
Navajo Reservoir Evaporation	27,350	29,235	-1,885
Utah International	39,000	31,388	7,612
San Juan Power Plant	16,200	16,200	0
Industrial Diversions near Bloomfield	2,500	2,500	0
Municipal and Industrial Uses	8,453	7,443	1,010
Scattered Rural Domestic Uses	1,400[3]	1,400	0
Scattered Stockponds & Livestock Uses	2,200[3]	2,200	0
Fish and Wildlife	1,400[3]	1,400	0
Total NM Non-Irrigation Depletion	**98,503**	**91,766**	**6,735**

[1] Baseline depletion values are from the Generation 2 San Juan River Basin Hydrology Model operated by the SJRIP and may change with new versions of the model or new basin hydrology. They are provided here as a reference point and would naturally be adjusted to match changes approved by the SJRIP.

[2] Includes 10,600 af of annual groundwater storage. At equilibrium this drops to 270,000 af, based on irrigation of the full 110,630 acres every year. The proposed schedule of anticipated depletions prepared by the New Mexico Interstate Stream Commission to reflect the Navajo Water Rights Settlement Agreement includes an equilibrium depletion for NIIP of 256,500 AF based on an average fallow acreage of 5%. While including fallow land in the depletion calculation is reasonable, the larger number is used here to be consistent with the NIIP Section 7 consultation and the full capacity of the project.

[3] Indicates offstream depletion accounted for in calculated natural gains.

Table 5 (Continued)

Depletion Category	Riverware Baseline (ac-ft)	Estimated Current (ac-ft)	Presently Unused (ac-ft)
San Juan-Chama Project Exportation	107,514	107,514	0
Unspecified Minor Depletions	4,500[4]	2,500	2,000
JANNRWSP	6,570[5]	0	6,570
Total NM Depletions (Excluding ALP)	**600,168**	**436,914**	**163,254**
Colorado Depletions - Upstream of Navajo			
Upper San Juan	10,858	9,270	1,588
Navajo-Blanco	7,865	6,972	893
Piedra	8,098	6,892	1,206
Pine River	71,671	69,775	1,886
Subtotal	**98,492**	**92,909**	**5,583**
Colorado Depletions - Downstream of Navajo			
Florida	28,607	27,749	858
Animas	25,119	24,099	1,020
La Plata	13,245	13,049	196
Long Hollow	1,339	0	1,339
Mancos	19,532	15,516	4,016
Subtotal	**87,842**	**80,413**	**7,429**
Total CO Depletions (Excluding ALP)	**186,334**	**173,322**	**13,012**
Total CO & NM Combined Depletions	**786,502**	**610,236**	**176,266**
ALP	57,133[6]	1,620	55,513
Subtotal	**843,635**	**611,856**	**231,779**
McElmo Basin Imports	-11,769	-11,769	0
Utah Depletions	9,140[7]	9,140	0
Arizona Depletions	10,010[5]	10,010	0
NET NM, CO, UT, AZ Depletion	**851,016**	**619,237**	**231,779**
NM Off River Depletions			
Chaco River	2,832[5]	2,832	0
Whiskey Creek	523[5]	523	0
GRAND TOTAL	**854,371**	**622,592**	**231,779**

[4] 1500 af of depletion from minor depletions approved of SJRIP in 1992. 3,000 af from 1999 Intra-service consultation, a portion of which may be in Colorado

[5] Biological Opinion lists this depletion as 6,654 af, but model configuration shows 6,570. Model configuration used.

[6] Actual approved depletion is 57,100 af. Small changes in reservoir evaporation between runs results in small variation from actual project depletion. Exact match would require multiple iterations because of model limitations.

[7] 1,705 San Juan River depletion, 7,435 off stream depletion

CONSERVATION MEASURES

The following conservation measures are part of the proposed action.

San Juan River and Other Water Crossings

1. Silt curtains, cofferdams, dikes, straw bales or other suitable erosion control measures will be used to prevent erosion from entering water bodies during construction.
2. Water quality parameters will be monitored before, during, and after construction to ensure compliance with State Water Quality Standards. In-water work will stop if State Water Quality Standards are exceeded at or below the worksite.
3. Construction of the cofferdam will be scheduled during minimal low flows to avoid and minimize direct or indirect effects to fish species. River flows up- and downstream of construction areas will be maintained. Fish passage around dewatered construction areas will be maintained at all times.
4. A fish net barrier will be installed upstream and downstream of the construction site during construction to exclude fish from the work area during periods of in-water work.
5. Reclamation will coordinate with the Service to have a biologist(s) on site to rescue any fish species stranded as a result of construction activities.
6. Concrete pours will occur in forms and/or behind cofferdams to prevent discharge into the river. Any wastewater from concrete-batching, vehicle wash-down and aggregate processing will be contained and treated or removed for off-site disposal.
7. Fuels, lubricants, hydraulic fluids, and other petrochemicals will be stored and dispensed outside the 100-year floodplain in an approved staging area. Equipment will be inspected daily for petrochemical leaks. Construction equipment will be parked, stored and serviced only at approved staging area, outside of the 100-year floodplain.
8. An oil spill response plan will be prepared for areas of work where spilled contaminants could flow into water bodies. All employees and workers, including those under separate contract, will be briefed and made familiar with this plan. The plan will be developed prior to initiation of construction. Oil spill response kit, which includes appropriate sized spill blankets, shall be easily accessible and on-site at all times.
9. On-site supervisors and equipment operators will be trained and knowledgeable in the use of spill containment equipment.
10. Appropriate Federal and State authorities will be immediately notified in the event of any contaminant spill.
11. Disturbed areas within the wetted channel will be covered with clean cobble or quarry stone from an upland source. Disturbed areas adjacent to the wetted channel will be stabilized and planted with native riparian vegetation.

The following conservation measures will be implemented for the Mesa Verde cactus (cactus):

1. Prior to the completion of final design, Reclamation will inventory known populations and suitable Mesa Verde Cactus habitat within 500 feet of the proposed pipeline alignment, pumping plant, and construction footprint. Because initial pre-engineering surveys were conducted in 2001 and 2002, during the drought, and because it will be many years between when the initial surveys were conducted and when the project will be constructed, it is important that these areas be surveyed again

2. Based on the results of these inventories, Reclamation will develop a detailed *Mesa Verde Cactus Construction Plan* (Construction Plan) for the purposes of avoiding and minimizing disturbance to Mesa Verde cacti and suitable habitat to the greatest extent possible. The Construction Plan will be submitted to the Service and Navajo Nation for review and comments thirty days prior to any construction activities occurring. Specific locations of cacti will be kept confidential and no Universal Transverse Mercator (UTM) coordinates or similar location data will be included in the final report available to the general public.

3. Construction areas, including pipeline alignments, pumping plants, temporary and permanent access roads, staging areas, etc., will be located in coordination with project engineers and Reclamation resource specialists to avoid individual cactus and habitat identified during the inventories. To the extent practicable, impacts to Mesa Verde Cacti and/or suitable Mesa Verde Cactus habitat will be minimized. Existing roads and previously disturbed areas (i.e. power lines, fence lines, prior construction staging areas) will be utilized where possible to minimize impacts. If temporary construction access roads are needed that will be sited closer than 50 feet from known individual cactus locations, these plants will be monitored during road use. The edges of these access roads will be flagged in the field.

4. When construction is complete, temporary access roads and staging areas within suitable Mesa Verde habitat will be closed and hand-raked to remove tire tracks. Because of the delicate natural of soil structure in areas that support Mesa Verde cacti, no post-construction reseeding will be implemented in these areas.

5. Pre-construction surveys for Mesa Verde cacti will be conducted in the spring of the year preceding the initiation of construction activities to identify any new cacti. All areas that may be affected (directly or indirectly) by construction, operation, or maintenance of the pipeline and pumping plant will be surveyed. The locations of any additional cacti identified during the pre-construction surveys will be incorporated into the Construction Plan. Appropriate mitigation measures will be developed in consultation with the Service and the Navajo Nation if impacts to these new plants cannot be avoided.

6. Reclamation will develop an education program for all Reclamation field staff and all contractor employees regarding identification and conservation of the Mesa Verde cactus.

The program will include information about the legal and biological status of the Mesa Verde cactus, the importance of habitat preservation, the occurrence of cactus and suitable habitat in the area, the Mesa Verde Cactus Construction Plan, fines for damaging or removing cactus, and procedures for reporting cacti not previously indentified.

7. All sites where Mesa Verde cacti are present will be fenced or flagged as detailed in the Construction Plan and monitored daily by Reclamation resource specialists when construction activities are ongoing in the vicinity. Fencing will extend 200 feet in both directions along access roads beyond the limits of each site. Where possible, fencing will include a 50 feet buffer around any known cacti during construction activities. All fencing will be inspected daily and maintained as needed to ensure adequate protection. All construction contracts will have "stop work clauses" if new cacti are discovered. Any disturbance to cacti observed by construction personnel will be reported immediately to Reclamation. A written account including a map, extent of the disturbance, the number of cacti, and the circumstances surrounding the disturbance will be submitted to the Service and Navajo Nation within 48 hours.

8. All traffic will be limited to routes specified in the Construction Plan via designated work area and access roads and previously inventoried for Mesa Verde cactus. Cross-county travel within occupied and/or suitable Mesa Verde cactus habitat will be strictly prohibited.

9. To reduce the likelihood of noxious plants, cleaning of construction equipment will be required before entry into occupied or suitable Mesa Verde cactus habitat.

10. Routine post-construction inspections of the pipeline in suitable Mesa Verde cactus habitat will be performed using defined access roads. Additional surveys for Mesa Verde Cactus in suitable habitat will be required prior to any ground disturbing activity for maintenance. Survey results will be valid for three years.

11. Where features cannot be re-routed or moved to avoid impacts to individual Mesa Verde cacti, the cacti will be transplanted in suitable habitat in cooperation with the Service and the Navajo Nation as described in the Construction Plan. Transplanted cacti will monitored for a minimum of 5 years. Applicable permits from the Service and Navajo Nation will be obtained prior to transplanting Mesa Verde cactus.

12. Noxious weeds will be continually controlled within disturbed areas.

The Service requires, as part of the Terms and Conditions that documentation and reporting on the implementation of the conservation measures will occur within six months after completion of the project. Annually, thereafter for a period of five years, documentation and reporting will occur on the status of transplanted and relocated cacti and on control of noxious weeds within the disturbed sites.

STATUS OF THE SPECIES AND CRITICAL HABITAT

Colorado Pikeminnow

The pikeminnow is the largest cyprinid (member of the minnow family, Cyprinidae) native to North America and it evolved as the top predator in the Colorado River system. It is an elongated pike-like fish that once grew as large as 1.8 meters (m) (6 feet) in length and weighed nearly 45 kilograms (100 pounds) (Behnke and Benson 1983); such fish were estimated to be 45-55 years old (Osmundson et al. 1997). Today, fish rarely exceed 1 m (approximately 3 feet) in length or weigh more than 8 kilograms (18 pounds). 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 pikeminnow longer than 80 to 100 millimeters (mm) (3 or 4 inches [in]) consists almost entirely of other fishes (Vanicek and Kramer 1969). Adults are strongly counter-shaded 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.

Based on early fish collection records, archaeological finds, and other observations, the pikeminnow was once found throughout warm water reaches of the entire Colorado River Basin down to the Gulf of California, including reaches of the upper Colorado River and its major tributaries, the Green River and its major tributaries, the San Juan River and some of its tributaries, and the Gila River system in Arizona (Seethaler 1978, Platania 1990). Pikeminnow apparently were never found in colder, headwater areas. Seethaler (1978) indicates that the species was abundant in suitable habitat throughout the entire Colorado River Basin prior to the 1850s. By the 1970s they were extirpated from the entire lower Basin (downstream of Glen Canyon Dam) and from portions of the upper Basin as a result of major alterations to the riverine environment. Having lost approximately 75-80 percent of its former range, the pikeminnow was federally listed as an endangered species in 1967 (Service 1967, Miller 1961, Moyle 1976, Tyus 1991, Osmundson and Burnham 1998).

Critical habitat is defined as the areas that provide physical or biological features that are essential for the recovery of the species. Critical habitat was designated for the pikeminnow in 1994, within the 100-year floodplain of the species' historical range in the following areas of the San Juan River Basin (59 FR 13374): New Mexico, San Juan County; and Utah, San Juan County. The San Juan River from the State Route 371 Bridge in T. 29 N., R. 13 W., section 17 to the full pool elevation at the mouth of Neskahai Canyon on the San Juan arm of Lake Powell in T. 41 S., R. 11 E., section 26.

The Service identified water, physical habitat, and the biological environment as primary constituent elements of critical habitat. This includes a quantity of water of sufficient quality that is delivered to specific habitats in accordance with a hydrologic regime that is required for the particular life stage for the 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, which when inundated provide access to spawning, nursery, feeding, and rearing habitats, are included. Food supply, predation, and competition are important elements of the biological environment.

Life History

The life history phases that appear to be most limiting for pikeminnow populations include spawning, egg hatching, development of larvae, and the first year of life. These phases of pikeminnow development are tied closely to specific habitat requirements. Natural spawning of pikeminnow is initiated on the descending limb of the annual hydrograph as water temperatures approach the range of 16˚C (60.8˚F) to 20˚C (68˚F) (Vanicek and Kramer 1969, Hamman 1981, Haynes et al. 1984, Tyus 1990, McAda and Kaeding 1991). Temperature at initiation of spawning varies by river. In the Green River, spawning begins as temperatures exceed 20-23˚C (68-73˚F); in the Yampa River, 16-23˚C (61-68˚F) (Bestgen et al. 1998); in the Colorado River, 18-22˚C (64-72˚F) (McAda and Kaeding 1991); in the San Juan River temperatures were estimated to be 16-22˚C (61-72˚F).

Spawning, both in the hatchery and under natural riverine conditions, generally occurs in a two-month period between late June and late August; however, sustained high flows during wet years may suppress river temperatures and extend spawning into September (McAda and Kaeding 1991). Conversely, during low flow years, when the water warms earlier, spawning may commence in mid-June. On the San Juan River, based on the collection of larval fish from 1993 to 2007, spawning has occurred between June 24 and July 18 (Brandenburg and Farrington 2008).

Temperature also has an effect on egg development and hatching success. In the laboratory, egg development was tested at 5 temperatures and hatching success was found to be highest at 20˚C (68˚F), and lower at 25˚C (77˚F). Mortality was 100 percent at 5, 10, 15, and 30˚C (41, 50, 59, and 86˚F). In addition, larval abnormalities were twice as high at 25˚C (77˚F) than at 20˚C (68˚F) (Marsh 1985). Experimental tests of temperature preference of yearling (Black and Bulkley 1985a) and adult (Bulkley et al. 1981) pikeminnow indicated that 25˚C (77˚F) was the most preferred temperature for both life phases. Additional experiments indicated that optimum growth of yearlings also occurs at temperatures near 25˚C (77˚F) (Black and Bulkley 1985b). Although no such tests were conducted using adults, the tests with yearlings supported the conclusions of Jobling (1981) that the final thermal preference of 25˚C (77˚F) provides a good indication of optimum growth temperature for all life phases.

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 in) in length (Vanicek and Kramer 1969, Seethaler 1978, Hamman 1981). Hatchery-reared males became sexually mature at 4 years of age and females at 5 years. Average fecundity of 24, 9-year old females was 77,400 (range, 57,766 to 113,341) or 55,533 eggs/kg, and average fecundity of 9 ten-year old females was 66,185 (range, 11,977 to 91,040) or 45,451 eggs/kg (Hamman 1986).

Most information on pikeminnow reproduction has been gathered from spawning sites on the lower 20 miles (12.2 kilometers) of the Yampa River and in Gray Canyon on the Green River (Tyus and McAda 1984, Tyus 1985, Wick et al. 1985, Tyus 1990). Pikeminnow spawn after peak runoff subsides. Spawning is probably triggered by several interacting variables such as day length, temperature, flow level, and perhaps substrate characteristics. Known spawning sites in the Yampa River are characterized by riffles or shallow runs with well-washed coarse substrate (cobble containing relatively deep interstitial voids (for egg deposition)) in association with deep pools or areas of slow non-turbulent flow used as staging areas by adults (Lamarra et al. 1985, Tyus 1990). Recent investigations at a spawning site in the San Juan River by Bliesner and Lamarra (1995) and at one site in the upper Colorado River (Service unpubl. data) indicate a similar association of habitats. The most unique feature at the sites used for spawning, in comparison with otherwise similar sites nearby, is the lack of embeddedness of the cobble substrate and the depth to which the rocks are devoid of fine sediments; this appears consistent at the sites in all three rivers (Lamarra et al. 1985, Bliesner and Lamarra 1995).

Collections of larvae and young-of-year (YOY) downstream of known spawning sites in the Green, Yampa, and San Juan rivers demonstrate that downstream drift of larval pikeminnow occurs following hatching (Haynes et al. 1984, Nesler et al. 1988, Tyus 1990, Tyus and Haines 1991, Platania 1990, Brandenburg and Farrington 2008). Studies on the Green and Colorado rivers found that YOY used backwaters almost exclusively (Holden 2000). During their first year of life, pikeminnow prefer warm, turbid, relatively deep (averaging 0.4 m [1.3 feet]) backwater areas of zero velocity (Tyus and Haines 1991). After about 1 year, young are rarely found in such habitats, although juveniles and subadults are often located in large deep backwaters during spring runoff (Service, unpublished data; Osmundson and Burnham 1998).

Pikeminnow often migrate considerable distances to spawn in the Green and Yampa Rivers (Miller et al. 1982, Archer et al. 1986, Tyus and McAda 1984, Tyus 1985, Tyus 1990), and similar movement has been noted in the main stem San Juan River. A fish captured and tagged in the San Juan arm of Lake Powell in April 1987, was recaptured in the San Juan River approximately 80 miles upstream in September 1987 (Platania 1990). Ryden and Ahlm (1996) report that a pikeminnow captured at river mile (RM) 74.8 (between Bluff and Mexican Hat) made a 50-60 mile migration during the spawning season in 1994, before returning to within 0.4 river miles of its original capture location.

Although migratory behavior has been documented for pikeminnow in the San Juan River (Platania 1990, Ryden and Ahlm 1996), of 13 radio-tagged fish tracked from 1991 to 1994, 12 were classified as sedentary and only one as migratory (Ryden and Ahlm 1996). Miller and Ptacek (2000) followed 7 radio-tagged wild pikeminnow in the San Juan River and found these fish used a localized area of the river (RM 120 to RM 142). In addition, wild adult pikeminnow were most abundant between RM 142 (the former Cudei Diversion) and Four Corners at RM 119 (Ryden and Ahlm 1996) and primarily used the San Juan River between these points (Ryden and Pfeifer 1993, 1994, 1995a, 1996). The highest catch rates for stocked pikeminnow are also between RM 120 to RM 141 (Davis and Furr 2008). The multi-threaded channel, habitat complexity, and mixture of substrate types in this area of the river appear to provide a diversity of habitats favorable to pikeminnow on a year-round basis (Holden and Masslich 1997).

In contrast to pikeminnow in the Green and Yampa rivers, the majority of pikeminnow in the San Juan River reside near the area in which they spawn (Ryden and Ahlm 1996, Miller and Ptacek 2000). During their study, Ryden and Ahlm (1996) found that pikeminnow in the San Juan River aggregated at the mouth of the Mancos River prior to spawning, a behavior not documented in other rivers in the upper Colorado River Basin. Miller and Ptacek (2000) also recorded two pikeminnow in both 1993 and 1994 at the mouth of the Mancos River prior to the spawning period.

Historical spawning areas for the pikeminnow in the San Juan River are unknown; however, Platania (1990) speculated that spawning likely occurred upstream at least to Rosa, New Mexico. Two locations in the San Juan River have been identified as potential spawning areas based on radio telemetry and visual observations (Ryden and Pfeifer 1994, Miller and Ptacek 2000). Both locations occur within the "Mixer" (RM 133.4 to 129.8), a geomorphically distinct reach of the San Juan River. The upper spawning location is located at RM 132 and the lower spawning location at approximately RM 131.1. Both locations consist of complex habitat associated with cobble bar and island complexes. Habitat at these locations is similar to spawning habitats described for the Yampa River and is composed of side channels, chutes, riffles, slow runs, backwaters, and slackwater areas near bars and islands. Substrate in the riffle areas is clean cobbles, primarily 7.6 to 10.2 centimeters (cm) (3 to 4 in) in diameter (Miller and Ptacek 2000). Habitat characteristics at the lower spawning area, based on radio telemetry and visual observations, include a fast narrow chute adjacent to a small eddy.

During 1993, radio-tagged pikeminnow were observed moving to potential spawning locations in the Mixer beginning around July 1. Fish were in the spawning areas from approximately July 12 to July 25. During this period flows in the San Juan River were on the descending limb of the spring runoff. Temperatures increased from approximately 20 to 25˚C (68 to 77˚F) during the same time period. Observations in other years show a similar pattern; however, specific spawning times and duration of the spawning period appear to vary from year to year. Information on radio-tagged adult pikeminnow during the fall suggests that pikeminnow seek out deep water areas in the Colorado River (Miller et al. 1982, Osmundson and Kaeding 1989), as do many other riverine species. Pools, runs, and other deep water areas, especially in upstream reaches, are important winter habitats for pikeminnow (Osmundson et al. 1995).

On the Green River, tributaries are an important habitat component for pikeminnow (Holden 2000). Both the Yampa and White rivers were heavily used by pikeminnow subadults and adults, apparently as foraging areas (Tyus 1991). The tributaries were the primary area of residence to which the adults returned after spawning. Nearly all tributaries to the San Juan River no longer provide habitat for adults because they are dewatered or access is restricted (Holden 2000); however, pikeminnow utilized the Animas River in the late 1800s and this river could still provide suitable habitat. Five stocked pikeminnow were documented in the lower reaches of the Animas River in 2004 (SJRRIP unpublished data). Since the installation of the selective fish passage structure at RM 166 in 2003, 28 pikeminnow have passed upstream increasing the probability that the Animas River, 15 miles upstream, will once again be utilized by this species. Pikeminnow aggregated at the mouth of the Mancos River prior to spawning in the early 1990s (Ryden and Ahlm 1996, Miller and Ptacek 2000).

Very little information is available on the influence of turbidity on the endangered Colorado River fishes. Osmundson and Kaeding (1989) found that turbidity allows use of relatively shallow habitats ostensibly by providing adults with cover; this allows foraging and resting in areas otherwise exposed to avian or terrestrial predators. Tyus and Haines (1991) found that young pikeminnow in the Green River preferred backwaters that were turbid. Bestgen et al. (2006) found that in a laboratory setting, turbidity provided some protection to larval pikeminnow from predation by red shiner. Clear conditions in shallow backwaters might expose larval and juvenile fish to predation from wading birds or non-native, sight-feeding, piscivorous fish. It is unknown whether the river was as turbid historically as it is today. Currently, it is assumed that the endemic fishes evolved under conditions of high turbidity. Therefore, the retention of highly turbid conditions is probably an important factor in maintaining the ability of pikeminnow to compete with, or avoid predation by non-natives that may not have evolved under similar conditions.

Population Dynamics

Between 1991 and 1995, 19 (17 adult and 2 juvenile) wild pikeminnow were collected in the San Juan River by electrofishing (Ryden 2000a). No wild adults have been captured in the San Juan River since 1999 (Ryden, annual adult monitoring reports, 2000-2008).

Estimates during the seven-year research period between 1991 and 1997 suggested that there were fewer than 50 adult pikeminnow in a given year (Ryden 2000a). Monitoring for adult pikeminnow occurs every year on the San Juan River. In 2007, 167 pikeminnow were collected during the monitoring trip, the fourth consecutive year that more than 100 pikeminnow were caught (Ryden 2008). However, only 2 of these fish were greater than 350 mm. In addition, 12 pikeminnow, greater than 400 mm were collected during the non-native fish removal trips in 2007 (Davis and Furr 2008). One of these individuals was 11 years old (709 mm) and was stocked in 1996 as an age-0 fish. Because of the low number of pikeminnow in the San Juan population estimates using mark-recapture techniques have not yet been used. However, the SJRRIP is considering modifying their monitoring so that population numbers can be estimated.

Pikeminnow reproduction was documented in the San Juan River in 1987, 1988, and 1992 through 1996, 2001, 2004, and 2007 by the collection of larvae and/or YOY (Archer et al. 1995, Buntjer et al. 1994, Lashmett 1994, Platania 1990, Brandenburg and Farrington 2008). The majority of the YOY pikeminnow were collected in the San Juan River inflow to Lake Powell (Archer et al. 1995, Buntjer et al. 1994, Lashmett 1994, Platania 1990). Some YOY pikeminnow have been collected near the Mancos River confluence, New Mexico and in the vicinity of the Montezuma Creek confluence near Bluff, Utah, and at a drift station near Mexican Hat, Utah (Buntjer et al. 1994, Snyder and Platania 1995). The collection of larval fish (only a few days old) at Mexican Hat in two different years suggests that perhaps another spawning area for pikeminnow exists somewhere below the Mixer (Platania 1996). Capture of a larval pikeminnow at RM 128 during August 1996 was the first larva collected immediately below the suspected spawning site in the Mixer (Holden and Masslich 1997).

Platania (1990) noted that, during 3 years of studies on the San Juan River (1987 - 1989), spring flows and pikeminnow reproduction were highest in 1987. He further noted catch rates for channel catfish were lowest in 1987. Subsequent studies (Brooks et al. 1994) found declines in channel catfish in 1993; these declines have been attributed to successive years of higher than normal spring runoffs from 1991 through 1993. Recent studies also found catch rates for YOY pikeminnow to be highest in high water years, such as 1993 (Buntjer et al. 1994, Lashmett 1994). Franssen et al. (2007) found that maintenance of a natural flow regime favored native fish reproduction and provided a prey base at the appropriate time for age-1 pikeminnow.

Tissue samples from pikeminnow caught during research conducted under the SJRRIP have been analyzed as part of a Basin-wide analysis of endangered fish genetics. The results of that analysis indicate that the San Juan River fish exhibit less genetic variability than the Green and Colorado river populations, likely due to the small population size, but were very similar to pikeminnow from the Green, Colorado, and Yampa rivers (Morizot in litt. 1996). These data suggest that the San Juan population is probably not a separate stock (Holden and Masslich 1997).

Competition and Predation

Pikeminnow in the upper Colorado River Basin live with about 20 species of warm-water non-native fishes (Tyus et al. 1982, Lentsch et al. 1996) that are potential predators, competitors, and vectors for parasites and disease. Backwaters and other low-velocity habitats in the San Juan River are important nursery areas for larval and juvenile pikeminnow (Holden 1999) and researchers believe that overlap in these habitats with non-native fish species limit the success of pikeminnow recruitment (Bestgen 1997, Bestgen et al. 1997, McAda and Ryel 1999). Osmundson (1987) documented predation by black bullhead (*Ameiurus melas*), green sunfish (*Lepomis cyanellus*), largemouth bass (*Micropterus salmoides*), and black crappie (*Pomoxis nigromaculatus*) as a significant mortality factor for YOY and yearling pikeminnow stocked in riverside ponds along the upper Colorado River. Pilger et al. (2008) found that although non-native fishes comprised more than 80 percent of the potential prey base in the San Juan River, significantly more native fishes were identified in the stomachs of juvenile largemouth bass.

Adult red shiners (*Cyprinella lutrensis*) are known predators of larval native fish in backwaters of the upper Basin (Ruppert et al. 1993) and laboratory predation experiments showed that red shiners were moderately successful and persistent predators of pikeminnow larvae (Bestgen et al. 2006). High spatial overlap in habitat use has been documented among young pikeminnow, red shiner, sand shiner (*Notropis stramineus*), and fathead minnow (*Pimephales promelas*). In laboratory experiments on behavioral interactions, Karp and Tyus (1990) observed that red shiner, fathead minnow, and green sunfish shared activity schedules and space with young pikeminnow and exhibited antagonistic behaviors to smaller pikeminnow. They hypothesized that pikeminnow may be at a competitive disadvantage in an environment that is resource limited.

Channel catfish (*Ictalurus punctatus*) has been identified as a threat to juvenile, subadult, and adult pikeminnow in the San Juan River. Channel catfish were first introduced in the upper Colorado River Basin in 1892 (Tyus and Nikirk 1990) and are now considered common to abundant throughout much of the upper Basin (Tyus et al. 1982, Nelson et al. 1995). The species is one of the most prolific predators in the upper Basin and, among the non-native fishes, is thought to have the greatest adverse effect on endangered fishes due to predation on juveniles and resource overlap with subadults and adults (Hawkins and Nesler 1991, Lentsch et al. 1996, Tyus and Saunders 1996). Stocked juvenile and adult pikeminnow that have preyed on channel catfish have died from choking on the pectoral spines (McAda 1983, Pimental et al. 1985, Ryden and Smith 2002). Although mechanical removal (electrofishing, seining) of channel catfish began in 1995, intensive efforts (10 trips/year) did not begin until 2001. Mechanical removal has not yet led to a positive population response in pikeminnow (Davis 2003); however, because the pikeminnow population is so low, documenting a population response would be extremely difficult.

Status and Distribution

The pikeminnow was designated as endangered prior to the ESA of 1973, as amended (16 U.S.C. 1531 et seq.); therefore, a formal listing package identifying threats was not prepared. Construction and operation of mainstem dams, non-native fish, and local eradication of native minnow and suckers in the early 1960s were recognized as early threats (Miller 1961, Holden 1991). The pikeminnow recovery goals (Service 2002a) summarize threats to the species as follows: stream regulation, habitat modification, competition with and predation by non-native fish, and pesticides and pollutants.

Major declines in pikeminnow populations occurred in the lower Colorado River Basin during the dam-building era of the 1930s through the 1960s. Behnke and Benson (1983) summarized the decline of the natural ecosystem, noting 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 main stem fragmented the river ecosystem into a series of disjunct segments, blocked native fish migrations, reduced water temperatures downstream of dams, created lake habitat, and provided conditions that allow competitive and predatory non-native 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 non-native fishes decimated populations of native fish and led to the listing of 7 of the 10 mainstem fishes as endangered (Mueller 2005).

In the upper Colorado River Basin, declines in pikeminnow populations occurred primarily after the 1960s, when the following dams were constructed: Glen Canyon Dam on the main stem Colorado River, Flaming Gorge Dam on the Green River, Navajo Dam on the San Juan River, and the Aspinall Unit dams on the Gunnison River. Some native fish populations in the upper Basin have managed to persist, while others are nearly extirpated. River reaches where native fish have declined more slowly, more closely resemble pre-dam hydrologic regimes, where adequate habitat for all life phases still exists, and where migration corridors allow connectivity among habitats used during the various life phases.

Two factors not considered when the pikeminnow was listed were water quality and climate change. Surface and ground water quality in the Animas, La Plata, Mancos, and San Juan River drainages are a concern (Abell 1994). Changes in water quality and contamination of associated biota are known to occur in Reclamation projects in the San Juan drainage (i.e., irrigated lands on the Pine and Mancos rivers) where return flows from irrigation make up a portion of the river flow (Sylvester et al. 1988). Increased loading of the San Juan River and its tributaries with heavy metals; elemental contaminants such as selenium, salts, polycyclic aromatic hydrocarbons (PAHs); and pesticides has degraded water quality of the San Juan River in critical habitat (Abell 1994, Wilson et. al. 1995, Holden 1999). In particular, mercury and selenium are a concern in the San Juan River.

Warming of the earth's climate is "unequivocal," as is now evident from observations of increases in average global air and ocean temperatures, widespread melting of glaciers and the polar ice cap, and rising sea level (IPCC 2007). The Intergovernmental Panel on Climate Change (2007) describes changes in natural ecosystems with potential wide-spread effects on many organisms, including freshwater fish. The potential for rapid climate change poses a significant challenge for fish and wildlife conservation. Species' abundance and distribution is dynamic, and dependent on a variety of factors, including climate (Parmesan and Galbraith 2004). Typically, as climate changes, the abundance and distribution of fish and wildlife change. In highly modified systems like the San Juan River, where the pikeminnow population is trapped between two dams, the ability to disperse to other, potentially more favorable habitats, has been lost. Highly specialized or endemic species are likely to be most susceptible to the stresses of changing climate. Based on these findings and other similar studies, the Department of the Interior (DOI) requires agencies under its direction to consider potential climate change effects as part of their long-range planning activities (Service 2007).

Climate change is of particular concern in the Colorado River Basin, of which the San Juan River is a tributary for several reasons. First, The Colorado River Compact which governs water allocations between the upper and lower Colorado River basin was signed in 1922, based on a short hydrological record of relatively high annual flows (Christensen and Lettenmaier 2006). Tree-ring reconstructions of Colorado River flows indicate that the gaged record covers only a small subset of the range of variability and the basin's future hydrology may not reasonably be based on the relatively short gaged record (NRC 2007). Consequently, there is less water available to allocate than originally thought. Second, the Colorado River basin has warmed approximately 1.4°C (2.5°F) over the past century with temperatures today at least 0.8°C (1.5°F) warmer than during the 1950 drought (NRC 2007, Lenart 2007). Both in terms of absolute degrees and in terms of annual standard deviation, the Colorado River Basin has warmed more than any region of the United States (NRC 2007). Increased air temperatures are expected to result in reduced runoff, even if precipitation were to increase. Third, increases in urban water demand will further stress supplies. Conflict over water is expected to increase, making it more challenging to maintain appropriate flows for endangered fishes.

In the Southwest, Hoerling (2007) states that relative to 1990–2005, model simulations indicate that a 25 percent decline in stream flow would occur from 2006–2030 and a 45 percent decline would occur from 2035–2060. Seager et al. (2007) demonstrate that there is a broad consensus among climate models that the Southwest will get drier in the 21st century and that the transition to an even more arid climate is already under way. Only one of 19 models demonstrated a trend toward a wetter climate in the Southwest (Seager et al. 2007). They project a decrease in runoff of 8 to 25 percent. The Colorado River basinwide snow water equivalent is projected to decline by 13 to 38 percent from 2025 to 2085 (Christensen and Lettenmeier 2006). Ray et al. (2008) and Udall (2007) summarize several studies which all point to an expected decline in runoff in the Colorado River basin. Although the San Juan River is not modeled independent of the entire Colorado River basin in these studies, it is reasonable to expect that a similar pattern will occur.

Because water allocations in the San Juan River were based on flows recorded during a relatively wet period, if climate change leads to a long-term decline in runoff, meeting the all the human demands, and the needs of the pikeminnow through the Flow Recommendations, could become challenging in the future. Other changes that are likely to occur from climate change are an earlier spring runoff and an increase in extreme events (i.e., drought or precipitation). A new environmental baseline will become established over time, with consequences to native species that are difficult to accurately predict.

In summary, at the time of listing few pikeminnow remained in the San Juan River as a result of human impacts. Since the initiation of the SJRRIP, based on numbers of fish, their status has improved primarily through an aggressive augmentation program. Their long-term viability remains uncertain because of the relatively limited habitat available between Navajo Dam and Lake Powell, competition and predation from nonnative fishes, water quality issues, and the uncertainty surrounding the changes that climate change will bring to the San Juan basin.

Razorback Sucker

Like all suckers (family Catastomidae, 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 lbs) in weight and 600 mm (2 ft) in length. Like pikeminnow, razorback suckers may live 40-plus years.

Historically, razorback suckers were found in the main stem Colorado River and major tributaries in Arizona, California, Colorado, Nevada, New Mexico, Utah, Wyoming, and in Mexico (Minckley 1983). Bestgen (1990) reported that this species was once so numerous that it was commonly used as food by early settlers and that a commercially marketable quantity was caught in Arizona as recently as 1949. In the upper Colorado River Basin, razorback suckers were reported to be very abundant in the Green River 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, the first documented razorback sucker from the river was documented in 1988 (Platania 1990); however, two adults were also collected from an irrigation pond attached to the river by a canal in 1976 (Platania 1990) and it is very likely that razorback sucker once occurred in the main stem as far upstream as Rosa, New Mexico (now inundated by Navajo Reservoir) (Ryden 1997).

A marked decline in populations of razorback suckers can be attributed to construction of dams and reservoirs, introduction of non-native fishes, and removal of large quantities of water from the Colorado River system. Dams on the main stem Colorado River and its major tributaries have fragmented populations and blocked migration routes. Dams also have drastically altered flows, water 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 non-native fishes, many of which have thrived due to man-induced changes to the natural riverine system. Habitat has been significantly degraded to a point where it impairs the essential life history functions of razorback sucker, such as reproduction and recruitment into the adult population.

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 that "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" (59 FR 13374). Recruitment of larval razorback suckers to juveniles and adults continues to be a problem.

Critical habitat was designated in 1994, within the 100-year flood plain of the razorback sucker's historical range in the following area of the San Juan River Basin (59 FR 13374): New Mexico, San Juan County; and Utah, San Juan County. The San Juan River from the Hogback Diversion in T. 29 N., R. 16 W., section 9 to the full pool elevation at the mouth of Neskahai Canyon on the San Juan arm of Lake Powell in T. 41 S., R. 11 E., section 26.

The primary constituent elements of critical habitat are the same as those described earlier for pikeminnow.

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 main stem river and that razorback suckers presumably moved to these areas for feeding, resting, sexual maturation, spawning, and other activities associated with their reproductive cycle.

While razorback suckers have never been directly observed spawning in turbid riverine environments within the upper Colorado River Basin, captures of ripe specimens, both males and females, have been recorded in the Yampa, Green, Colorado, and San Juan rivers (Valdez et al. 1982, McAda and Wydoski 1980, Tyus 1987, Osmundson and Kaeding 1989, Tyus and Karp 1989, Tyus and Karp 1990, Osmundson and Kaeding 1991, Platania 1990, Ryden 2000b). Because of the relatively steep gradient in the San Juan River and lack of a wide flood plain, razorback sucker are likely spawning in low velocity, turbid, main channel habitats. Based on catches of protolarvae, it appears that there are most likely three spawning locations in the San Juan River (Brandenburg and Farrington 2008).

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. Both sexes mature as early as age four (McAda and Wydoski 1980). Fecundity, based on ovarian egg counts, ranges from 75,000 to 144,000 eggs (Minckley 1983). McAda and Wydoski (1980) reported an average fecundity (N=10) of 46,740 eggs/fish (range, 27,614 to 76,576). Several males attend each female; no nest is built. The adhesive eggs drift to the bottom and hatch there (Sublette et al. 1990). Marsh (1985) reported that percentage egg hatch was greatest at 20°C (68°F) and all embryos died at incubation temperatures of 5, 10, and 30°C (41, 50, and 86°F).

Bestgen (2008) found that growth of early life stages was positively related to water temperature and that fastest growth occurred at 25.5˚C (79.9˚F). Average weight of razorback suckers raised in 25.5˚C (79.9˚F) water was about 4 times that of those in 16.5˚C (61.7˚F) (Bestgen 2008).

Because young and juvenile razorback suckers are rarely encountered, their habitat requirements in the wild are not well known, particularly in native riverine environments. However, it is assumed that low-velocity backwaters and side channels are important for YOY and juveniles, as it is to the early life stages of most riverine fish. Prior to construction of large main stem dams and the suppression of spring peak flows, low velocity, off-channel habitats (seasonally flooded bottomlands and shorelines) were commonly available throughout the upper Colorado River Basin (Tyus and Karp 1989, Osmundson and Kaeding 1991). Modde (1996) found that on the Green River, larval razorback suckers entered flooded bottomlands that are connected to the main channel during high flow. Because of the relatively steep gradient of the San Juan River and the lack of a wide flood plain, flooded bottomlands are probably much less important in this system than are other low velocity habitats such as backwaters and secondary channels (Ryden, Service, in litt. 2004).

Reduction in spring peak flows eliminates or reduces the frequency of inundation of off-channel and bottomland habitats. The absence of these seasonally flooded riverine habitats is believed to be a limiting factor in the successful recruitment of razorback suckers in other upper Colorado River streams (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 that provide adequate zooplankton densities for larval food as one of the most important factors limiting recruitment. Maintaining low velocity habitats is important for the survival of larval razorback suckers.

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). Their diet consists primarily of algae, plant debris, and aquatic insect larvae (Sublette et al. 1990).

Population Dynamics

Because wild razorback sucker are rarely encountered and they are a long-lived fish, it is difficult to determine natural fluctuations in the population. The existing scientific literature and historic accounts by local residents strongly suggest that razorback suckers were once a viable, reproducing member of the native fish community in the San Juan River drainage. Currently, razorback sucker is rare throughout its historic range and extremely rare in the main stem San Juan River. Until 2003, there was very limited evidence indicating natural recruitment to any population of razorback sucker in the Colorado River system (Bestgen 1990, Platania 1990, Platania et al. 1991, Tyus 1987, McCarthy and Minckley 1987, Osmundson and Kaeding 1989, Modde et al. 1996). In 2003, two juvenile (age-2) razorback sucker, 249 and 270 mm (9.8 and 10.6 in), thought to be wild-produced from stocked fish were collected in the lower San Juan River (RM 35.7 and 4.8) (Ryden, Service, in litt., 2004). One age-1 razorback sucker, also thought to be wild-produced, was caught each in 2004 and 2006 (Brandenburg and Farrington 2007) indicating limited recruitment may be occurring.

Competition and Predation

Many species of non-native fishes occur in occupied habitat of the razorback sucker. These non-native fishes are predators, competitors, and vectors of parasites and diseases (Tyus et al. 1982, Lentsch et al. 1996, Pacey and Marsh 1999, Marsh et al. 2001). Many researchers believe that non-native species are a major cause for the lack of recruitment (e.g., McAda and Wydoski 1980, Minckley 1983, Tyus 1987, Muth et al. 2000). There are reports of predation of razorback sucker eggs and larvae by common carp (*Cyprinus carpio*), channel catfish, smallmouth bass (*Micropterus dolomeiui*), largemouth bass, bluegill (*Lepomis macrochirus*), green sunfish, and redear sunfish (*Lepomis microlophus*) (Jonez and Sumner 1954, Marsh and Langshorst 1988, Langhorst 1989). Marsh and Langhorst (1988) found higher growth rates in larval razorback sucker in the absence of predators in Lake Mohave, and Marsh and Brooks (1989) reported that channel catfish and flathead catfish were major predators of stocked razorback sucker in the Gila River. Juvenile razorback sucker (average total length 171 mm [6.7 in]) stocked in isolated coves along the Colorado River in California, suffered extensive predation by channel catfish and largemouth bass (Langhorst 1989). Aggressive behavior between channel catfish and adult razorback sucker has been inferred from the presence of distinct bite marks on the dorsal keels of four razorback suckers that match the bite characteristics of channel catfish (Ryden, Service, in litt. 2004).

Carpenter and Mueller (2008) tested nine non-native species of fish that co-occur with razorback sucker and found that seven species consumed significant numbers of larval razorback suckers. The seven species consumed an average of 54-99 percent of the razorback sucker larvae even though alternative food was available (Carpenter and Mueller 2008). Lentsch et al. (1996) identified six species of non-native fishes in the upper Colorado River Basin as threats to razorback sucker: red shiner, common carp, sand shiner, fathead minnow, channel catfish, and green sunfish. Smaller fish, such as adult red shiner, are known predators of larval native fish (Ruppert et al. 1993). Large predators, such as walleye (*Stizostedion vitreum*), northern pike, and striped bass (*Morone saxatilis*), also pose a threat to subadult and adult razorback sucker (Tyus and Beard 1990). Pilger et al. (2008) found that although non-native fishes comprised more than 80 percent of the potential prey base in the San Juan River, significantly more native fishes were identified in the stomachs of juvenile largemouth bass.

Status and Distribution

Currently, the largest concentration of razorback sucker remaining in the Colorado River Basin is in Lake Mohave. 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 fewer than 3,000 in 2001 (Marsh et al. 2003). A repatriation program was begun in Lake Mohave in 1991 and it appears that repatriated fish have begun to contribute to larval cohorts (Turner et al. 2007). 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, Marsh et al. 2003). Natural populations elsewhere in the Colorado River system remain non-sustaining or have been extirpated (Marsh et al. 2003).

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). Lanigan and Tyus (1989) estimated a population of 948 adults (95 percent confidence interval: 758 to 1,138) in the upper Green River. Eight years later, the population was estimated at 524 adults (95 percent confidence interval: 351-696) and the population was characterized as stable or declining slowly with some evidence of recruitment (Modde et al. 1996). They attributed this suspected recruitment to unusually high spring flows during 1983–1986 that inundated portions of the floodplain used as nurseries by young. 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).

Scientifically documented records of wild razorback sucker adults in the San Juan River are limited to two fish captured in a riverside pond near Bluff, Utah in 1976, and one fish captured in the river in 1988, also near Bluff (Platania 1990). Large numbers were anecdotally reported from a drained pond near Bluff in 1976, but no specimens were preserved to verify the species. No wild razorback sucker were found during the 7-year research period (1991-1997) of the SJRRIP (Holden 1999). Hatchery-reared razorback sucker, especially fish greater than 350 mm (13.8 in), introduced into the San Juan River in the 1990s have survived and reproduced, as evidenced by recapture data and collection of larval fish (Brandenburg and Farrington 2008).

Without intervention through propagation and augmentation programs, razorback sucker would be in imminent danger of extirpation in the wild. The razorback sucker was listed as endangered October 23, 1991 (56 FR 54957). 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 non-native 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 razorback sucker recovery goals identified streamflow regulation, habitat modification, predation by non-native fish species, and pesticides and pollutants as the primary threats to the species (Service 2002b). Within the upper Colorado River Basin, recovery efforts include the capture and removal of razorback suckers from all known locations for genetic analyses and development of brood stocks. In the short-term, augmentation (stocking) may be the only means to prevent the extirpation of razorback sucker in the upper Colorado River Basin. However, in the long-term it is expected that natural reproduction and recruitment will occur. A genetics management plan and augmentation plan have been written for the razorback sucker (Crist and Ryden 2003).

Two factors not considered when the razorback sucker was listed were water quality and climate change. These factors were discussed above under "Status and Distribution" for pikeminnow and are equally important to razorback sucker. In summary, at the time of listing, few razorback sucker remained in the San Juan River. Since the initiation of the SJRRIP, based on number of fish, razorback sucker status has improved primarily through an aggressive augmentation program. Their long-term viability remains uncertain because of the relatively limited habitat available to them between Navajo Dam and Lake Powell, competition and predation from nonnative fishes, water quality issues, and the uncertainty surrounding the changes that climate change will bring to the San Juan basin.

Mesa Verde cactus

Species Description

The Mesa Verde cactus is a small globose, usually single-stemmed, plant 3.2 to 9 cm (1.5 to 3.5 in) in diameter. Each stem has 13 to 17 ribs. Although single-stemmed plants are most common, mechanical damage from insects or mammals may create plants with multiple stems (Ladyman 2004). In years of normal precipitation, stem diameter growth is about 2.6 mm (0.05 to 0.1 in) (Colorado Natural Areas Program 2005). Once the stems grow to about 9 cm (3.5 in), they stop growing consistently larger, and tend to increase or decrease as much as 1.5 cm (0.6 in) in diameter in response to wet and dry years (Colorado Natural Areas Program 2005). The spines are 6 - 13 mm (0.25 - 0.50 in) long in clusters of 8 - 11. The flowers are about 2 cm (0.75 inch) in diameter, cream to yellow-colored, and bloom in late April or early May. The seeds are black, 2.5-3 mm (0.09 in) long (Heil 1984).

Mesa Verde cactus grows in clay soils derived from shales of the Mancos and Fruitland formations. These formations erode easily forming low rolling hills. The soils have high alkalinity, are gypsiferous, and have shrink-swell properties that make them harsh sites for plant growth. The sparse vegetation in the area is dominated by two species of saltbush (*Atriplex corrugata* and *A. nuttallii*) on the uplands, and several species of forbs and grasses (*Chrysothamnus greenei*, *Sphaeralcea coccinea*, *Abronia elliptica*, *Sporobolus cryptandrus*, and *Hilaria jamesii*) in the drainages.

Density varies greatly within populations. As many as 20 Mesa Verde cacti may occur within a 50 m^2 area or there may be a single specimen within several hundred meters. It typically occurs in groups of less than 10 to more than 200 plants on small eroded hills and ridges. Adjacent clusters of cacti may be very close or widely separated by several kilometers of what appears to be suitable, but unoccupied, habitat.

Life History

Mesa Verde cactus is a long-lived perennial (over 40 years) that grows slowly (Ladyman 2004). The flowers possess both stamens and ovaries and are partially self-compatible. Vegetative reproduction also occurs through stem sprouts. Pollinators appear to be primarily hymenopterans in the family Halictidae. Stems begin producing flowers when they are approximately 2.0 cm in diameter and the number of buds, flowers, and fruits are positively correlated with stem diameter (Coles 2003). On average, each MesaVerde cactus produces 200 seeds, approximately 20-30 seeds per fruit (Heil 1984). Seeds are most likely distributed through rain runoff; but wind and ants may also be important in distribution (Ladyman 2004). Seeds ripen in late May to early June but the seed coat must be scarified before germination will occur. It is thought that freezing and thawing the cracks the seed coat (Ladyman 2004). Germination and successful seedling establishment have been observed during years of normal or better than average annual precipitation (Sivinski 2003, Coles 2004). Seedling mortality and lack of germination were noted during periods of severe drought (Sivinski 2003, Coles 2004).

Population Dynamics

Reproductive characteristics were measured annually on more than 1600 Mesa Verde cactus stems in Montezuma County, Colorado, beginning in 1986 (Colorado Natural Areas Program 2005). Coles (2003) identified “recruitment events” which were defined as a single-year population increase greater than 25 percent higher than the long term average. Three recruitment events occurred over 20 years and were concentrated within a single plot in any given year (Colorado Natural Areas Program 2005). Years in which sprout recruitment was high tended to be years with average precipitation that followed an infestation of the longhorn beetle, *Moneilema semipunctatum*. Several years could pass without substantial recruitment in any plot (Coles 2003). Seedling and sprout survivorship was 37 and 69 percent, respectively. Individuals that grew from seed took an average of 8 years to reach reproductive maturity while sprouts took an average of 2.2 years (Colorado Natural Areas Program 2005).

Average mortality rates varied from 5-10 percent with rare die offs of up to 25 percent or more (Coles 2003, Ladyman 2004). A consistent source of mortality was desiccation of stems less than 1.0 cm (0.4 in). Most mortality was caused by periodic insect infestations (Coles 2003). In summary, there was low recruitment and mortality in most years, punctuated with significant reproduction and recruitment events at infrequent intervals.

The Navajo Natural Heritage Program began monitoring Mesa Verde cactus in 1992 in three different sites. Intensive sampling at one site was discontinued due to poor sampling design in 2002, although general population updates continue to be collected (Service 2008). Additional study plots were established on the Navajo Nation Reservation near Shiprock and Sheep Springs, but these sites were monitored for only two or three years and then were eliminated from the monitoring effort. By 2004, all but six Mesa Verde cactus plants had died in the monitored plots, and formal monitoring was discontinued (Service 2008). No Mesa Verde cactus was found at the Sheep Springs site from 2004-2006 and the population may be extirpated. Surveys will be conducted again in 2009.

The 1984 recovery plan estimated there were about 5,000 to 10,000 Mesa Verde cactus plants (Heil 1984). Additional populations were subsequently discovered on the Navajo Nation Reservation and by 1999 field botanists working with this plant estimated the total number of Mesa Verde cacti was at least two times the original estimate, if not more (Service 2008). Fluctuations in the monitored natural populations appeared to be normal and relatively stable until 2002-2003 when a significant die-off of adult cacti occurred. A long-term drought began in the early 2000s, which resulted in increased insect attacks on the species. From 2002 to 2003, species populations declined by 80 percent in New Mexico (Muldavin et al. 2003).

BLM biologists estimated greater than 80 percent mortality from insect damage on plots that they monitor (BLM 2003). Sivinski (2003) found most mature cacti at the Waterflow plots had been killed by beetles. The highest population density in this plot was 235 individuals in 1999, which was reduced to 74 individuals by 2003. Coles (2003) documented a less severe reduction of 20.4 percent of cactus numbers in two Colorado plots. However, 96 of 535 living stems were judged to be in poor condition in 2003 and were expected to die before April 2004, for a two-year mortality figure of almost 36 percent (Coles 2003).

In 2004, Ladyman conducted extensive surveys on Navajo lands for the Navajo Nation Heritage Program. Sites of prior occurrences were re-surveyed along with seven new sites where suitable habitat appeared to exist (Ladyman 2004). Unlike past surveys, at no site were thousands or even hundreds of Mesa Verde cactus found. As an example, near Many Devils Wash the survey team found 27 plants; 23 dead and 4 alive. This was a 99.7 percent decrease from the 1,500 or more individuals reported at the site in 1989 (Ladyman 2004). In summary, more than 56 areas covering more than seven sections (about 4,723 acres) within Navajo Nation lands were surveyed in 2004. Several of these sites once had more than 1,500 cacti; the 2004 survey found that few sites supported more than 20 individuals. The total number of plants counted at all sites surveyed was 948 live cacti, 428 dead cacti, and 20 damaged cacti, whose viability was questionable (Ladyman 2004).

In summary, in 1999, after two years of above average precipitation, it was estimated that there were approximately 10,000 to 20,000 Mesa Verde cactus plants across their range. A significant die-off occurred in 2002-2003 in response to a severe drought and insect predation. On monitored plots, mortality ranged from a low of 20 percent in Colorado (Coles 2003) to a high of nearly 100 percent (Many Devils Wash, Sheep Springs) in New Mexico (Ladyman 2004). If we assume that on average 85 percent of the plants were lost in the die-off, the population was reduced to about 1,500-3,000 plants.

Continued monitoring indicates that Mesa Verde cactus is populations are slowly increasing. In Colorado, relatively slow recovery has been documented (Colorado Natural Areas Program 2005). Although there has been an increase in the number of stems sprouting from cactus damaged by beetle attack during the drought, the number of seedlings has been far less than expected (7 in 2004, 3 in 2005) in spite of average or above average precipitation (Colorado Natural Areas Program 2005). Two hypotheses have been suggested to explain the lack of seedling recruitment. One is that nurse plants such as mat saltbush (*Atriplex corrugata, A. gardneri, A. confertifola*) have not recovered from the drought. The second hypothesis is that the seeds of Mesa Verde cactus may be short-lived and the seed bank may be exhausted as a consequence of virtually no reproduction during the drought (Colorado Natural Areas Program 2005).

In New Mexico, the Waterflow plot now has 113 plants compared to 74 in 2003 (Sivinski 2007).

However, in 2007, only 2 of the plants were larger than 6 cm, compared to 28 in 1999 and 5 in 2003 (Sivinski 2007). Since reproductive output is directly related to size of plant, reproduction potential is still limited. Some areas like Sheep Springs where no plants have been documented since the drought may be permanently impacted. Other areas such as Malpais Conservation Area show signs of recovery. In 2004, 116 plants were found across 300 acres in the Malpais Conservation Area (Ladyman 2004). A survey conducted in 2006 found 350 live plants within the Conservation Area and about 1,022 cacti east of the area along the proposed alignment for the Navajo Transmission Project (Ecosphere 2006). However, it is not known if the methods and area covered by the 2004 and 2006 surveys are similar. It does indicate that there are at least 1,300 plants in and near the Malpais Conservation Area currently. In sites monitored for transplant success, mortality rates have decreased since 2003, and new plants continue to be recruited into population, although at a very low level (Roth 2008).

Predation and Disease

Predation by the cactus borer beetle, *Moneilema semipunctatum* causes significant fluctuations in the Mesa Verde cactus populations. The beetle is a specialist on cactus. Adult beetles lay eggs at the base of the cactus stem and when the larvae hatch, they bore into the stem and eat it, usually killing the plant. Three significant mortality events caused by the beetle were recorded in long-term monitoring in Colorado (Coles 2003). During an outbreak, most stems greater than 2 cm (0.8 in) were killed but plants from 0.6 to 10.4 cm (0.24 to 4.0 in) in diameter were attacked. About 15 percent of the plants survived attacks and subsequently sprouted (Coles 2003). The beetle caused widespread mortality to Mesa Verde cactus populations in association with a severe drought in 2001-2002 (Ladyman 2004). It is not known if the increased mortality was caused because the plants were weakened by water stress, because the drought led to increased numbers of beetles, or because the beetles targeted Mesa Verde cactus over other cactus species.

The army cutworm (*Euxoa* sp.) has also been associated with predation on Mesa Verde cactus. Cutworms are lepidopterans and the caterpillars chew through the cactus stems. In 2003, many of the Mesa Verde cacti on the BLM Farmington Resource District were infested with cutworms which were eating both the stem and roots (BLM 2003). It is not known if the cutworm is a typical predator on the cactus or if the drought caused the infestation.

Mesa Verde cactus is occasional susceptible to lethal microbial infection, possibly introduced through insect damage (Boissevain & Davidson 1940). There is no reason to suspect that the microbial agents responsible are not native to the biotic environment.

Propagation and Transplantation

The 1984 Recovery Plan (Heil 1984) recommended that a program be developed for artificial propagation Mesa Verde cactus. Recommendations included developing improved artificial propagation techniques, providing stock to outlets for commercial use, and developing a program for salvage of individual Mesa Verde cactus that are unavoidably threatened with destruction (Heil 1984). Mesa Verde cactus has proved to be difficult to cultivate (Service 2008). As many as 90 percent of the plants collected may rot and die within the first year (Heil 1984). Exact conditions are needed for successful germination, cultivation, and survival. It is especially difficult to cultivate in areas of high humidity because the stem rots so easily (Service 2008).

Several transplantations have occurred to move Mesa verde cactus plants out of the path of ground-disturbing projects. In 1989, 35 cacti were transplanted within the Shiprock-Gallup oil field. In August of the same year, the site was visited, and only a few individuals had survived, and no live plants were found in 2004 (Ladyman 2004). In the spring of 1995, the Navajo Natural Heritage Program transplanted 29 cacti from a road right-of-way into 4 monitoring plots outside the right-of-way but in close proximity to their original location (Roth 2004). In addition to the transplanted cacti there were 22 naturally occurring cacti in the plots that functioned as controls (Roth 2004). All naturally occurring and transplanted cacti were mapped and tagged. Between 1995 and 2002, 69 percent of the transplanted plants survived and 55 percent of the naturally occurring plants remained, indicating that the transplantation was successful. However, a precipitous decline occurred at the monitoring plots between 2002 and 2004. The number of surviving transplanted plants dropped from 20, in 2002, to 4 individuals in 2004, and the number of naturally occurring plants dropped from 12 to 2 individuals in the same period (Roth 2004). Drought and insect infestation appeared largely responsible for the decline (Roth 2004).

In 2001, the Navajo Natural Heritage Program initiated another transplanting and monitoring study. Five monitoring plots were established within a designated non-development zone south of Shiprock. Fifty-four cacti were excavated from the south-central portion of the proposed Northern Navajo Fairgrounds site, and transplanted into the monitoring plots (Roth 2008). Forty-nine cacti that naturally occurred within the plots served as controls to determine the success of the transplantation (Roth 2008). All plants were mapped, numbered, and tagged. Monitoring has taken place annually since 2001. Seventy-six percent and 65 percent of the naturally occurring and transplanted cacti died, respectively, between 2001 and 2004. In 2008, 17 of the 49 naturally occurring and 19 of the 54 transplanted cacti were alive. Mortality rates have decreased since 2003, and new plants continue to be recruited into population, although at a very low level (Roth 2008). In 2007 and 2008 vigor was rated as excellent for all naturally occurring plants and for a majority of the transplants, likely due to increased rainfall (Roth 2008).

In summary, it is difficult to accurately assess the long-term success of transplantation because the most closely monitored projects were heavily affected by the drought and insect predation. These natural events were equally devastating for naturally occurring cacti and transplants. One of the first transplantation efforts, for the Shiprock-Gallup oil field, was a failure but the reasons for the failure are unknown. Subsequent transplantations may have used the lessons learned from this first effort and led to the higher success rates.

Status and Distribution

The distribution of Mesa Verde cactus encompasses a roughly rectangular area extending north to south from about 15 miles north of the Colorado-New Mexico border to the vicinity of Sheep Springs, New Mexico, and east to west from the vicinity of Waterflow, New Mexico, to about 15 miles west of Shiprock, New Mexico. Plants can occur sporadically anywhere that soils are suitable, but there appear to be five areas of concentration. These areas are near the base of the Mesa Verde Escarpment in Montezuma County, Colorado, near the Colorado-New Mexico state line, in the vicinity of Shiprock, in the vicinity of Sheep Springs (although the current condition of this population is unknown), and north of Waterflow. The New Mexico plants are concentrated in north-central San Juan County.

Most Mesa Verde cactus populations occur on tribal lands. Approximately 70 percent of occurrences are on the Navajo Reservation and another 20 percent on the Ute Mountain Ute Indian Reservation. On the Navajo Nation, the majority of plants are within a 20-mile radius of Shiprock. Historically, an additional population was found in the Sheep Springs area. The other 10 percent of the populations occur east of the Hogback on private lands and on public lands administered by the BLM.

The Mesa Verde cactus was federally listed as threatened on October 30, 1979 (44 FR 62472). No critical habitat was designated. When listed, existing or potential threats included coal, oil, and gas exploration and production; commercial and residential development; road, powerline, and pipeline construction; commercial and private collecting; ORV impacts; livestock trampling; and natural threats of disease and predation. These threats have continued since listing. Ladyman (2004) documented several sites that had historical occurrences and no live plants in 2004, due to oil field development, housing subdivision, agricultural development, and livestock use.

An additional threat not considered when the plant was listed is climate change. According to the Intergovernmental Panel on Climate Change Report (IPCC 2007), warming of the earth's climate is "unequivocal," as is now evident from observations of increases in average global air and ocean temperatures, widespread melting of glaciers and the polar ice cap, and rising sea level. The 2007 IPCC report describes changes in natural ecosystems with potential wide-spread effects on many organisms, including plants. The potential for rapid climate change poses a significant challenge for fish and wildlife conservation. Species' abundance and distribution are dynamic, and dependent on a variety of factors, including climate (Parmesan and Galbraith 2004). Highly specialized or endemic species, like Mesa Verde cactus, are likely to be most susceptible to the stresses of changing climate. Based on these findings and other similar studies, the Department of the Interior (DOI) requires agencies under its direction to consider potential climate change effects as part of their long-range planning activities (Service 2007).

In the Colorado River basin, widespread, reliable instrumental records are available for about the past 150 years. These records document an annual mean air surface temperature increase of approximately 2.5°F (1.4°C) over the past century with temperatures today at least 1.5°F (0.8°C) warmer than during the 1950 drought (NRC 2007, Lenart 2007). Udall (2007) found that multiple independent data sets confirm widespread warming in the West. Both in terms of absolute degrees and in terms of annual standard deviation, the Colorado River Basin has warmed more than any region of the United States (NRC 2007). Predicting with certainty the amount of warming that may occur in the future is not possible; however, the IPCC (2007) has concluded that continued warming of the climate is unequivocal. Over western North America, median temperatures are projected to increase between 2.3°F (1.3°C) and 7.9°F (4.4°C) by 2100 depending on the rate of green house gas emissions (Christensen and Lettenmaier 2006).

The IPCC also projects that there will very likely be an increase in the frequency of hot extremes, heat waves, and heavy precipitation events (IPCC 2007). Climate forecasts project a northward shift in the jet stream and associated winter-spring storm tracks, which are consistent with observed trends over recent decades (CCSP SAP 1.1, 2006). This would result in future drier conditions for the Southwest and an ever-increasing probability of drought for the region (Trenberth et al. 2007).

The drought in the early 2000s and concurrent insect infestations significantly reduced Mesa Verde cactus populations. Although warmer air temperatures alone may not have an effect on the species, it is evident that widespread and/or long-lasting drought could be devastating. Changes in precipitation patterns that lead to either wetter or drier conditions for this narrow endemic could lead to conditions that are no longer suitable for its survival. In addition, changes in climate could lead to the establishment or spread of nonnative plants, to the detriment of Mesa Verde cactus. Because other recognized threats to the species such as development and livestock use continue, the additional threat of climate change further imperils this species.

ENVIRONMENTAL BASELINE

The environmental baseline includes the past and present impacts of all Federal, State, and private actions and other human activities in the action area; the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal section 7 consultation; and the impact of State or private actions contemporaneous with the consultation process. All projects previously built or consulted on, and those State or private projects presently being built or considered that deplete water from the San Juan River Basin are in the Environmental Baseline for this proposed action. The baseline does not include the effects of the action under review, only actions that have occurred previously.

The Service describes the environmental baseline in terms of the biological requirements for habitat features and processes necessary to support life stages of the subject species within the action area. When the environmental baseline departs from those biological requirements, the adverse effects of a proposed action on the species or proposed critical habitat are more likely to jeopardize the listed species or result in destruction or adverse modification of proposed critical habitat.

Status of the Species Within The Action Area

Colorado pikeminnow

Platania and Young (1989) summarized historic fish collections in the San Juan River drainage that indicate that pikeminnow once inhabited reaches above what is now Navajo Dam and Reservoir near Rosa, New Mexico (now inundated by Navajo Reservoir). Lake Powell and Navajo Reservoir resulted in the direct loss of approximately 161 km (100 mi) of San Juan River habitat for the two endangered fishes (Holden 2000). Since closure of Navajo Dam in 1963, the accompanying fish eradication program, physical changes associated with the dam, and barriers to movement, wild pikeminnow have been eliminated from the upper San Juan River upstream of Navajo Dam. Below Navajo Dam, summer water temperatures are colder and winter water temperatures are warmer than the pre-dam condition. The first 10 km (6.2 mi) below the dam are essentially sediment free, resulting in the clearest water of any reach (Miller and Ptacek 2000). The cool, clear water has allowed development of an intensively managed blue-ribbon trout fishery to the exclusion of most native species (Miller and Ptacek 2000).

During the seven-year research period (1991 to 1997) it was estimated that there were fewer than 50 adult pikeminnow in the San Juan River in any given year (Ryden 2000a). In 2000, it was estimated that there were 19 wild adult pikeminnow in the San Juan River from river-mile (RM) 136.6 to RM 119.2 (95 percent C.I. 10-42; Ryden 2000a). No wild pikeminnow have been captured since 1999 (Ryden annual monitoring reports 2000-2008, Davis and Furr 2008). Current monitoring protocol is not designed to determine population estimates and no estimates have been made in recent years.

Radio tagged adults and monitoring results indicate that pikeminnow in the San Juan appear to have relatively small home ranges and primarily use habitats from RM 109 to RM 142 (Holden 2000). Spawning has been documented in a region of high channel complexity characterized by shifting gravel bars from RM 133.4 to RM 129.8 (Ryden 2000a). Additional suitable spawning habitat has been identified at RM 173.7 and 168.4 (Bliesner and Lamarra 2003). Drift data from 1995 suggested a spawning site considerably downstream of RM 129 (Platania et al. 2000) but its location was not identified. Prior to spawning, adults stage at the mouth of the Mancos River. Based on the collection of larval fish from 1993 to 2007, spawning has occurred between June 24 and July 18 (Brandenburg and Farrington 2008). Larval and juvenile pikeminnow have been collected from low velocity shoreline and backwater habitats downstream of RM 130 (Ryden 2000a, Brandenburg and Farrington 2008).

The SJRRIP has a multi-pronged approach to recovery that has involved removal of migration barriers, augmentation, mimicry of a natural hydrograph, adult and larval fish monitoring, habitat and water quality monitoring and control of non-native species. Between 1987 and 1996, no wild pikeminnow adults were caught above Shiprock (approximately RM 150). One of the goals of the SJRRIP is range expansion of pikeminnow through the removal of migration barriers (SJRRIP 1995). The removal of the diversion at Cudei (RM 142), construction of non-selective fish passage at the Hogback Diversion (158.6) and the completion of the PNM (RM 166.1) selective fish passage ladder in 2003 has restored fish access to about 36 miles of critical habitat on the San Juan River for pikeminnow. From 2003 to 2007, 27 pikeminnow passed through the selective fish passage ladder as well as over 65,000 other native fishes (Lapahie 2007, in litt). In 2004, 5 pikeminnow (226-250 total length [8.9-9.8 in]) were caught in the lower few miles of the Animas River (Ryden 2005a). These fish were all age-2 that had been stocked in June 2004 about 0.3 RMs downstream of the Animas River confluence (Ryden 2005a).

Experimental stocking of pikeminnow in the San Juan River began in 1996. Between 1996 and 2000, approximately 832,000 larval pikeminnow were stocked in the San Juan River. About 727,000 were stocked between RM 141 and 158. The balance was stocked at RM 52 (Ryden, 2003b). Initial retention was encouraging and over winter survival was high (spring captures = 62.5-62.7 percent of fall captures) and survival between age-1 and age-2 based on recapture rates neared 100 percent (Archer et al. 2000). As a result of this initial success an augmentation plan began in 2002 with a goal of stocking and monitoring 300,000 age-0 pikeminnow at RM 180.2 and RM 158.6 for seven years. A total of 1,781,154 Colorado pikeminnow was stocked into the San Juan River between 2002 and 2007 (Ryden 2008b). Target stocking numbers were exceeded in 2007 with 475,970 age-0 fish stocked (target 300,000) and 3,256 age-1 fish stocked (target 3,000) (Ryden 2008b). The target for age-1 fish was also exceeded in 2008 with 4,857 fish stocked (Ulibarri 2008 in litt.). Although capture of age-4 and older pikeminnow is rare (Ryden 2008a), the capture of an age-11 pikeminnow that was stocked in 1996 as an age-0 fish (Davis and Furr 2008) indicates that at least some of stocked fish are surviving to reproductive age.

Razorback sucker

As described for pikeminnow, the construction of Lake Powell and Navajo Reservoir resulted in the direct loss of approximately 161 km (100 mi) of habitat in the San Juan River for razorback sucker. Since closure of Navajo Dam in 1963, the accompanying fish eradication program, physical changes associated with the dam, and barriers to movement, razorback sucker have been eliminated from the San Juan River above Navajo Dam. The first10 km (6.2 mi) below Navajo Dam, summer water temperatures are colder and the cool, clear water has allowed development of an intensively managed blue-ribbon trout fishery to the exclusion of most native species, including razorback sucker (Miller and Ptacek 2000).

Beginning in May 1987, and continuing through October 1989, complementary investigations of fishes in the San Juan River were conducted in Colorado, New Mexico, and Utah (Platania 1990, Platania et al. 1991). In 1987, a total of 18 adult razorbacks were collected (six were recaptured once) on the south shore of the San Juan arm of Lake Powell (Platania 1990, Platania et al. 1991). These fish were captured near a concrete boat ramp at Piute Farms Marina and were believed to be either a spawning aggregation or possibly a staging area used in preparation for migration to a spawning site. Of the 12 razorback suckers handled in 1987, 8 were ripe males and the other 4 specimens were females that appeared gravid.

In 1988, a total of 10 razorback suckers were handled at the same general location, 5 of which were in reproductive condition (Platania et al. 1991). Six of the 10 individual specimens in the 1988 samples were recaptures from 1987. Also in 1988, a single adult tuberculate male razorback sucker was captured in the San Juan River near Bluff, Utah (RM 80) (Platania 1990, Platania et al. 1991). This was the first confirmed record of this species from the main stem San Juan River and suggested that razorback suckers were attempting to spawn in the river. No wild razorback suckers have been collected on the San Juan River since 1988 (Ryden, Service, pers. comm. 2005). A Schnabel multiple-census population model estimated that there were approximately 1200 razorback suckers in the San Juan River from RM 158.6 to 2.9 in October 2004 (Ryden 2005b). This population estimate refers to stocked razorback sucker.

In March 1994, 15 radio-tagged razorback suckers were stocked in the San Juan River at Bluff, Utah (RM 79.6), near Four Corners Bridge (RM 117.5), and above the Mixer in New Mexico (RM 136.6). Monitoring found these razorback suckers using slow or slackwater habitats such as eddies, pools, backwaters, and shoals in March and April, and fast water 92 percent of the time in June and August (Ryden and Pfeifer 1995b). An additional 16 radio-tagged adults and 656 PIT-tagged fish were stocked in the same locations and at an additional site just below the Hogback Diversion in New Mexico (RM 158.5) in October 1994. Radio-tagged and PIT-tagged razorback suckers were found in small numbers from the Hogback Diversion (RM 158.6) to 38.1 river miles above Lake Powell in 1995, indicating that the San Juan River provided suitable habitat to support subadult and adult razorback sucker on a year-round basis (Ryden and Pfeifer 1996).

As described for pikeminnow, the SJRRIP has a multi-pronged approach to recovery that has involved removal of migration barriers, augmentation, mimicry of a natural hydrograph, adult and larval fish monitoring, habitat and water quality monitoring and control of non-native species. One of the goals of the SJRRIP is range expansion of razorback sucker through the removal of migration barriers (SJRRIP 1995). The removal of the diversion at Cudei (RM 142), construction of non-selective fish passage at the Hogback Diversion (158.6) and the completion of the PNM (RM 166.1) selective fish passage ladder in 2003 has restored fish access to about 36 miles of habitat on the San Juan River for razorback sucker. From 2003 to 2007, 21 razorback suckers passed through the selective fish passage ladder (Lapahie 2007, in litt).

In September 1995 and October 1996, 16 and 237 razorback suckers were stocked, respectively. The SJRRIP initiated a 5-year augmentation program for the razorback sucker in 1997 (Ryden 1997). Between September 1997, and November 2001, 5,896 subadult razorback sucker were stocked below Hogback Diversion Dam (RM 158.5). In 2007, 22,836 razorback sucker were stocked into the San Juan River. This was the second consecutive year that the target stocking number for razorback sucker (target = 11,400 fish) was met or exceeded. Approximately 13,800 of the stocked fish were less than the target stocking size of 300 mm (11.8 in) total length and approximately 9,000 fish met the target size.

Fish that were stocked in 1995 are still being collected during annual sampling (Ryden 2008a). Larval razorback suckers have been collected each year since 1998, indicating that the stocked fish are successfully spawning in the San Juan River (Brandenburg and Farrington 2008). Razorback sucker spawning aggregations have been identified at RM 100.2 in 1997, 1999, and 2001 (Ryden 2004), at RM 17.6 in 2002 (Ryden 2004) and at RM 154.27 in 2004 (Ryden 2005b). In 2007, 207 stocked razorback sucker were collected during annual adult monitoring (Ryden 2008a). Their sizes ranged from 221-516 mm (8.7- 20.3 in) total length (age-1 to15) (Ryden 2008a). Razorback sucker were captured from RM 170.0 to RM 7. These results indicate the augmentation program has been successful in increasing the number of razorback sucker in the San Juan River in a relatively short time, increasing the number of fish much faster than if augmentation had not taken place.

Mesa Verde cactus

Five population centers are known for Mesa Verde cactus; one in the southwestern corner of Colorado and four in northwestern New Mexico. The area around Shiprock, New Mexico represents the largest population center (Heil 1984) and it is this population that occurs within the action area of the proposed project. Numerous activities in Mesa Verde cactus habitat have required section 7 consultation, and five have resulted in formal consultations. All of the consultations have had a non-jeopardy determination. The projects have included road and transmission line construction, a BLM Resource Management Plan, and fairground construction near Shiprock.

The 1984 recovery plan estimated there were about 5,000 to 10,000 Mesa Verde cactus plants (Heil 1984). Additional populations were subsequently discovered on the Navajo Nation Reservation and by 1999 field botanists working with this plant estimated the total number of Mesa Verde cacti was at least two times the original estimate, if not more (Service 2008).

Fluctuations in the monitored natural populations appeared to be normal and relatively stable until 2002-2003 when a significant die-off of adult cacti occurred. From 2001 to 2003 severe drought created conditions suitable for insect predators to increase their negative effects on Mesa Verde cactus throughout its range (Service 2008). On monitored plots in New Mexico mortality ranged from around 65 percent (Roth 2008) to a high of nearly 100 percent (Many Devils Wash, Sheep Springs) (Ladyman 2004). Monitoring of transplanted Mesa Verde cacti in a non-development zone south of Shiprock showed that 76 and 65 percent of the naturally occurring and transplanted cacti died, respectively, between 2001 and 2004. Mortality rates have decreased since 2003, and new plants continue to be recruited into population, although at a very low level (Roth 2008

In 2004, Ladyman conducted extensive surveys on Navajo lands for the Navajo Nation Heritage Program. The surveyed areas include sites that could be impacted by the proposed project. Sites of prior occurrences were re-surveyed along with seven new sites where suitable habitat appeared to exist (Ladyman 2004). Unlike past surveys, at no site were thousands or even hundreds of Mesa Verde cactus found. More than 56 areas covering more than seven sections (about 4,723 acres) within Navajo Nation lands were surveyed. Several of these sites once had more than 1,500 cacti; the 2004 survey found that few sites supported more than 20 individuals. The total number of plants counted at all sites surveyed was 948 live cacti, 428 dead cacti, and 20 damaged cacti, whose viability was questionable (Ladyman 2004).

When the Mesa Verde cactus was listed in 1979, threats to the plant were well documented. However, those threats continue to be a source of mortality. In 1985, surveys were conducted by Ecosphere for BLM on all areas of potential habitat in the Hogback-Waterflow area (Ecosphere 1985). In the report they note that the San Juan Generating Plant was built on Mesa Verde cactus habitat and that power transmission lines had been built through the Waterflow population. However, ORV use was determined to be the greatest threat to the population at that time and several sites were noted as being heavily impacted by ORV use (Ecosphere 1985). In addition, livestock trampling was recorded and one cow was documented eating a Mesa Verde cactus (Ecosphere 1985). Ladyman (2004) noted complete loss of plants in historical sites from oil field development, a housing subdivision, livestock damage, and agriculture. In Colorado, livestock trampling was noted as the primary source of mortality in 2005 (Colorado Natural Areas Program 2005). In 2006, Western Area Power Administration bladed about 20 miles of Mesa Verde cactus habitat, including 4.5 miles through the Malpais Conservation Area. Based on a width of 12 feet, about 22 acres of what was at least moderate habitat was bladed (Service 2007). These examples indicate that habitat degradation remains a problem for this species.

It is still too early to determine if climate change is affecting the status of Mesa Verde cactus. However, one of the predicted effects of climate change is an increase in extreme events, including drought (IPCC 2007). Because of the documented effects of the drought in the early 2000s on the Mesa Verde cactus, it is clear that a longer lasting drought or more frequently occurring droughts could have a devastating impact on this plant.

Indications are that since the drought, Mesa Verde cactus has returned to normal levels of low mortality and low recruitment that are typically seen (Roth 2008). However, because recruitment is typically low, and reproductive output is directly related to plant age/size, it is anticipated that it will take many years for the population numbers to recover to pre-drought levels (Ladyman 2004).

FACTORS AFFECTING SPECIES ENVIRONMENT WITHIN THE ACTION AREA

Colorado Pikeminnow and Razorback Sucker

The San Juan River is a tributary to the Colorado River and drains a basin of approximately 25,000 mi^2 (65,000 km^2) located in Colorado, New Mexico, Utah, and Arizona (Reclamation 2003). From its origins in the San Juan Mountains of southwestern Colorado (at an elevation exceeding 13,943 ft) (4,250 m), the river flows westward through New Mexico, Colorado, and into Lake Powell, Utah. The majority of water that feeds the 345 mi (570 km) of river is from the mountains of Colorado. From a water resources perspective, the area of influence for the proposed project begins at the inflow areas of Navajo Reservoir, and extends west from Navajo Dam approximately 224 mi (359 km) along the San Juan River to Lake Powell. The dam is operated and maintained by Reclamation (Reclamation 2003). The major perennial tributaries in the project area are the Los Pinos, Piedra, Navajo, Animas, La Plata, and Mancos Rivers, and McElmo Creek. There are also numerous ephemeral arroyos and washes that contribute little flow to the San Juan River, but large sediment loads.

As recognized in the Draft Environmental Impact Statement for Navajo Reservoir Operations (Reclamation 2002) (DEIS), changes in biodiversity associated with the historical San Juan River occurred when Navajo Dam was placed into operation. The reservoir physically altered the San Juan River and surrounding terrain and modified the pattern of flows downstream. Similar to rivers downstream of other dam operations in the southwestern United States, the San Juan River downstream of the dam became clearer due to sediment retained in the reservoir, and the water became colder, because it is released from a deep pool of water. The DEIS states that all species of plants and animals that existed along the river channel were affected to varying degrees. The disruption of natural patterns of flow caused changes to the vegetation along the river banks by altering the previously established conditions under which the plants reproduced and survived.

Navajo Dam regulates river flows, provides flood control and contributes to recreational and fishery activities (Reclamation 2002). In addition to the changes caused to the river by dam operations, the DEIS (Reclamation 2002) recognized that there were changes to how the lands in the area were used. Irrigation water provided by Navajo Dam contributed to agriculture being practiced on a large scale. The reservoir stores water for the NIIP (Consultations #2-22-91-F-241, #2-22-92-F-080, and #2-22-99-F-381), the Hammond Irrigation Project, and various municipal and industrial uses making it possible to nearly double the amount of irrigation in the basin. At present, the NIIP diverts an annual average of approximately 160,000 af from the reservoir for irrigation south of Farmington (Reclamation 2002). In the future, this use is expected to approximately double (Reclamation 2002). This will further affect the river and the native species dependent on the river both directly, through flow diversions, and indirectly, through changes in water quality, as a result of the water acquiring salts, pesticides, and fertilizers from the irrigated lands' return flows to the river (Reclamation 2002).

In addition to the effects of operating Navajo Dam, over the last century, the San Juan River has experienced diversions for municipal use, resulting in a variety of return flows to the river, including industrial waste, stormwater runoff, and discharges from sewage treatment plants. Compounding these changes has been the intentional and non-intentional introduction of non-native species of fish which compete with and predate on native species (Reclamation 2002).

Although there are impacts to the river ecosystem from dam construction itself, dams have many impacts that continue after the structure is complete. Dams affect the physical, chemical, and biological components of a stream ecosystem (Williams and Wolman 1984, Collier et al. 2000, Service 1998, Mueller and Marsh 2002). Some of these effects include a change in water temperature, a reduction in lateral channel migration, channel scouring, blockage of fish passage, transformation of riverine habitat into lake habitat, channel narrowing, changes in the riparian community, diminished peak flows, changes in the timing of high and low flows, and a loss of connectivity between the river and its flood plain (e.g., Sherrard and Erskine 1991, Power et al. 1996, Kondolf 1997, Polzin and Rood 2000, Collier et al. 2000, Shields et al. 2000). Of these, change in water temperature, blockage of fish passage, transformation of riverine habitat into lake habitat, changes in the timing and magnitude of high and low flows, and changes in channel morphology are discussed in greater detail.

Water Temperature

The cold water below Navajo Dam limits the potential spawning habitat of the endangered fishes in the San Juan River. Prior to dam construction water temperatures at Archuleta (approximately 10 km [6.1 mi] below the dam) were above the threshold spawning temperature of 20º C (68º F) for approximately 2 months (Holden 1999). Based on cumulative degree days spawning could have occurred at Archuleta by July 11 prior to dam closure (Lamarra 2007). Since dam construction, water temperature at that site is rarely over 15º C (59º F) and is too cold for successful pikeminnow spawning (Holden 1999, Cutler 2006, Lamarra 2007). The threshold temperatures for spawning at Shiprock (approximately 125 km [78 mi] below the dam) occur about 2 weeks later on average than pre-dam (Holden 1999, Lamarra 2007). Spawning is unlikely to occur from Navajo Dam to the confluence of the Animas River (approximately 72 km [45 mi] below the dam) and would be delayed for two weeks or more from the confluence with the Animas River down to Shiprock (Lamarra 2007).

Water temperatures at Shiprock before the construction of Navajo Dam were above 20º C (68º F) from approximately mid-June until mid-September (three months) (Holden 1999). Projected temperatures at Shiprock from 1993-1996, during a portion of the 7-year research period, were above 20º C (68º F) for more than one month (August) (Holden 1999). Because fish are cold-blooded, their metabolism and growth depend on water temperature. The amount of food eaten, assimilation efficiency, and time to sexual maturity are affected by temperature (Lagler et al. 1977). Cold water typically decreases food consumption, decreases assimilation efficiency, decreases growth rate, and increases the time to sexual maturity (Lagler et al. 1977).

Development time of pikeminnow and razorback sucker embryos is inversely related to temperature and survival is reduced at temperatures that depart from 20º C (68ºF) (Bulkley et al. 1981, Hamman 1982, Bestgen 2008). Marsh (1985) found that for razorback suckers, time to peak hatch was 216 hours (9 days) at 15ºC (59ºF) and 84 hours (3.5 days) at 25ºC (77ºF) and that the percent of eggs hatched was highest at 20ºC (68ºF). Bestgen (2008) found that fastest growth of razorback sucker occurred at 25.5ºC (77.9ºF). Fast larval growth may be linked to higher survival rates because the faster the larval fish grow, the less time they are highly susceptible to predation.

All pikeminnow eggs tested died at incubation temperatures of 15ºC (59ºF) or lower (Marsh 1985). Marsh (1985) concluded that his results indicated that survival and hatching success were maximized near 20º C (68º F). Bestgen and Williams (1994) found that mean hatch of pikeminnow was 54 to 79 percent for temperatures of 18, 22, and 26ºC (64.4, 71.6, and 78.8 ºF) and that there was no significant difference among the treatments showing a relatively wide range of acceptable incubation temperatures above 18ºC (64.4 ºF). In addition, Bestgen et al. (2006) found that early hatching pikeminnow larvae in the Green River were almost twice the size of late hatching ones because they had more time to grow.

Because the combination of a suitable spawning bar (an area of sediment-free cobbles) and suitable temperatures occur low on the San Juan at the Mixer (RM 133.4 to RM 129.8), there is a greater chance that larval fish will drift into Lake Powell and be lost from the population. Dudley and Platania (2000) found, based on a neutral buoyancy bead study, that drifting larval pikeminnow would be transported from the Mixer to Lake Powell in as little as three days. For those larval fish not carried into Lake Powell, a delay in spawning (which reduces the amount of time YOY have to grow before winter) and overall colder water temperatures (resulting in slower growth) could lead to smaller, less fit YOY, and reduce survival. While this reasoning is biologically sound, because there are so few pikeminnow in the San Juan River, the consequences of lower water temperatures on survival and recruitment of pikeminnow have not been tested for this river. There is speculation that the large volume of cold water in the upper Green River may be a major reason why larval pikeminnow drift so far downstream (Holden 2000). The same pattern may also occur on the San Juan River.

In conclusion, cold water released from Navajo Dam has the following effects on razorback sucker and pikeminnow: water temperatures that were once suitable for spawning for pikeminnow near Archuleta are no longer suitable; and, if spawning were to occur near Shiprock, it would be delayed by approximately 2 weeks compared to pre-dam conditions. A delay in spawning reduces the amount of time that larval fish have to grow before winter and colder temperatures reduce growth rate increasing the amount of time that the larval fish are highly susceptible to predation.

Blockage of Fish Passage

Like other major dams on the Colorado River and its tributaries, Navajo Dam blocked all fish passage. While native fish once could move unimpeded from the San Juan River into the Colorado River and its tributaries, they are now confined to a relatively short reach of 362 km (225 mi) between Lake Powell and Navajo Dam. If adverse conditions occur (extreme low flow, extreme high flow, unfavorable temperatures or water quality) the fish cannot escape or seek refuge in the Colorado River as they once could. Razorback sucker and pikeminnow that may have been trapped above the reservoir have all died or were killed during treatment with rotenone (Olson 1962, Holden 1999). In addition to the major dams, diversion structures constructed in the San Juan River have also created barriers to fish passage.

Ryden and Pfeifer (1993) identified five diversion structures between Farmington, New Mexico, and the Utah state line that potentially acted as barriers to fish passage at certain flows (Cudei, Hogback, Four Corners Power Plant, San Juan Generating Station (PNM weir), and Fruitland Irrigation Canal diversions). When radio telemetry studies were initiated on the San Juan River in 1991, only one radio-tagged pikeminnow was recorded moving upstream past one of the diversions. In 1995, an adult pikeminnow moved above the Cudei Diversion and then returned back downstream (Miller and Ptacek 2000). Other native fish had been found to move either upstream or downstream over all five of the weirs (Buntjer and Brooks 1997, Ryden 2000a). In 2001, Cudei Diversion (RM 142) was removed from the river and Hogback Diversion (previously an earth and gravel berm structure), which had to be rebuilt every year, was made into a permanent structure with non-selective fish passage. Channel catfish that were tagged downstream of the Hogback Diversion in spring and summer 2002 were recaptured upstream of the structure in summer and fall 2002. It is likely that pikeminnow, razorback sucker, and other native fishes can negotiate the ladder. The removal of Cudei Diversion and installation of the fish ladder at Hogback Diversion improved access for native fishes over a 24.5 mile reach of river.

Until 2003, the PNM weir (RM 166) was also a barrier to fish passage. Thanks to funding and technical assistance from the SJRRIP and operation and maintenance by the Navajo Nation, the PNM selective fish ladder was completed and has been operational since 2003. This has allowed passage past that structure by pikeminnow and razorback suckers. From 2003 to 2007, 65,596 native fish used the passage including 27 pikeminnow and 21 razorback suckers (LaPahie 2007 in litt). However, the Four Corners Power Plant (Arizona Public Service) Diversion at RM 163.3 can act as a fish barrier when the control gate for the structure is closed (Masslich and Holden 1996). Above the PNM weir, at the Fruitland Irrigation Canal Diversion (RM 178.5), model results reported in Evaluation of the Need for Fish Passage (Stamp and Golden 2005) suggest that the rock dam structure does not significantly hinder fish passage, expect perhaps at very high discharges (8,000 cfs and greater).

Dams have fragmented razorback sucker and pikeminnow habitat throughout the Colorado River system. Within the San Juan River, fish passage was once impeded by five in-stream structures. One of these structures has been removed, two have been equipped with fish passage structures, and two remain as impediments to fish passage for part of the year depending on flow. However, no remaining structures are complete barriers within critical habitat. Pikeminnow and razorback sucker can potentially navigate from Lake Powell, past the Animas River, up to the Hammond Diversion Dam, a total of approximately 338 km (210 mi).

Transformation of Riverine into Lake Habitat

Lake Powell inundated the lower 87 km (54 mi) of the San Juan River and Navajo Reservoir inundated another 43 km (27 mi). The two reservoirs reduced the potential range and habitat for the two endangered fishes from about 523 km (325 mi) to 362 km (225 mi) and inundated potential pikeminnow spawning areas in the upper San Juan River (Holden 2000). Although the loss of habitat is substantial, several other problems for native fishes resulted from the creation of lakes. The larvae of razorback sucker and pikeminnow drift downstream until they find suitable nursery habitat (backwaters or other low velocity areas) (Holden 2000). Because the river has been truncated 87 km (54 mi) on the lower end, there are many fewer stream miles available for nursery habitat. Some pikeminnow in the Green and Colorado River systems drift up to 322 km (200 mi) from spawning areas before finding nursery habitat, while others use nursery areas only a few miles below the spawning areas (Trammell and Chart 1999). The majority of YOY pikeminnow that have been collected in the San Juan River have been at the inflow to Lake Powell (Buntjer et al. 1994, Lashmett 1994, Archer et al. 1995, Platania 1996). Because of the many predators present and lack of suitable habitat, it is unlikely that larvae survive in Lake Powell.

In 1961, prior to the filling of Navajo Dam, New Mexico Department of Game and Fish used rotenone "to eliminate trash fish species" from the Pine River (24 km [15 mi]), the Navajo River (9.6 km [6 mi]), and the San Juan River (120 km [75 mi]) (Olson 1962). Fourteen species of fish were eliminated in the treated section of river (Olson 1962). There were three drip stations on the San Juan River that effectively killed the majority of the fish from the Colorado state line, near Rosa, New Mexico, down to Fruitland, approximately 64 km (40 mi) below Navajo Dam (Olson 1962). Included in the list of fish eliminated was pikeminnow (Olson 1962). The number of fish killed was not recorded because of the large scale of the project (Olson 1962). The intent of the project was to reduce (eliminate) competition and predation between native fish and the non-native trout fishery that was to be established.

Lake Powell is populated by several fish species not native to the Colorado River that are predators on native fish. As mentioned earlier, larval native fish that drift into Lake Powell are almost certainly lost to predation by largemouth bass, smallmouth bass, striped bass, walleye, or crappie (*Pomoxis* sp.). Striped bass migrates up the San Juan River as far upstream as the PNM weir (RM 166) in some years (Davis 2003). Adult striped bass are piscivorous (Moyle 1976). In 2000, 432 striped bass were captured during monitoring trips for pikeminnow and during trips to remove non-native fishes (Davis 2003). The contents of 38 stomachs were analyzed and native suckers were found in 41 percent (Davis 2003). This migratory predator is a threat to both YOY and juvenile native fish.

In conclusion, the transformation of riverine habitat into lake habitat had the following impacts on razorback sucker and pikeminnow:

1) Approximately 128 km (80 mi) of river was inundated and no longer provide suitable habitat for both fish with the exception of adult razorback sucker, which can use portions of Lake Powell (Platania et al. 1991).

2) Nursery habitat for both species was inundated when Lake Powell was created (and filled).

3) The emphasis of fisheries management shifted to game fish production. Consequently riverine habitat that supported native fish, including razorback sucker and pikeminnow, was treated with rotenone (after Navajo Dam was constructed) so that game fish production in the reservoirs could be promoted (Olson 1962, Holden 1991, Quartarone

and Young 1995).

4) Non-native game fish were stocked in Lake Powell and Navajo Reservoir. Non-native fish are believed to limit the success of pikeminnow and razorback sucker recruitment and are considered biological threats to the species (McAda and Wydoski 1980, Minckley 1983, Osmundson 1987, Tyus 1987, Ruppert et al. 1993, Bestgen 1997, Bestgen et al. 1997, Service 1998, McAda and Ryel 1999, Muth et al. 2000).

Changes in the Timing and Magnitude of Flows

Natural flow regimes are essential to the ecological integrity of large western rivers (Service 1998) and for the maintenance or restoration of native aquatic communities (Lytle and Poff 2004, Propst and Gido 2004, Propst et al. 2008). The flow regime works in concert with the geomorphology of the basin to establish and maintain the physical, chemical, and biological components of a stream ecosystem (Williams and Wolman 1984, Allan 1995, Collier et al. 2000, Service 1998, Mueller and Marsh 2002). With a natural flow regime streams and rivers retain those ecological attributes with which the native fauna evolved. Some of these ecological attributes and biological components include the native aquatic communities, water temperature, channel formation and migration, the riparian community, connectivity between the river and its flood plain (e.g., Sherrard and Erskine 1991, Allan 1995, Power et al. 1996, Kondolf 1997, Polzin and Rood 2000, Collier et al. 2000, Shields et al. 2000). Equally important is that a natural flow regime is less likely to provide the conditions suitable for the establishment and colonization of systems by nonnative species which evolved under a different set of biotic and abiotic conditions (Propst et al. 2008).

Typical of rivers in the Southwest, the San Juan River was originally characterized by large spring snowmelt peak flows, low summer and winter base flows, and high-magnitude, short-duration summer and fall storm events (Holden 1999). The completion of Navajo Dam in 1962 and subsequent dam operations through 1991 substantially altered the natural hydrograph of the San Juan River (Holden 1999). Operations appreciable reduced the magnitude and a changed the timing of the annual spring peak. Historically, flows in the San Juan River were highly variable and ranged from a low of 44 cfs in September 1956, to a high of 19,790 cfs in May 1941 (mean monthly values) at the U.S. Geological Survey (USGS) Station gauge near Shiprock, New Mexico. The flows for this period of time do not necessarily represent a "natural" condition because water development began in the basin near the turn of the century and many irrigation projects that diverted and depleted water from the San Juan River were already in place. For the 49 years of record prior to Navajo Dam a peak spring flow greater than 15,200 cfs occurred 13 times (25 percent of the time). The highest spring peak flow recorded (daily mean) was 52,000 cfs (June 30, 1927). In wet years, dam releases began early to create space in the reservoir to store runoff (Holden 1999). The peak discharge averaged 54 percent of the spring peak of pre-dam years. The highest mean monthly flow was 9,508 cfs (June 1979), a decrease of more than 10,000 cfs compared to pre-dam years. Base flows were substantially elevated in comparison to pre-dam years. The median monthly flow for the base flow months (August-February) averaged 168 percent of the pre-dam period (Holden 1999). Minimum flows were elevated and periods of near-zero flow were eliminated with a minimum monthly flow during base-flow periods of 250 cfs compared to 65 cfs for the pre-dam period (Holden 1999). The hydrograph was flatter during this time period.

During the 1991 to 1997 research period, flows were manipulated by Reclamation in coordination with the SJRRIP to determine fish population and habitat responses when Navajo Dam was operated to mimic a natural hydrograph (Holden 1999). Reclamation's flexibility in managing flows and the technical input from the SJRRIP during this period of experimental flow manipulations allowed researchers an opportunity to develop flow recommendations. A more natural hydrograph was maintained during this period (1991 to 1997) of experimental flows. The research flow period was more similar to the years that followed (1998 to present) than they were prior to 1991. For this reason, the years from 1991 to present were used to analyze the effects of the Flow Recommendations on physical habitat and endangered fish populations.

Navajo Dam has been operated to meet the Flow Recommendations since their publication in 1999 (Holden 1999). A natural hydrograph has been mimicked but not replicated. Achieving peak magnitudes is no longer possible because of release restrictions at the dam. The more natural hydrograph created by the Flow Recommendations is an improvement over the pre-1991 hydrograph. With the reoperation of Navajo Dam the native fish receive the proper cues at the proper times to trigger spawning and more suitable habitat is available at the proper times for young fish.

A second factor which may affect the timing and magnitude of flows in the San Juan River is climate change. In the Colorado River basin, records document an annual mean air surface temperature increase of approximately 1.4°C (2.5°F) over the past century with temperatures today at least 0.8°C (1.5°F) warmer than during the 1950 drought (NRC 2007, Lenart 2007). Udall and Bates (2007) found that multiple independent data sets confirm widespread warming in the West. Both in terms of absolute degrees and in terms of annual standard deviation, the Colorado River Basin has warmed more than any region of the United States (NRC 2007).

One expected outcome of increased air temperature is increased evaporation from Navajo Reservoir. An historical and ongoing adverse effect of Navajo Reservoir on the endangered fishes in the San Juan River is the evaporative loss of water. Approximately 27,400 acre feet are currently lost annually from the reservoir (Reclamation 2003). Water and air temperature are important elements in calculating evaporation rate. Unless humidity increases and wind decreases at Navajo Reservoir because of climate change, an increase in air temperature will lead to increased evaporation loss from the reservoir impacting the amount of water available for all uses. In addition, the Animas-La Plata project will soon divert water from the Animas River into a newly created reservoir (Lake Nighthorse), which will be an additional source of evaporative loss from the system that can be expected to increase as air temperature increases. Although an evaporative loss from Lake Nighthorse of approximately 2,700 acre-feet per year is accounted for in calculating depletions for the project, additional increases due to climate change are not.

In addition to increased depletions due to evaporative losses, Hoerling (2007) projects that in the Southwest, relative to 1990–2005, model simulations indicate that a 25 percent decline in stream flow will occur from 2006–2030 and a 45 percent decline will occur from 2035–2060. Seager et al. (2007) demonstrate that there is a broad consensus among climate models that the Southwest will get drier in the 21st century and that the transition to an even more arid climate is already under way. Only one of 19 models demonstrated a trend toward a wetter climate in the Southwest (Seager et al. 2007). They project a decrease in runoff of 8 to 25 percent. The Colorado River basinwide snow water equivalent is projected to decline by 13 to 38 percent from 2025 to 2085 (Christensen and Lettenmeier 2006). Ray et al. (2008) and Udall (2007) summarize several studies which all point to an expected decline in runoff in the Colorado River basin. Although the San Juan River is not modeled independent of the entire Colorado River basin in these studies, it is reasonable to expect that a similar pattern will occur.

The consequence of increased evaporation and decreased runoff is that there will be less water available to meet all demands. This consequence could potentially impact the magnitude of flows that can be released for the endangered fishes. The Flow Recommendations were developed based on the historical hydrograph. Spring flows from 2,500 to 10,000 cfs are scheduled to occur, on average, in intervals from 2 to 10 years, respectively (Holden 1999). A maximum of 5,000 cfs can be released from the gates at Navajo Dam. Releases from the dam are timed with spring runoff from the Animas River to meet the high target flows. It may become more challenging to meet the higher target flows in the future if Navajo Lake storage is reduced or runoff from the Animas River decreases. This is particularly important because when high flows are reduced in magnitude or frequency, nonnative vegetation is encroaches on the channel causing the channel to simplify (Bliesner et al. 2008). Habitat complexity is the desirable condition for pikeminnow and razorback sucker. Releasing high spring flows to maintain and create suitable habitat for the endangered fishes will continue to be an important element of the Flow Recommendations in the future.

Another documented effect of climate change, is that in the western United States warming has resulted in a shift of the timing of spring snowmelt. Stewart et al. (2004) show that timing of spring snowmelt and runoff in the western United States during the last five decades has shifted so that the major peak runoff now arrives 1 to 4 weeks earlier, resulting in less flow in the spring and summer. Rauscher et al. (2008) suggest that with air temperature increases of 3º to 5ºC, snowmelt driven runoff in the western United States could occur as much as two months earlier than present. While it is reasonable to expect that runoff in the San Juan River is occurring earlier because of warmer air temperatures, analysis of the timing of spring runoff has not been done. However, Westfall and Bliesner (2008) looked at the predictions of several models using two emission scenarios and all of them predicted that by 2099 runoff in the San Juan River would occur approximately one month earlier than historical conditions. How much earlier spring runoff is currently occurring, if at all, compared to the historical condition has not been analyzed.

It is difficult to predict how a change in the timing of runoff will affect the endangered fishes. It appears that spawning is cued to temperature and increases (razorback sucker) or decreases (pikeminnow) in snowmelt runoff. It is unknown if day length plays a role in preparing the fish to spawn, if a minimum amount of time is required for gamete development, and how plastic the fish are in adjusting to new environmental conditions. Theoretically, the fish may not be able to adjust to an earlier spawning date, especially if it were one or two months earlier. However, if successful spawning occurs earlier, larval fish would have a longer growing season before winter. Because water temperatures in the San Juan River are colder than historical conditions in

the summer because of deep water releases from Navajo Reservoir, having a longer growing season could have a positive effect on recruitment of endangered fish.
In conclusion, climate change is occurring and will continue to increase air temperatures in the Colorado River basin. The most likely consequences of warmer air temperatures are increased evaporation, evapotranspiration, and decreased runoff. An additional effect of climate change is earlier spring runoff. To the extent that climate change reduces the amount of water available in the river, it is anticipated that negative impacts could occur to the endangered fishes because simultaneously there will be an increased demand for water for human uses. The effect of earlier spring runoff on the fishes is unknown and will need to be monitored.

Changes in Channel Morphology

The quantity and timing of flows influence how the channel and various habitats are formed and maintained. It is hypothesized that the channel width during the 1930s was much wider than the historical condition as large amounts of sediment entered the river in response to upland habitat degradation and erosion caused by overgrazing (Holden 1999). Channel narrowing is a problem because as the channel width decreases, water velocity increases, and the amount of low velocity habitats, important to the early life stages of the fish, decreases (Service 1998). Between the 1930s and 1950s the channel narrowed by an average of 29 percent between the present day site of Navajo Dam (RM 224) and River Mile 67 (Holden 1999). From 1930 to 1942, suspended sediment load was approximately 47,200,000 tons/year (Holden 1999). Between 1943 and 1973, suspended load dropped by half to 20,100,000 tons/year (Holden 1999). The 1930s aerial photography shows a sand-loaded system, and where the channel was not confined, the river was broad during high flows and braided during low flows (Holden 1999).

Channel narrowing before 1962 was most likely due primarily to the reduction in sediment load. Channel narrowing in later years (after 1962) corresponds to the modification of flows by Navajo Dam and the introduction and encroachment of Russian olive (Holden 1999). Reduced peak flows after Navajo Dam was completed (1962 to 1991) exacerbated the growth of exotic riparian vegetation (primarily salt cedar and Russian olive). These non-native trees armored the channel banks and contributed to the creation of a narrower channel (Bliesner and Lamarra 1994). Modification of flows and non-native vegetation led to more stabilized channel banks, a deeper, narrower main channel, and fewer active secondary channels (Holden 1999).

Since 1992, when a natural hydrograph was mimicked, peak flows have been higher than in the pre-experimental research flow period (prior to 1991). Backwater habitat, an important nursery area for fish, reached a low in 2003 at about 20 percent of the peak value (Bliesner et al. 2008). The trend reversed in 2004 and in 2005, more backwaters were recorded. There was not an increase in 2006, a dry year with a small release from the reservoir (Bliesner et al. 2008). Other low velocity habitat (i.e., pools, eddies), slackwater, and shoal areas have not changed significantly since 1992 (Bliesner 2004).

Channel complexity is another important component of razorback sucker and pikeminnow habitat. One measure of channel complexity is the number and area of islands present. Between 1950 and 1960 there was a large decrease in island area (Bliesner 2004). Vegetation encroached on the channel and long secondary channels were cut off as the floodplain stabilized. The increase in vegetation during this period coincided with a long-term drought, which contributed to channel simplification (Bliesner 2004). Between 1960 and 1988, island area increased to the levels that were present in 1934 (Bliesner 2004). The 10 years prior to 1988 were the wettest on record, so although salt cedar and Russian olive continued to increase in the floodplain, the large flows opened secondary channels, creating large islands. Since 1992, there has been a cumulative reduction in island count at low flow of about 25% (Bliesner and Lamarra 2007). The island count, normalized for flow at mapping shows a significant ($p=<0.01$) downward trend with time, indicating channel simplification. The greatest loss of islands has occurred in Reach 5. Channel simplification is of particular concern here because Reach 5 includes known spawning habitat for pikeminnow.

A second related relationship of total wetted area over time, normalized for flow at mapping, shows a trend of total wetted area decreasing by about 10% (Bliesner and Lamarra 2007). This channel simplification has been attributed to extended drought and encroachment of Russian olive and salt cedar. The encroachment is exacerbated during dry periods when flow in secondary channels is inadequate to remove young vegetation or prevent establishment of new vegetation. Once the vegetation is established it becomes an effective trap for fine sediments by creating increased channel roughness and low boundary velocities. Once vegetation is established on main channel margins and within secondary channels it is more difficult for those channels to be flushed and for new ones to be created during high flow years (Bliesner and Lamarra 2007).

At current population levels, habitat does not appear to be a limiting factor for either the razorback sucker or pikeminnow adults (Holden 2000). However, the habitat needs of larval fish have not been thoroughly explored and further research may find specific habitat needs that are not being met or that are limiting (Holden 2000). In conclusion, there is a trend towards channel simplification, channel narrowing, reduced wetted area, and loss of islands (Bliesner et al. 2008). Although channel morphology has been monitored for a relatively short time and the recent drought and lack of high flows may have an over-riding influence on channel-forming processes it appears that flow manipulation alone may be inadequate to restore channel complexity.

Water Quality

In addition to the physical changes from dams and water diversions, and biological changes from introduction of non-native fish, chemical changes have occurred as a result of widespread irrigation and drainwater disposal in the Colorado River Basin (Finger et al. 1995, Thomas et al. 1998, Engberg et al. 1998). Quartarone and Young (1995) interviewed 111 people who recounted numerous experiences from the 1920s to the early 1950s and noted that in the late 1940s and early 1950s, Colorado “whitefish” (as pikeminnow were called at the time) were becoming rare in the upper Colorado River Basin. They believed that this rarity was the result of pollution in the rivers from dumping of raw sewage, railroad oil, and wastewaters.

Surface and groundwater quality in the Animas, La Plata, Mancos, and San Juan River drainages have become significant concerns (Abell 1994). Changes in water quality and contamination of associated biota are known to occur in Reclamation projects in the San Juan drainage (specifically associated with irrigated lands on the Pine and Mancos Rivers) where return flows from irrigation make up a portion of the river flow (Sylvester et al. 1988). Increased loading of the San Juan River and its tributaries with heavy metals; elemental contaminants such as selenium, salts, polycyclic aromatic hydrocarbons (PAHs); and pesticides have degraded water quality of the San Juan River in critical habitat (Abell 1994, Wilson et al. 1995, Simpson and Lusk 1999).

Information on existing water quality in the San Juan River has been derived from data gathered by the U.S. Department of the Interior (DOI) as part of its National Irrigation Water Quality Program investigation of the San Juan River area in Colorado, New Mexico, and Utah; results from Reclamation's water quality data for the Animas-La Plata Project; and ongoing contaminant monitoring and research conducted as part of the SJRRIP. Some of this information has been presented in Blanchard et al. (1993), Abell (1994), Wilson et al. (1995), Thomas et al. (1998), and other references cited in Simpson and Lusk (1999). Thomas et al. (1998) found that concentrations of most potentially toxic elements analyzed from the San Juan River drainage in their study, other than selenium, were generally not high enough to be of concern to fish, wildlife, or humans.

PAHs are compounds that may reach aquatic environments in domestic and industrial sewage effluents, in surface runoff from land, from deposition of airborne particulates, and particularly from spillage of petroleum and petroleum products into water bodies (Eisler 1989). Wilson et al. (1995) reported that concentrations of PAHs were elevated in the Animas River, but no identification of source location or activity has been made. The San Juan River below Montezuma Creek also had elevated levels of PAHs; and seasonal increases in PAH concentrations were detected in the Mixer area of the river (a potential spawning site for pikeminnow). PAH levels in the bile of common carp and channel catfish sampled were high in one fish and moderate in several other fish from the San Juan River. The presence of PAH metabolites in bile of every fish sampled suggested some level of exposure to hydrocarbons (Wilson et al. 1995). Service analyses of PAH contamination of aquatic biota of the San Juan River, and liver tissue examinations of fish in the river, raised concerns regarding the exposure of these organisms to contaminants introduced into the basin. However, PAHs did not appear to be a system-wide stressor to native fishes in the San Juan at the time of the study (Holden 2000).

Selenium (a trace element) occurs naturally in many soil types, and is abundant in the drier soils of the West. Selenium enters surface waters through erosion, leaching and runoff. Sources of selenium, both anthropogenic and natural, in the San Juan River, have been reported by O'Brien (1987), Blanchard et al. (1993), and Thomas et al. (1997, 1998). Selenium, although required in the diet of fish at very low concentrations (less than 0.5 micrograms per gram on a dry weight basis (µg/g), is toxic at higher levels (> 3 µg/g), and may be adversely affecting endangered fish in the upper Colorado River Basin (Hamilton 1999). Excess dietary selenium causes elevated concentrations of selenium to be deposited into developing eggs, particularly the yolk (Buhl and Hamilton 2000). If concentrations in the egg are sufficiently high, developing proteins and enzymes become dysfunctional and lead to deformed embryos or embryos that may be at higher risk for mortality.

Selenium concentrations in the San Juan River Basin are of concern because of its documented effects on fish and wildlife reproduction and survival and high levels detected in some locations within the basin (Blanchard et al. 1993, Wilson et al. 1995, Thomas et al. 1998). Selenium concentrations can be elevated in areas where irrigation occurs on soils which are derived from or which overlie Upper Cretaceous marine sediments. Thomas et al. (1998) found that water samples from DOI project irrigation-drainage sites developed on Cretaceous soils contained a mean selenium concentration about 10 times greater than those in samples from DOI project sites developed on non-Cretaceous soils. Percolation of irrigation water through these soils and sediments leaches selenium into receiving waters. Other sources of selenium likely include power plant fly ash and oil refineries in the basin (Abell 1994). Water depletions, by reducing dilution effects, can increase the concentrations of selenium and other contaminants in water, sediments, and biota (Osmundson et al. 2000).

Some tributaries to the San Juan River carry higher concentrations of selenium than found in the main stem river immediately upstream from their confluence with the San Juan River (Thomas et al. 1998). Increased selenium concentrations may also result from the introduction of ground water to the main stem of the river along its course. Although these levels are diluted by the flow of the San Juan River, the net effect is a gradual accumulation of the element in the river as it travels downstream. For example, concentrations of selenium in water samples collected from the main stem of the San Juan River exhibited a general increase in maximum recorded values with distance downstream from Archuleta, New Mexico, to Bluff, Utah, (less than 1 µg/L [micrograms per liter] to 4 µg/L) (Wilson et al. 1995). The safe levels of selenium concentrations for protection of fish and wildlife in water are considered to be less than 2 µg/L and toxic levels are considered to be greater than 2.7 µg/L (Lemly 1993, Maier and Knight 1994, Wilson et al. 1995). However, dietary selenium is the primary source for selenium in fish (Lemly 1993, Buhl and Hamilton 1995). Thus, sediment and biotic analyses are necessary to further elucidate the risk of selenium to fish and wildlife.

From 1998 to 2005 the SJRRIP annually monitored water quality constituents. Trends of the constituents with time were examined by linear correlation. There were no statistically significant trends for this data set. During the drought years in the latter part of the record there was a slight elevation in total dissolved solids and the associated constituents due to reduced flows and increased percentage of return flow during the late summer. However, the water quality remained good even during these drought times.

Selenium concentrations remain low in the mainstem, with most readings below detection. Looking at the trend with time from 1994 to 2003, there appear to be fewer detectable readings. There is an increasing trend of detectable readings down river as more tributary flow enters the system, but this has not increased with time. With the exception of the measurement of 9 ppb total recoverable selenium at Mexican Hat, the maximum concentration measured in the San Juan River during the 1994 to 2003 period was 2 ppb, with most of the detectable readings at 1 ppb, the detection limit. The water quality standard exceedences do not appear to be a result of implementation of the flow recommendations and there is no trend with time.

The SJRRIP arranged for toxicity tests to be conducted to determine the effects of environmental contaminants in water (Hamilton and Buhl 1995), and in diet and tissues of the razorback sucker and pikeminnow in the San Juan River (Buhl and Hamilton 2000). The waterborne toxicity tests showed a potential threat to endangered fishes from waterborne concentrations of copper and contaminant mixtures created to simulate the water quality conditions of two irrigation drains (Hamilton and Buhl 1995, 1997). However, the results of the dietary toxicity tests showed that dietary selenium (as opposed to water borne selenium) was the primary source of selenium accumulation in pikeminnow, accumulated selenium left the tissues slowly after exposure ended, and the selenium concentrations in eggs were significantly greater than concentrations in the parent (Buhl and Hamilton 2000). However, the concentrations accumulated in the eggs (9.8-11.6 μg/gram) were lower than those in eggs linked with reproductive impairment in fish (Buhl and Hamilton 2000). Unfortunately, due to small sample size, the reproductive metrics (number of eggs expressed, egg weight, hatchability, time to hatch, and survival, growth, and deformities of the larvae) could not be statistically evaluated in this study (Buhl and Hamilton 2000).

Quartarone and Young (1995) suggested that irrigation and pollution were contributing factors to razorback sucker and pikeminnow population declines, and Hamilton (1999) hypothesized that historic selenium contamination of the upper and lower Colorado River Basins contributed to the decline of these endangered fish by affecting their overall reproductive success. However, because riverine systems are open systems where concentrations can vary considerably over time in relation to flow (as opposed to a closed system like a lake where concentrations tend to remain steady or increase), and because results from the 7-year research period were inconclusive, selenium concentrations are not currently seen as a limiting factor to native fishes in the San Juan River (Holden 2000). However, as recovery of the pikeminnow and razorback sucker proceeds, research should continue on this issue. These fish can live over 40 years (Behnke and Benson 1983), increasing their frequency of exposure to selenium. In addition, they often stage at tributary mouths such as the Mancos River before spawning, increasing their exposure to elevated levels of dietary selenium (Wilson et al. 1995). The impact of selenium on reproductive success may become more important in coming years as more reproduction occurs within the river from resident fish as opposed to stocked fish.

Climate change could increase pikeminnow and razorback sucker exposure to contaminants through two mechanisms. First, it is anticipated that runoff will decrease (Udall 2007, Ray et al. 2008). If discharge decreases, contaminants will be more concentrated than they are currently. Second, with warmer air temperatures, evaporation of irrigation water on fields will increase, and return flows may decrease, increasing the concentration of contaminants such as selenium in the irrigation flows that return to the San Juan River. Consequently, pikeminnow and razorback sucker may be exposed to increasing concentrations of contaminants over time as a result of climate change.

As a result of the lack of statistically significant water quality trend data, the SJRRIP discontinued annually monitoring of water quality constituents in 2005 and has recommended conducting toxicity tests every five years to determine the effects of environmental contaminants in water, and in diet and tissues of the

Propagation and Stocking

Colorado pikeminnow

Because of human impacts to the Colorado and San Juan Rivers, pikeminnow was thought to be extirpated from the San Juan River (Tyus et al. 1982). Surveys conducted from 1987-1989 revealed that pikeminnow was still present in the San Juan River, but in very low numbers (Platania et al. 1991). Because of the extremely low numbers of wild pikeminnow and poor recruitment into the population, a stocking program was initiated to augment pikeminnow numbers. When the SJRRIP was established in 1992, one of the program elements was the protection of genetic integrity, management, and augmentation of populations of the endangered fish.

Experimental stocking of 100,000 YOY pikeminnow was conducted in November 1996, to test habitat suitability and quality for young life stages (Lentsch et al. 1996). Monitoring in late 1996 and 1997, found these fish scattered in suitable habitats from just below the upstream stocking site at Shiprock, New Mexico, to Lake Powell. During the fall of 1997, the fish stocked in 1996 were caught in relatively high numbers and exhibited good growth and survival rates (Holden and Masslich 1997). In August 1997, an additional 100,000 YOY pikeminnow were stocked in the river. In October 1997, the YOY stocked two months previously were found distributed below stocking sites and in relatively large numbers nearly 10 miles above the Shiprock stocking location. The 1997 stocked fish were smaller in size than those stocked in 1996, but apparently could move about the river to find suitable habitats (Holden and Masslich 1997). Because of the initial success of the stocked fish, pikeminnow have been stocked every year since 1996. The number of pikeminnow stocked each year is recorded in annual reports and can be viewed at the San Juan programs website (http://www.fws.gov/southwest/sjrip/).

A total of 1,781,154 pikeminnow were stocked into the San Juan River from 2002 to 2007 (Ryden 2008b). In 2007, target stocking numbers were exceeded for age-0 pikeminnow, with 475,970 fish stocked (target is 300,000), and age-1 fish, 3,256 stocked (target is 3,000). Pikeminnow from several size-classes are now captured in the San Juan River, indicating that there has been survival from several years (Ryden 2008b). The SJRRIPs augmentation program has been successful in increasing the number of pikeminnow in the San Juan River in a relatively short time, increasing the number of fish much faster than if augmentation had not taken place.

Razorback sucker

Although evidence suggests that razorback suckers were once abundant in the San Juan River at least up to the confluence with the Animas River (Platania and Young 1989), wild razorback suckers, if they still exist, are extremely rare in the river. Even with intensive sampling only one adult was captured in the river from 1987- 1989, and 292 collections of larval fish during that same time recovered no razorback sucker (Platania et al. 1991). Because of the limited number of razorback sucker and the lack of recruitment, a stocking program was begun to supplement the population. In 1997, the SJRRIP initiated a 5-year augmentation program for the razorback sucker (Ryden 1997). The number of razorback sucker stocked each year is recorded in annual reports available at the San Juan programs website (http://www.fws.gov/southwest/sjrip/).

Between 1994 and 2007, a total of 54,472 hatchery and pond raised razorback suckers were stocked into the San Juan River (Ryden 2008c). In 2007, 22,836 razorback sucker were stocked, the second consecutive year that the target stocking number for razorback sucker (target = 11,400 fish) was met or exceeded. Razorback sucker that have been in the river for 6 or more overwinter periods have been collected every year since 2001 (Ryden 2008c). Larval razorback suckers have been collected each year since 1998, indicating that the stocked fish are successfully spawning in the San Juan River (Brandenburg and Farrington 2008). The augmentation program has been successful in increasing the number of razorback sucker in the San Juan River in a relatively short time, increasing the number of fish much faster than if augmentation had not taken place.

Water Depletions

As discussed previously, natural flow regimes are essential to the ecological integrity of large western rivers (Service 1998) and for the maintenance or restoration of native aquatic communities (Lytle and Poff 2004, Propst and Gido 2004, Propst et al. 2008). The flow regime works in concert with the geomorphology of the basin to establish and maintain the physical, chemical, and biological components of a stream ecosystem (Williams and Wolman 1984, Allan 1995, Collier et al. 2000, Service 1998, Mueller and Marsh 2002). Depletions play a major role in limiting the amount of water available for achieving the Flow Recommendations.

Significant depletions and redistribution of flows of the San Juan River have occurred as a result of other major water development projects, including the NIIP and the San Juan-Chama Project. At the current level of development, average annual flows at Bluff, Utah, already have been depleted by 30 percent (Holden 1999). By comparison, the Green and Colorado Rivers have been depleted approximately 20 percent (at Green River) and 32 percent (at Cisco), respectively (Holden 1999). These depletions have likely contributed to the decline in pikeminnow and razorback sucker populations (Service 1998). Depletions are expected to increase as full development of water rights and water projects occurs. To the extent that water is exported out of the basin (San Juan-Chama Project) or consumptively used (e.g., evaporation from fields, irrigation canals, reservoir surface) it is not available to maintain flows within the river. Maintenance of streamflow is essential to the ecological integrity of large western rivers (Service 1998).

Water depletion projects that were in existence prior to November 1, 1992, are considered to be historic depletions because they occurred before the initiation of the SJRRIP. Projects that began after this date are considered new projects. On May 21, 1999 the Service issued a BO (R2/ES-TE CL 04-054) determining that new depletions of 100 af or less, up to a cumulative total of 3,000 af, would not: 1) Limit the provision of flows identified for the recovery of the pikeminnow and razorback sucker, 2) be likely to jeopardize the endangered fish species, or 3) result in the destruction or adverse modification of their critical habitat. Consequently, any new depletions under 100 af, up to a cumulative total of 3,000 af, may be incorporated under the May 21, 1999, BO, but would still require consultation.

Consultations contributing to the baseline conditions (depletions) used reoperation of Navajo Reservoir in accordance with the Flow Recommendations as part of their section 7 compliance. Some of these projects have been completed (e.g., PNM Water Contract with Jicarilla Apache Nation), some are partially complete (e.g., NIIP), and some have not been fully implemented (e.g., Animas-La Plata Project). As these projects are fully implemented, the amount of water available for operational flexibility will decrease.

As discussed above under “Changes in the Timing and Magnitude of Flow” it is anticipated that climate change will create additional depletions to the San Juan River in the future. The magnitude and timing of the depletions cannot be predicted with certainty at this time. However, increased air temperatures will increase evaporation from all water surfaces, increase plant evapotranspiration, and decrease snow water equivalent reducing the amount of water in the basin. As reviewed above, several studies project a decrease in stream flow from 8 to 45 percent depending on the model used, the time frame, and the methods (Christensen and Lettenmeier 2006, Hoerling 2007, Seager et al. 2007, Udall 2007, Ray et al. 2008). Although the San Juan River was not modeled independent of the entire Colorado River basin in these studies, based on the projections of the IPCC (2007) for warmer temperatures, an increase in the frequency of hot extremes and heat waves, it is reasonable to expect that there will be a decrease in stream flow in the future.

In summary, as the San Juan Basin water-users move towards fully utilizing their respective water rights, the amount of water available for operational flexibility will decrease. We anticipate that climate change will place additional constraints on the amount of water available for operational flexibility.

Diversion Structures

There are numerous points of diversion on the San Juan River for irrigation and energy production. In addition to acting as fish passage impediments (as discussed earlier), most of these structures do not have screens or other devices to prevent fish from entering (Holden 2000). Although anecdotal, Quartarone and Young (1995) present many stories from senior citizens that recalled seeing or catching razorback suckers from irrigation ditches, sometimes in very large numbers. Trammell (2000) reported that after stocking 500,000 larval pikeminnow below Hogback Diversion structure, 63 larvae were collected from the Cudei Diversion canal. This number represented 0.013 percent of the total stocked. Catch rate was 4.39 pikeminnow/100 m^3 of water sampled.

In December 2004, 140 pikeminnow in 3 size classes were caught in the Hogback Diversion (Platania and Renfro 2005). Most of the individuals (92 percent) were between 33-65 mm standard length (SL) (1.3-2.5 in) that had been stocked in October 2004. Seven were between 130-187 mm SL (5.1-7.4 in) and 4 were 210-264 mm SL (8.3-10.4 in) (Platania and Renfro 2005). Pikeminnow were caught from 0.5 to 17.8 canal miles from the diversion structure (Platania and Renfro 2005). In 2005, recently-stocked pikeminnow were captured in the Hogback and Fruitland Diversion canals.

Pikeminnow that enter diversion structures face an uncertain fate, although fish may find their way back to the river. Because the number of fish entrained at diversion structures is unknown the SJRRIP is analyzing entrainment at all of the diversion structures. Diversions that entrain fish will be addressed by the SJRRIP.

Non-native Fish

Nearly 70 non-native fish species have been introduced into the Colorado River system over the last 100 years (Service 1998). Non-native fish in the San Juan River include rainbow trout (*Oncorhynchus gairdneri*), brown trout (*Salmo trutta*), striped bass, walleye, channel catfish, black bullhead, yellow bullhead, largemouth bass, smallmouth bass, green sunfish, long-ear sunfish (*Lepomis megalotis*), bluegill, white crappie, fathead minnow, red shiner, Western mosquitofish, common carp, white sucker, white sucker x flannelmouth sucker hybrids, white sucker x bluehead sucker hybrids, threadfin shad, grass carp, and plains killifish (Ryden 2000a, Buntjer 2003). Channel catfish was first introduced in the upper Colorado River Basin in 1892 (Tyus and Nikirk 1990) and is thought to have the greatest adverse effect on endangered fishes due to predation on juveniles and resource overlap with subadults and adults (Hawkins and Nesler 1991, Lentsch et al. 1996, Tyus and Saunders 1996). Adult and juvenile pikeminnow that have preyed on channel catfish and black bullhead have died from choking on the pectoral spines (McAda 1983, Pimental et al. 1985, Quartarone and Young 1995, Ryden and Smith 2002). Mechanical removal of non-native fish (seining and electrofishing) from the San Juan River began in 1995, but was not instituted as a management tool until 1998 (Smith and Brooks 2000). Removal efforts have focused on channel catfish and common carp because they are the most abundant large-bodied non-native fishes and are known predators on native fish and eggs (Davis 2003).

For more than 50 years, researchers have been concerned that non-native fishes have contributed to the decline of native fishes in the Colorado River Basin (Service 1989). Non-native species are potential predators, competitors and vectors for parasites and disease (Tyus et al. 1982, Lentsch et al. 1996, Pacey and Marsh 1999, Marsh et al. 2001). Because non-native fish are considered to be an important biological threat to pikeminnow and razorback sucker, control of non-native fishes through removal has become part of the SJRRIP. Recent adult monitoring reports show evidence that the nonnative fish removal efforts are having a marked and measurable effect on the channel catfish and common carp populations in the San Juan River (Davis and Furr 2008). There is also an upward trend in both abundance and longitudinal distribution among both flannelmouth sucker and bluehead sucker that corresponds with the intensive nonnative fish removal efforts which began in 2001 (RM 166.6 – 147.9) and (RM 52.9 – 2.9).

From 1998-2005, 32,367 channel catfish and 16,335 common carp were removed from the river (Davis 2005). Catch rates did not decrease for either species. For channel catfish, both adult and juvenile size classes saw general, although not significant, declines in 2005 (Davis 2005). The advantages of reducing the mean length of channel catfish is that they are not thought to be piscivorous until they reach a length of about 450 mm (17.7 in), and fecundity (number of eggs) is much greater in larger fish (Davis 2005). An increase in the number of smaller fish could potentially lead to an increase in competitive or aggressive interactions with native fish. However, it is expected that continued removal efforts will eventually reduce the numbers of smaller channel catfish as well (Davis 2005).

The primary method used to capture large-bodied non-native species is electrofishing. In 1999, one, three-day trip was made and non-natives were removed from Hogback diversion structure to the PNM weir. In 2000, two trips were made and in 2001 and 2002, 10 trips were made each year to this same section. In 2003, non-natives were removed from a second reach, RM 166.6 down to Shiprock (RM 148). During non-native fish removal, razorback sucker and pikeminnow are also shocked and captured. Electrofishing has been shown to have negative effects on trout (Kocovsky et al. 1997, Nielsen 1998). While no direct mortality has been documented, there could be adverse effects to pikeminnow and razorback sucker from repeated shocking and handling.

Mesa Verde Cactus

Mesa Verde cactus occurs in the Four Corners Region of northwestern New Mexico and southwestern Colorado. It is a San Juan River Basin endemic within the Colorado Plateau subdivision of the Great Basin Desert. The total range of this cactus is encompassed within a rectangular area of about 120 x 48 km (75 x 30 miles), from near Naschitti in southern San Juan County, New Mexico to about 16 km (ca 10 miles) north of the New Mexico border in Montezuma County, Colorado. Distribution within this range is not continuous and is quite sporadic and widely scattered. Shiprock, New Mexico (population 8,755) is the largest town near Mesa Verde cactus population concentrations. The region is sparsely populated but has significant natural resources such as coal, oil, and natural gas.

Energy and Mineral Development

Energy and mineral development is extensive in the area occupied by Mesa Verde cactus. The development of the oil, gas and coal resources has included the creation and expansion roads, pipelines, powerlines, and associated commercial and associated residential development.

Only a few populations occur on or near the coal reserves of the Fruitland Formation in the Waterflow area of New Mexico. At least 90 percent of the total Mesa Verde cactus habitat is believed unlikely to be impacted by coal mining because it occurs on geologic formations with uneconomical or no coal reserves (Parker et al. 1977).

Nearly all Mesa Verde cactus habitats have the potential to be affected by natural gas or oil exploration and production. Currently, some well fields have been established within or near cactus populations that occur on the Fruitland Formation; some of these occur on the Navajo Nation lands. Negative effects to cacti can occur from oil and gas development; these include but are not limited to plug and abandonment activities, exploration activities, and pipeline transmission of natural gas produced from adjacent areas (Service 2008). Most Mesa Verde cactus habitats are on the Mancos Formation, with the Rattlesnake, Shiprock-Gallup, Horseshoe-Gallup, and Hogback oil fields located within high-quality Mesa Verde cactus habitat. Fields here are either still active or have been plugged. Habitat destruction in these areas is extensive (Roth, personal communication, 2008).

Humates are an additional extractable resource underlying some Mesa Verde cactus habitats (Ladyman 2004). Humate is used as a soil conditioner and additive to drilling muds. About 12.1 billion short tons of humate resources are within the San Juan Basin (McLemore and Hoffman 2003).

Urbanization and Associated Impacts

Beyond the effects of the drought, the most significant impacts to Mesa Verde cactus are the numerous, continuous, small conversions of habitat to urban use in the Shiprock area and to home-site development in the more rural areas. These losses are individually small but becoming cumulatively significant. Development of homes, roads, waterlines, recreation areas, and additional facilities continue to expand within and around the Shiprock area and are increasingly conflicting with Mesa Verde cactus habitat (Roth, personal communication, 2004). These impacts are not severe on the Ute Mountain Ute Reservation in the Colorado portion of the Mesa Verde cactus range (Coles, personal communication, 2006). Off-road-vehicle use is increasing as the population of the Navajo Nation and San Juan County increases. Negative effects to Mesa Verde cactus and its habitat are evident in unauthorized roadways, trails, flattened and denuded landscape and continually increasing sizes of such areas, whether near homes or farther away. Livestock concentrated around residences compact the soil, eliminating potential Mesa Verde cactus growth or recovery (Sivinski, personal observations, 1990-2004).

Livestock Grazing

Although the habitat that Mesa Verde cactus occupies would by most accounts be described as "barren," livestock grazing occurs across most of the occupied habitat. Nearly all surveys record some disturbance by livestock. In 1985, in surveys conducted for BLM, livestock trampling was recorded and one cow was documented eating a Mesa Verde cactus (Ecosphere 1985). Ladyman (2004) noted heavy sheep and cattle grazing at two Sheep Springs sites that once supported Mesa Verde cactus. Three additional sites noted extensive livestock damage (Ladyman 2004). In Colorado, livestock trampling was noted as the primary source of mortality in 2005 (Colorado Natural Areas Program 2005). Loss of cacti around homes and watering facilities is highly likely to occur to any Mesa Verde cacti occurring within the zone of intense livestock concentration through trampling and soil compaction. A more recent concern are effects from large-scale roundups of Navajo Nation feral horse herds that result in compacted soils in Mesa Verde cactus habitat (Roth, personal communication, 2008).

Disease and Predation

All Mesa Verde cactus within its range is susceptible to disease and predation as described above under the "Status of the Species." In summary, the cactus longhorn beetle (*Moneilema semipunctata*) preys upon Mesa Verde cactus, usually with lethal consequence. The beetle is a native species that may have caused significant, undocumented episodes of Mesa Verde cactus die-off in the past. The beetle cannot fly, so it is probably a resident within cactus populations. An estimated 80 percent of all Mesa Verde cactus succumbed to beetle attack in a large die-off in the early 2000s (Muldavin et al. 2003). The few cacti that survived this extreme episode of beetle predation were small juvenile plants that are less susceptible to attack (Sivinski 2003, Ladyman 2004). The army cutworm (*Euxoa* sp.) has also been associated with predation on Mesa Verde cactus. In 2003, many of the Mesa Verde cacti on the BLM Farmington Resource District were infested with cutworms which were eating both the stem and roots (BLM 2003). Navajo Nation botanist Daniela Roth (Roth 2008) also believed that Mesa Verde cactus on the Navajo Nation died from extreme army cutworm infestations during the drought.

Some new Mesa Verde cactus are appearing from seeds in the soil seed bank, but they are immature and will take several years to become reproductively mature; therefore, we assume it will take many years for Mesa Verde cactus to return to former population levels.

Climate Change

Climate change may also affect the environmental baseline of Mesa Verde cactus. Over a 41 year period, the average annual precipitation at the Shiprock, New Mexico has been 6.93 in (Western Regional Climate Center 2008). In 1995, the annual precipitation equaled the long term average; every year since then it has been below the average. In 2002, no precipitation was recorded and in 2004, 1.27 in was recorded which is the third lowest level measured since 1926. Mean annual precipitation since 1996 has been 3.96 in, well below the long-term average. In no other period since 1926 have there been so many consecutive years of precipitation below the average (Western Regional Climate Center 2008). Concurrent with below average precipitation are above average temperatures which may further stress the plants, especially in the summer.

Because it has been observed that germination and recruitment improves in years of normal or above normal precipitation, it is expected that recovery from the population decline in the early 2000s will be slow under current conditions of below average precipitation.

The IPCC (2007) projects that there will very likely be an increase in the frequency of hot extremes, heat waves, and heavy precipitation events as a result of climate change. Climate forecasts project a northward shift in the jet stream and associated winter-spring storm tracks, which are consistent with observed trends over recent decades (CCSP SAP 1.1, 2006). This would result in future drier conditions for the Southwest and an ever-increasing probability of drought for the region (IPCC 2007b, Trenberth et al. 2007). Because of the documented decline of Mesa Verde cactus concurrent with the drought of the early 2000s, we would expect that if a change in climate led to increased severity or frequency of drought, it would have a negative impact on the plant in the future. Narrow endemics, like Mesa Verde cactus, often have very specific habitat requirements. Because plants are unable to move, a change in climate that causes mortality to exceed reproduction and recruitment, could lead to the extirpation of Mesa Verde cactus.

EFFECTS OF THE ACTION

'Effects of the action' means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but are still reasonably certain to occur. If the proposed action includes offsite measures to reduce net adverse impacts by improving habitat conditions and survival, the Service will evaluate the net combined effects of the proposed action and the offsite measures as interrelated actions.

'Interrelated actions' are those that are part of a larger action and depend on the larger action for their justification; 'interdependent actions' are those that have no independent utility apart from the action under consideration (50 CFR 402.02). Future Federal actions that are not a direct effect of the action under consideration, and not included in the environmental baseline or treated as indirect effects, are not considered in this BO.

Effects of the action on pikeminnow and razorback sucker

Entrainment of Larval Fish

Colorado pikeminnow

The proposed action includes the diversion of 59 cfs per day from the San Juan River into the existing PNM diversion dam at river mile 167. Although the diversion would be equipped with a fish screen with 3/32 inch openings, it would not exclude larval fish. Consequently, larval pikeminnow could be directly affected by the diversion in the future. While no spawning sites have been documented above the proposed diversion, the quality of gravel bars suggests that there is potential spawning habitat between the diversion and RM 180 (Bliesner 2003). Spawning has been documented between RM 129.8 and RM 133.4 (Ryden 2000a). Given the known range of spawning, the availability of spawning habitat above the diversion and assuming a relatively uniform distribution of available spawning habitat between RM 128 and RM 180, about 25 percent of pikeminnow spawning activity could occur above the proposed intake at some point in the future (13 of 52 miles of potential spawning habitat).

Based on capture of larval pikeminnow in the San Juan River, larvae typically enter the drift from mid-July to early-August (Brandenburg and Farrington 2008) and drift passively for 3 to 6 days after emergence (Dudley and Platania 2000). Therefore, larval pikeminnow spawned above the diversion would be subject to loss into the diversion for about 30 days. Flows during peak pikeminnow larvae drift average about 1,500 cfs at the Farmington gage (1993-2003; USGS 2003). The proposed intake will divert about 4 percent (59 cfs) of the total river flow during this time frame. Larval pikeminnow will not be excluded by a 3/32 inch screen. Thus, we estimate a loss of about 4 percent of larvae spawned above the intake. Because only 25 percent or less of the spawn is expected above the diversion, the net loss is expected to be approximately 1 percent of all pikeminnow larvae produced in the San Juan River.

There are no additional measures that could be used to minimize take from this diversion. While no spawning sites have been documented above the proposed diversion, the net loss of pikeminnow larvae is expected to be approximately 1 percent of all pikeminnow larvae produced in the San Juan River once a viable pikeminnow population is reestablished. Because the SJJRIP will continue to augment the pikeminnow population, the take of 1 percent of all pikeminnow larvae produced in the San Juan River is expected to be de minimis during reestablishment. After a viable pikeminnow population is reestablished, the take of 1 percent of all pikeminnow larvae produced in the San Juan River is expected to be de minimis and the level of anticipated take is not likely to result in jeopardy to pikeminnow.

Razorback sucker

It is anticipated that razorback sucker will be adversely affected by the diversion of 59 cfs at RM 167 in the future due to the loss of larval fish into the diversion structure. Spawning typically occurs on the ascending limb of the hydrograph during spring (Brandenburg and Farrington 2008). Based on the capture of larval razorback sucker, larvae are found in the drift from late March to early July (Brandenburg and Farrington 2008). With an assumed potential spawning range between RM 100 to RM 180 and a uniform distribution of spawning adults in the future, about 16 percent of the larval drift could occur above the diversion. Average flow during spawning from 2003 to 2007 ranged from 717 to 6455 cfs (Brandenburg and Farrington 2008). Based on this range, which represents high and low runoff years, the diversion could take from 0.9 to 8 percent of the flow. Therefore, from approximately 0.1 to 1.3 percent of the drifting larvae would be subject to loss in the diversion.

There are no additional measures that could be used to minimize take from this diversion. While no spawning sites have been documented above the proposed diversion, the net loss of razorback sucker larvae is expected to be approximately 0.1 to 1.3 percent of all razorback sucker larvae produced in the San Juan River once a viable razorback sucker population is reestablished. Because the SJJRIP will continue to augment the razorback sucker population, the take of 0.1 to 1.3 percent of all razorback sucker larvae produced in the San Juan River is expected to be de minimis during reestablishment. After a viable razorback sucker population is reestablished, the take of 0.1 to 1.3 percent of all razorback sucker larvae produced in the San Juan River is expected to be de minimis and the level of anticipated take is not likely to result in jeopardy to razorback sucker.

Water Quality

Water quality changes will be undetectable because project withdrawals will only reduce base flow (500cfs) by less than 0.5 percent on average with the greatest impact being less than 3 percent. Return flow from all sources accounts for about 10 percent of the flow of the river during base flow periods. Most constituents are concentrated about 4 fold in return flow through evaporative losses so the increase in water quality constituent concentrations below the diversion due to withdrawal will be about 0.9 percent, with a similar reduction in concentrations above that location due to increased flow. Return flow at Shiprock will be through the Shiprock treatment plant, meeting the requirements of the NPDES permit, with an average annual flow of 5.0 cfs (1 percent of the base flow). During runoff months, flows are slightly increased, so water contaminant concentrations in the water will decrease. The net increase in any water quality parameter will be less than 2 percent. Because the increase in water quality constituents will be undetectable, the effect to pikeminnow and razorback sucker will be insignificant and discountable.

Depletions

The project would reduce the amount of water in the river system by 5,271 af /year. The effects to pikeminnow and razorback sucker would result from the effects of the action upon their habitats. In general, the SJRRIP determined that mimicry of a natural hydrograph would create, maintain, and maximize key habitats, and mimicry could be accomplished through operations at Navajo Dam. The Flow Recommendations (Holden 1999) were developed by the SJRRIP to address dam releases directly and are the primary source of information concerning the research and management actions taken to develop the recommendations.

The SJRRIP determined that to maximize key habitats for native fishes, flows in the San Juan River needed to more closely match a natural hydrograph in magnitude, duration, and timing than they had since Navajo Dam's completion. High spring flows were a natural San Juan River characteristic and a characteristic that is needed to create and maintain key habitats for the endangered and native species. The life histories of the endangered species are closely tied to the magnitude, duration, and timing of the natural hydrograph. Habitat for spawning and rearing young, although very different for the two endangered species is expected to improve and be maximized with a relatively natural annual hydrograph. To meet this need, the Flow Recommendations provided increased spring peak magnitude and duration, while maintaining timing more similar to pre-dam conditions than to post-dam flows. Base flows were also altered to resemble the magnitude and timing of pre-dam conditions.

To the extent that the proposed diversion would reduce flows and contribute to further habitat alteration, the depletion was modeled using the San Juan River Basin Riverware model to determine its effect on the Flow Recommendations developed by the SJRRIP Biology Committee for the recovery of the listed fish species. The modeled results show that the depletion will prevent the flow recommendations from being met less than 0.01 percent of the time for 2,500 cfs criteria of recommended discharges. This means the 2,500 cfs criteria will be missed by about 12 percent for three days in one year out of the 65 year analysis period. All other flow recommendations are fully met, including base flow requirements and runoff flow statistics. While base flows are slightly reduced from baseline conditions (less than 3 percent in any month and less than 0.5 percent average), minimum flow requirements and runoff flow statistics of the flow recommendations are met. Baseline flows upstream of the PNM weir will be increased with return flows from the project

Because the Integration Report found that the flows at 5,000 cfs and 2,500 cfs are not causing the expected response (Miller 2005), minor effects to these flows are not expected to have a measurable adverse effect for the endangered fish and will not preclude recovery of the species.

Effects to pikeminnow and Razorback Sucker Critical Habitat

Water Quantity

The proposed action will result in an increase in depletions in the San Juan River of not more than 5,271 af /year over the environmental baseline but does not impact the ability for the San Juan River Flow Recommendations to be met.

The SJRRIP determined that mimicry of a natural hydrograph would create, maintain, and maximize key habitats for the endangered fishes, and that hydrograph mimicry could be accomplished through operations at Navajo Dam. The Flow Recommendations (Holden 1999) were developed by the SJRRIP to address dam releases directly and are the primary source of information concerning the research and management actions taken to develop the recommendations.

The SJRRIP determined that to maximize key habitats for native fishes, flows in the San Juan River needed to more-closely match a natural hydrograph in magnitude, duration, and timing than they had since Navajo Dam’s completion. High spring flows were a natural San Juan River characteristic and a characteristic that is needed to create and maintain key habitats for the endangered and native species. The life histories of the endangered species are closely tied to the magnitude, duration, and timing of the natural hydrograph. Habitat for spawning and rearing young, although very different for the two endangered species is expected to improve and be maximized with a relatively natural annual hydrograph. To meet this need, the Flow

Recommendations provided increased spring peak magnitude and duration, while maintaining timing more similar to pre-dam conditions than to post-dam flows. Base flows were also altered to resemble the magnitude and timing of pre-dam conditions.

Because the proposed diversion does not impact the ability for the San Juan River Flow Recommendations to be met with the 5,271 af /year depletion, it is expected that key habitats for the endangered fish will continue to be created, maintained and maximized and the proposed diversion will not result in an adverse modification to pikeminnow or razorback sucker critical habitat.

Water Quality

Water quality changes will be undetectable because project withdrawals will only reduce base flow by less than 0.5 percent on average with the greatest impact being less than 3 percent. Return flow from all sources accounts for about 10 percent of the flow of the river during base flow periods. Most constituents are concentrated about 4 fold in return flow through evaporative losses so the increase in water quality constituent concentrations below the diversion due to withdrawal will be about 0.9 percent, with a similar reduction in concentrations above that location due to increased flow. Return flow at Shiprock will be through the Shiprock treatment plant, meeting the requirements of the NPDES permit, with an average annual flow of 5.0 cfs (1 percent of the minimum flow). During runoff months, flows are slightly increased, so water contaminant concentrations in the water will decrease. The net increase in any water quality parameter will be less than 2 percent. The Biological Assessment for the NIIP (Keller-Bliesner Engineering, 1999) concluded that the water quality risk to the endangered species was low for all parameters. Because the increase in water quality constituents will be undetectable, the effect to pikeminnow and razorback sucker will be insignificant and discountable.

Physical Habitat

The modification of flow regimes, water temperatures, sediment levels, and other habitat conditions caused by water depletions has contributed to alteration of many habitat elements important to pikeminnow and razorback sucker. Water depletions during spring runoff affect physical habitat in several ways. High spring flows are important for creating and maintaining complex channel geomorphology and suitable spawning substrates, and in creating and providing larvae, YOY and juvenile access to off-channel habitats. The Flow Recommendations were developed because native fish species evolved under certain flow patterns. A basic premise of the SJRRIP was that reoperation of Navajo Dam to mimic a natural hydrograph would improve both habitat quantity and quality by re-establishing a spring peak and low late-summer, autumn, and winter base flows. It was the consensus of biologists working with the endangered fishes in the Colorado River Basin that natural flow patterns and magnitudes were needed by these fishes (Holden 1979, Minckley et al. 1991, Tyus 1991). The life histories of most native species are integrally tied to the timing, duration, and magnitude of the natural hydrograph. Razorback sucker spawn during high spring flows, and their larvae are adapted to utilize habitats that are most available during that time of year. Pikeminnow spawn later in the summer as flows recede, and their larvae utilize habitats that are most available during the low flow periods of late summer and autumn. Because the depletion does not affect the implementation of the Flow Recommendations, the depletion is not expected to impact the recovery of the pikeminnow or razorback sucker in the San Juan River. The depletions caused by the proposed project will not adversely modify critical habitat for pikeminnow and razorback sucker.

Biological Environment

The Flow Recommendations were developed because native fish species evolved under certain flow patterns. A basic premise of the SJRRIP was that reoperation of Navajo Dam to mimic a natural hydrograph would improve both habitat quantity and quality by re-establishing a spring peak and low late-summer, autumn, and winter base flows (Holden 1979, Minckley et al. 1991, Tyus 1991). The life histories of most native species are integrally tied to the timing, duration, and magnitude of the natural hydrograph. Razorback sucker spawn during high spring flows, and their larvae are adapted to utilize habitats that are most available during that time of year. Pikeminnow spawn later in the summer as flows recede, and their larvae utilize habitats that are most available during the low flow periods of late summer and autumn. Because the depletion does not affect the implementation of the Flow Recommendations, the depletion is not expected to impact the recovery of the pikeminnow or razorback sucker in the San Juan River. The modification of flow regimes, water temperatures, sediment levels, and other habitat conditions caused by water depletions has also contributed to the establishment of nonnative fishes.

Because of current depletions and structural limitations of Navajo Dam, there are limitations on the amount of water that can be delivered to the San Juan River. The largest spring peak flow to occur in the 40 years since the construction of Navajo Dam is 15,200 cfs (2.5 percent of the years) (measured at the USGS Bluff gauge, May 30, 1979). In the 49 years prior to dam construction there were spring peak flows greater than 15,200 cfs in 13 years (26 percent of the time). Because of the short period of time that the Flow Recommendations have been in place, it is unknown if a peak flow of 10,000 cfs will be sufficient to maintain the channel and habitat complexity over the long-term. However, monitoring of key habitat characteristics is ongoing. The Service expects that adjustments to the San Juan River Flow Recommendations will be made if long-term monitoring indicates that changes are warranted.

Summary

The proposed action will result in an increase in depletions in the San Juan River of not more than 5,271 af /year over the environmental baseline but does not impact the ability for the San Juan River Flow Recommendations to be met. By following the Flow Recommendations, the operation of Navajo Dam will mimic the natural hydrograph and result in flow patterns similar to those that occurred prior to 1962. Because the flows now mimic the natural hydrograph, the Service anticipates that the response of designated critical habitat will be that key habitats for the endangered fish continue to be created, maintained and maximized.

Effects of the Action on Mesa Verde Cactus

Intensive pre-engineering surveys were conducted during the spring and early summer of 2001 and 2002 to map and inventory all Mesa Verde cacti and associated habitats within 500 feet of the proposed pipeline that may be disturbed by construction, operation, or maintenance of the project. One population south-southeast of the junction of Highway 491 and 36 is within the proposed route for the San Juan Lateral pipeline and an associated booster pumping station. Potentially, the pumping station would remove about one acre of cactus habitat. Three additional areas of potential habitat were documented (1) south of the junction of Hwy 491 and N36 for approximately 15 miles to the vicinity of Little Water, New Mexico (2) north of Navajo Route N36 and west of the Hogback (3) immediately east of the Hogback from the Amarillo Canal to Highway 491. Approximately 150 acres were surveyed. Although no Mesa Verde cacti were observed, the area was in the midst of a prolonged drought. During drought conditions cacti recede into the ground and become very difficult to distinguish (Reclamation 2003).

The proposed action may result in the loss of Mesa Verde cacti within the proposed project area. Based on implementation of the conservation measures, the number of cacti lost should be very small. The placement the San Juan Lateral and associated booster pumping station will be based on the pre-engineering and pre-construction surveys with the objective of avoidance of cacti and minimizing disturbance to habitat. All Mesa Verde cacti near areas of activities will be clearly marked and protected to avoid effects. However, because of the small size and cryptic appearance of the Mesa Verde cactus, surveys almost certainly are incapable of locating all individual plants. In addition, it may not be possible to locate structures and facilities to avoid all cacti in all situations. Based on implementation of the conservation measures and locating the facilities to avoid the Mesa Verde cactus, we anticipate adverse effects to no more than 3 individual cacti. This number is based on the proposed location of the San Juan lateral and pumping station and the likelihood that effects to cacti in this area may be unavoidable.

Adverse effects include disturbance due to fugitive dust, water from dust abatement activities, physical damage to cacti, and transplantation. If, during the course of the construction, more than 3 cacti are damaged or transplanted, this would constitute new information about the extent of the effects of the action not considered in this biological opinion and may necessitate reinitiation of consultation per the Reinitiation Notice. If more than 3 cacti are damaged or destroyed, Reclamation will contact us to discuss the need for reinitiation. We also anticipate that an unknown, but limited, number of plants that may be found in future surveys may also be adversely affected. It is our opinion that this number will be very small based on the relocation of facilities.

The proposed action may also result in disturbance to seeds, reducing their viability or resulting in their loss. Because of recent large losses of individual plants and populations from predation and drought, the delineation of potential seed bank areas for the species cannot currently be determined. Therefore, any disturbance in suitable habitat may result in effects on seeds.

INDIRECT EFFECTS

Indirect effects are those that are caused by, or result from, the proposed action, and are later in time, but are reasonably certain to occur.

Colorado Pikeminnow and Razorback Sucker

Occasional maintenance activities for the diversion structure and fish screen are indirect effects resulting from the implementation of the proposed action. It is our expectation that injury or mortality of individuals could occur through the implementation of maintenance activities.

Mesa Verde Cactus

The proposed action would result in the loss or modification of habitat from construction activities. Habitat would be modified through disturbance to soil structure and compaction of soil, which may affect recruitment of new plants in the future. Soil disturbance can also increase erosion, which would result in the loss of soil and may affect individual cacti and habitat down-gradient. The number of plants that may not become established in the future because of these altered soil conditions cannot be estimated.

The pipeline and associated structures would not facilitate ORV travel because the majority of the pipeline route parallels existing roads. The pipeline corridor will be reseeded with native grass seeding and with native shrub seed in upland areas where shrub cover is diminished due to pipeline disturbance (Reclamation 2007). The reseeding will be monitored to ensure plant establishment and noxious weeds will be controlled in disturbed areas (Reclamation 2007). Reclamation will ensure that contractor's fence areas that have been reseeded to prevent grazing activities until disturbed areas become re-established (Reclamation 2007). Fencing would also deter ORV travel and access from potential plant collectors. Because best management practices will be used during construction activities for soils protection, we do not anticipate an increase in fugitive dust, or increased risk of fire or fuel spill (Reclamation 2007).

INTERRELATED AND INTERDEPENDENT EFFECTS

Colorado Pikeminnow and Razorback Sucker

As proposed, the NGWSP could not operate without the presence of Navajo Dam, therefore it is interrelated with this proposed action. Because the effects of Navajo Dam and NIIP projects were already considered in previous consultations, they are part of the environmental baseline of this consultation.

Mesa Verde Cactus

The use of access roads and vehicles in the action area is considered interrelated and interdependent with the construction of current proposed project. Although the majority of vehicles will likely stay on roads, effects of the project from interdependent and interrelated actions will likely result in cacti being crushed by vehicles or personnel while constructing the proposed pipeline.

The draft environmental impact statement for the project states that a long-term sustainable water supply is needed to improve the standard of living for current and future populations and to support economic growth in the eastern section of the Navajo Nation, the southwestern part of the Jicarilla Apache nation, the City of Gallup, New Mexico, and Window Rock, Arizona (Reclamation 2007). The proposed project would be designed to serve a future population of approximately 250,000 people by the year 2040 (Reclamation 2007). Although the proposed project would provide water for future residential or commercial development activities within the action area, the majority of the area is not cactus habitat. Reclamation indicated that additional development and changes in land use to meet expected future population demands will likely occur on Tribal lands as directed by the Tribes. The proposed project connects to existing water delivery systems and additional residential development is expected to be limited to those areas. It is unknown whether any of these developments would occur within occupied cactus habitat. If information becomes available through the NEPA analysis that indicates future development would occur within cactus habitat and adversely affect the species, this consultation must be reinitiated.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local, or private actions on endangered or threatened species or critical habitat that are reasonably certain to occur in the foreseeable future in the action area considered in this BO. 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 Act. Cumulative effects analysis as stated here applies to section 7 of the Act and should not be confused with the broader use of this term in the NEPA or other environmental laws.

Colorado pikeminnow and razorback sucker

Coalbed Methane Development

The San Juan Basin in southwestern Colorado and northwestern New Mexico is rich in coalbed methane and development of this resource has increased rapidly in the last ten years. There are currently more than 3,000 coalbed methane wells in the San Juan Basin in the Fruitland Coal Formation. Historically, one well per 320 acres was allowed in this area; however, the Colorado Oil and Gas Commission approved an increase of the well spacing to one well per 160 acres. Potentially more than 700 additional wells may be drilled and approximately 250 of these could occur on private or State land. Coalbed methane development requires the extraction of groundwater to induce gas flow. It was estimated that the wells would be drilled in about 10 years (by 2013) but, because of slow groundwater movement, water depletion effects would not be incurred until at least 2025.

A study was initiated in 1998 to determine the effects of groundwater extraction from the Fruitland Formation. The study is called the 3M Project (mapping, modeling, and monitoring) and is being conducted by the Colorado Oil and Gas Conservation Commission (COGCC) in cooperation with the Southern Ute Indian Tribe, the BLM, the Forest Service and the industry. The mapping and modeling studies were completed in 2000. Mapping results are presented in the Colorado Geological Survey’s Open File Report 00-18. Modeling results are available at the COGCC’s website and through the BLM’s San Juan Public Lands Center. A follow-up project was funded by the Ground Water Protection Research Foundation (GWPRF), and the report is available through the BLM.

The Fruitland Formation and the underlying Pictured Cliffs Sandstone were shown to be an aquifer system. In general terms, the groundwater produced from near-outcrop coalbed methane wells is recent recharge water that would, under predevelopment conditions, discharge to the Animas, Pine, Florida and Piedra rivers. These rivers provide flow to the San Juan River.

Coalbed methane wells occur on Federal, State, Tribal and private lands. The BLM prepared an Environmental Impact Statement to address coalbed methane development on the Southern Ute Indian Reservation. The BLM also prepared a separate EIS to address coalbed methane development on Federal lands. Water depletions associated with coalbed methane development on Tribal and Federal lands will be addressed during future section 7 consultation with the BLM. There will not be future section 7 consultations for coalbed methane development on private or State lands if there is no Federal action associated with these wells. Therefore, water depletions associated with coalbed methane development on private and State lands are considered a cumulative effect that is reasonably certain to occur within the action area.

The GWPRF used a groundwater model and a reservoir model to determine water budgets and depletions associated with coalbed methane development. Three areas around the Animas, Pine, and Florida rivers were modeled using 3-D multi-layer models to account for aquifer-river interactions and the effects of coalbed methane development. Baseline conditions were simulated with a single-phase ground water flow model (MODFLOW), and predictive runs were made using two-phase flow models (EXODUS and COALGAS). The predictive model run results are summarized in Table 6.

Table 6. Surface Water Depletions: Model Summaries

River	Pre-CBM Discharge (AF/yr)	Current Depletion (AF/yr)	Maximum Depletion (AF/yr)	Year when Max Depletions Begin
Animas	66	41	66	2045
Pine	61	31	61	2025
Florida	17.5	2	12.5	2050
Piedra*	60	0	60	**
Total	204.5	74	199.5	

*Piedra River depletions are estimated based on discharges simulated from the 3M Project and the depletions modeled in the GWPRF at other rivers.

**Maximum depletions at the Piedra River will depend on the rate of coalbed methane development in the northeastern portion of the San Juan Basin.

The model results show that prior to coalbed methane development, the Fruitland Formation discharged approximately 205 ac-ft /year to the San Juan River. Modeling shows approximately 74 ac-ft /year is currently being depleted with existing wells and predicts the maximum depletions to be approximately 200 ac-ft /year.

The RiverWare Model, which is used to evaluate hydrologic conditions on the San Juan River and its tributaries, requires a defined project to determine project compatibility with the San Juan River flow recommendations. Because future coalbed methane development on State and private land is not a defined project and the depletions associated with it are relatively small and not specifically quantified, the RiverWare Model is not an appropriate tool to use to determine the compatibility with the flow recommendations. However, on May 21, 1999, the Service issued a BO that addressed the impacts of future Federal projects that individually involve small water depletions up to a total of 3,000 ac-ft /year. It was determined in that BO that these small depletions would not diminish the capability of the system to meet the flow levels, durations, or frequencies outlined in the San Juan River flow recommendations. The coalbed methane development on State and private lands was not addressed in the small depletion BO. This development does not involve future Federal actions but does involve small individual depletions similar to the projects addressed by the small depletion BO. Therefore, the Service concludes that an additional future depletion of approximately 200 ac-ft /year from the San Juan River associated with coalbed methane development on State and private land, would not significantly impact the ability to meet the San Juan River Flow Recommendations.

Future section 7 consultations in the San Juan River Basin will need to consider the cumulative effects of coalbed methane development on State and private land using the best scientific information available to determine the water depletions associated with development.

Other Depletions and Diversions from the San Juan River Basin

We believe most of these depletions are accounted for in the environmental baseline depletions and are therefore considered in meeting the Flow Recommendations. There are irrigation ditches and canals below Navajo Dam that could entrain pikeminnow and razorback sucker: Citizens, Hammond, Fruitland, San Juan Generating Station, Jewett Ditch, Four Corners Power Plant Diversion, and Hogback. Increased urban and suburban use of water, including municipal and private uses will increase demands for water. Further use of surface water from the San Juan River will reduce river flow and decrease available habitat for the razorback sucker and pikeminnow. Livestock grazing may adversely impact razorback sucker and pikeminnow by removal of water for drinking and the reduction in soil water holding capacity in the floodplain, and resulting reduction in base flows.
Increases in development and urbanization in the historic floodplain that result in reduced peak flows because of the flooding threat. Development in the floodplain makes it more difficult to transport large quantities of water that would overbank and create low velocity habitats that the razorback sucker and pikeminnow need for their various life history stages.

Contamination of the Water (i.e., sewage treatment plants, runoff from feedlots, residential development and roads)

A decrease in water quality could adversely affect the razorback sucker and pikeminnow, and their critical habitat.

Gradual Change in Floodplain Vegetation from Native Riparian Species to Non-native Species e.g., Russian olive)

Channel narrowing leads to a deeper channel with higher water velocity. Pikeminnow and razorback sucker larvae require low velocity habitats for development. Therefore, there will be less nursery habitat available for both species.

Non-native fish Species in Lake Powell

The presence of striped bass, walleye and channel catfish in Lake Powell constitutes a future threat to pikeminnow and razorback sucker in the San Juan River. When the water elevation of Lake Powell is high enough to inundate a barrier created by a waterfall, striped bass, walleye, channel catfish, and other nonnative fish species can enter the San Juan River.

Increased boating, fishing, off-highway vehicle use, and camping in the San Juan River basin is expected to increase as the human population increases.

Potential impacts include angling pressure, non-point source pollution, increased fire threat, the introduction of additional nonnative species, and the potential for harassment of native fishes.

Mesa Verde Cactus

The amount of non-federal future development within the action area that may occur is unknown. Development is less likely in the action area and far more likely in the community of Shiprock, New Mexico. The growth of Shiprock has affected plants in the vicinity of the town. However, most development on the Navajo Nation typically involves a Federal action, so effects to Mesa Verde cactus would be subject to section 7 consultation.

The open clay badlands where this plant occurs are attractive for ORV use. With population growth there is expected to be increased recreational use in the area including increased ORV trails which may affect Mesa Verde cactus populations.

Mesa Verde cactus is difficult to cultivate and there are few commercial sources of the plant. As a result, signs of collecting are periodically seen at the best known localities. Collection leads to the direct loss of plants, and if larger plants are targeted, to a substantial decrease in reproductive potential.

CONCLUSION

Pikeminnow and Razorback Sucker

After reviewing the current status of the pikeminnow and razorback sucker, 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, as described, is not likely to jeopardize the continued existence of the pikeminnow and razorback sucker and is not likely to adversely modify their designated critical habitat. The rationale for our opinion is provided below.

According to the "Principles for Conducting Endangered Species Act Section 7 Consultations on Water Development and Water Management Activities Affecting Endangered Fish Species in the San Juan River Basin," (Principles) (2001) the Service must determine if progress toward recovery of the two fish species has been sufficient for the SJRRIP to serve as a Reasonable and Prudent Measure for water development projects. To make this determination we have reviewed: 1) the Program Evaluation Report (Holden 2000), 2) The Long Range Plan (1995), 3) the Draft Final Program Integration Report (Miller 2005), 4) scopes of work proposed for 2005-2007, 5) SJRRIP Biology Committee meeting notes, hydrological and biological data, and 6) have spoken with SJRRIP committee members to evaluate the effectiveness of the Flow Recommendations and other elements of the SJRRIP in conserving populations of pikeminnow and razorback sucker in the San Juan River.

Under the Principles, we are to determine progress toward recovery based on (SJRRIP 2001):

1) Actions that will result in a measurable positive population response, a measurable improvement in habitat for the fishes, legal protection of flows needed for recovery, or a reduction in the threat of immediate extinction
2) Status of fish populations
3) Adequacy of flow
4) Magnitude of the impact of the activity (including but not limited to, contaminant and fish migration impacts)

Each of these points are summarized below.

1) Actions that will result in a measurable positive population response, a measurable improvement in habitat for the fishes, legal protection of flows needed for recovery, or a reduction in the threat of immediate extinction are:

Provide and Restore Habitat

Flow Recommendations were developed in 1999 and have been implemented. The BO on Navajo Reservoir Operations, which requires that the Flow Recommendations be implemented, was completed on January 6, 2006; the NEPA EIS Record of Decision was signed July 31, 2006.

With the Flow Recommendations in place, the annual hydrograph mimics the natural hydrograph more closely than in the pre-Flow Recommendations period. The Flow Recommendations provide a peak spring flow improving spawning conditions and the summer base flows are lower, more closely resembling the pre-dam conditions. We expect that a more natural hydrograph provided by the implementation of the Flow Recommendations will have a beneficial effect on native species compared to the pre-Flow Recommendation conditions. However, because population numbers of the endangered fish are so low and because so many actions are occurring simultaneously, documenting a positive population response that is a direct result of any one particular action alone may not be possible.

Because the Flow Recommendations have been implemented for a relatively short period of time the channel may still be adjusting to the new hydrologic regime and changes in watershed conditions. As studies continue and the Flow Recommendations are implemented over a longer period of time, the improvement, maintenance, or deterioration of habitat can be assessed more accurately. The SJRRIP has appropriate long-term monitoring in place to make this assessment.

Population Augmentation

The action that has probably led to the largest population response of endangered fishes is stocking/augmentation because it has had the direct effect of increasing fish numbers. Because both species are long-lived it will take many years to determine whether the SJRRIP is successful. However, stocking goals for pikeminnow and razorback sucker are being met and annual monitoring of larval fishes indicates that razorback sucker is reproducing. Although few larval pikeminnow are caught, the number of subadults and adults caught is increasing. Recruitment and retention of large adult pikeminnow remain areas of concern.

Eliminate movement barriers within occupied habitat

The SJRRIP has restored access to approximately 36 miles of critical habitat. In 2002, the Hogback Diversion was reconstructed to provide for improved fish passage as well as improved irrigation diversion control. The SJRRIP funded that portion of the Hogback Diversion reconstruction assignable to fish passage. Also in 2002, the Program funded removal of the Cudei Diversion and installation of a siphon to connect the Cudei project to the Hogback canal to improve upstream passage for endangered fish species in the river.

In 2003, the SJRRIP funded the construction and operation of a selective fish passage facility at the San Juan Generating Station diversion weir, located just downstream of Fruitland. The SJRRIP provides annual funding to the Navajo Nation to operate the selective fish passage facility.

In 2005, the APS and Fruitland Diversion structures were technically evaluated as to their effect on access to spawning and rearing habitat upstream. The final report was issued in October 2005, and the Biology Committee is currently evaluating the need for future remedial work at these two diversion structures. The Fruitland Diversion is located at RM 178.5, between the confluences of the Animas and La Plata rivers with the San Juan River. The APS diversion, also known as the Four Corners Power Plant Diversion, is located at RM 163.3. Both of these diversions are located within the designated critical habitat for pikeminnow and razorback sucker.

Minimize entrainment of sub-adults and adults at diversion structures, including canal headings and pumping stations

In 2004, the SJRRIP funded an assessment of fish entrainment in the Hogback Diversion canal. The results of this assessment lead to a 2005 project for a design study of a fish screen at the Hogback Diversion. Concerns regarding potential entrainment of endangered fish into the diversion structures located below the confluence of the San Juan and Animas rivers are currently being evaluated.

Control nonnative fishes

Nonnative mechanical removal began in 1997 and is an on-going activity of the SJRRIP. While a positive endangered fish population response cannot yet be linked to this effort, it is expected that the amount of predation and competition between native and non-native fish is reduced, promoting the survival of native fish. Additionally, nonnative fish removed during research and monitoring activities contribute to the removal effort. Intensive removal efforts began in 1999 in the upper river near Farmington, New Mexico and in 2002 in the canyon section between Mexican Hat and Clay Hills, Utah. Other means to control nonnative fishes such as the selective fish passage structure at PNM Weir have been implemented and will continue. Flow manipulation with Navajo Dam releases and Lake Powell elevation regulation will be evaluated as to their effect on nonnative populations. Measurable objectives and methods for assessing and maintaining effectiveness of removal efforts will be developed and implemented. Nonnative fish stocking and baitfish policies of affected states are evaluated by the Biology Committee.

Status of the Fish Populations

The SJRRIP actions implemented to date have addressed all of the management actions identified in the 2002 recovery plans and the short-term (2002-2006) population response criteria developed for razorback sucker and pikeminnow in 2001 have been met. The population response criteria for pikeminnow and razorback sucker are listed below.

Pikeminnow

1A) *Collection of 10 or more pikeminnow (greater than 350 mm [13.8 in] total length) during a standardized monitoring trip.* On the fall 2004 standardized monitoring trip, 159 pikeminnow ranging from 130-360 mm TL were captured, two of which were greater than 350 mm TL (Ryden 2005). On the fall 2005 standardized monitoring trip, 127 pikeminnow ranging from 125-419 mm TL were captured, four of which were greater than 350 mm TL. On the fall 2006 standardized monitoring trip, 323 pikeminnow were captured, of which approximately 100 were greater than 350 mm TL. However, 1,981 age-5 fish (average TL ranged from 333 to 518 mm) were stocked in the San Juan River in 2006, and these fish were caught during the fall monitoring trip (Ryden 2007b). In 2007, 167 pikeminnow were caught during the standardized monitoring trip of which two were greater than 350 mm TL. In addition, in 2007, one age-11 pikeminnow was caught during the nonnative fish removal effort that most likely had been stocked as an age-0 fish in 1996 (Ryden 2008a).

1B) *A population estimate of pikeminnow (greater than 350 mm [13.8 in] total length) which is significantly greater (alpha = 0.05) than the Ryden (2000a) estimate of 50 fish. This estimate (N=19; 95 percent CI 10-42) was for adult fish collected between RM 136.6 and 119.2 and is the only such metric available for this species in the San Juan River*. Because of the low number of pikeminnow in the San Juan River, conducting an accurate population estimate still is not feasible. However, the Biology Committee is well aware of the need to make a population estimate and it will be done as soon as it is believed reliable results can be obtained.

2A) *Presence of wild larval or YOY pikeminnow in standardized monitoring collections in 2 of 5 years.* The capture of wild larval pikeminnow has been infrequent. One larval pikeminnow was caught in 2001, two individuals were caught in 2004, and three were caught in 2007 (Brandenburg and Farrington 2008). Not until stocked pikeminnow become adults and begin reproducing in fairly large numbers will wild larval fish begin to be detected more regularly. The very low survival rates observed from previous (1996-2000) stocking/augmentation of early life stage pikeminnow and the subsequent lack of recruitment of those fish into adulthood is partially responsible for this criterion not being met. However, the lack of wild adult fish and associated progeny is also a factor.

2B) Range expansion above Hogback Diversion following removal and/or modification of this and other fish barriers identified by the SJRRIP. This criterion has been met, via augmentation efforts. Cudei Diversion has been removed from the river and both Hogback Diversion and the PNM Weir have fish passage structures that are in operation. Studies are now in progress to assess the need for fish passage at both the Arizona Public Service Weir and the Fruitland Diversion. Pikeminnow are being stocked on an annual basis upstream of all of these diversions, as well as immediately downstream of Hogback.

Razorback sucker

1A) *Collection of more than 20 razorback sucker greater than 300 mm (11.8 in) total length during the annual fall standardized monitoring.* This criterion was met in 2002 (23 fish caught), but fell 2 fish short in 2003. In 2004, 2005, and 2006 this criterion was again met, when 113, 51, and 103 razorback sucker (greater than 300 mm TL) were collected, respectively.

1B) *Collection of greater than 0.15 razorback sucker greater than 300 mm (11.8 in) total length per hour of electrofishing.* This criterion was met in 2002, 2003, 2004, 2005, and 2006 with the collection of 0.25, 0.19, 1.21, 0.59, and 0.9 razorback sucker (greater than 300 mm TL) per hour of electrofishing, respectively.

2) *Evidence of reproduction (i.e., presence of wild larvae and/or YOY) during standardized monitoring in at least 2 of 5 years.* This criterion has been met. Larval razor back suckers have been caught for the last 10 consecutive years (Brandenburg and Farrington 2008).

From these data, we conclude that the razorback sucker and pikeminnow populations in the San Juan River are more secure today than they were in the 1980s and 1990s and that the threat of extinction has been reduced. Of the two species, the razorback sucker population currently appears to be benefiting more from management efforts. The number of razorback sucker larval fish caught appears to be increasing (Brandenburg and Farrington 2008) and in 2003, two juvenile razorback sucker (249 and 274 mm TL) were collected in the lower San Juan River (at RM 35.7 and 4.8, respectively). Their size at time of capture and lack of a PIT tag strongly implied that these were likely wild-produced progeny of stocked razorback sucker, providing the first evidence of recruitment in the San Juan River.

Between 1991 and 1995, 19 (17 adult and 2 juvenile) wild pikeminnow were collected in the San Juan River by electrofishing (Ryden 2000a). In 2004 and 2005, 159 and 127 sub-adult pikeminnow were caught during the fall standardized monitoring trips. While it is still too early to determine if these fish will survive to the adult stage and reproduce, the trend is encouraging. Because the riverine habitat in the San Juan River has been shortened by 161 km (100 mi) by inundation of Lake Powell (at full pool) and Navajo Lake, and cold water releases further reduce the amount of spawning habitat available, it is unclear if self-sustaining populations of pikeminnow can be established without the presence of warmer water so that spawning can occur farther upstream. However, with continued management (e.g., adherence to the Flow Recommendations, removal of fish passage barriers) and stocking/augmentation, it is expected that population numbers will increase and be maintained.

Adequacy of Flow

The proposed project includes a new depletion of 5,271 acre feet annually. All other depletions associated with the project will be offset by unused Navajo Nation depletions in the San Juan basin, including forbearance of uses for the NIIP, if needed. The new depletion is relatively small and modeling shows that it will not have a significant effect on the SJRRIP's ability to meet the Flow Recommendations. Only the flows at 2,500 cfs will be affected by the project, by a small quantity, and for a very limited amount of time. Because flows at 5,000 cfs and 2,500 cfs are not causing the expected habitat response (Miller 2005), this reduction is not expected to have a measurable adverse effect for the endangered fish or their designated critical habitat and will not preclude recovery of the species.

Magnitude of Impact

The proposed action will affect the San Juan River from RM 167 where 59 cfs will be diverted out of the river, to Lake Powell, and extends in perpetuity. Water quality changes will be undetectable because the water diversion will reduce base flow by less than 0.5 percent on average with the greatest impact being less than 3 percent. The 2,500 cfs criteria of the Flow Recommendations are missed by about 12 % for three days in one year out of the 65 year analysis period, or 0.01% of the time. All other flow recommendations are fully met. No component of the project will impede fish passage. If pikeminnow and razorback sucker spawn at locations above RM 167 in the future, their larvae will be subject to entrainment into the diversion structure. Larger size fish will be excluded by a fish screen. It is estimated that the loss of larvae would only be about one percent of those produced. For these reasons, we conclude that the magnitude of impact from this project is low.

It is essential that the SJRRIP continue with the same level of agency commitment and funding to monitor and address the effects of this and other water depletion projects. As full implementation of projects increases, leading to greater depletions, the SJRRIP will need to determine if, and when, conditions become detrimental to the endangered fishes. Continued long-term monitoring is essential. In addition, the effects of climate change are anticipated to become more evident in the coming years, including increased depletions due to increased evaporation, reduced runoff, and a change in the timing of runoff. It is very important that the SJRRIP implement new approaches to create and maintain habitat in the San Juan River for the endangered fishes. The SJRRIP also needs to continue current monitoring and implement new studies as needed to understand the biological and physical characteristics of the San Juan River and the effects climate change may have on the system and the endangered fishes. The Service believes that the SJRRIP has been prudent in its selection of research topics and monitoring and depends on the research that is conducted in its analysis of proposed projects.

Mesa Verde Cactus

After reviewing the current status of the cactus, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the Service's BO that implementation of the action, as proposed, is not likely to jeopardize the continued existence of the Mesa Verde cactus. No critical habitat has been designated for this species; therefore, none will be affected.

We based this conclusion on the following:

- Mesa Verde cactus is recovering from the significant range-wide decline of 2002-2003. Information collected at monitoring plots indicates Mesa Verde cactus is recovering range-wide from this decline at a modest rate. Recovery is expected to continue at low rates under the current climatic conditions.

- Direct effects from the action, including impacts to the population south-southeast of the junction of Highway 491 and 36 by the San Juan Lateral pipeline and an associated booster pumping station will be minimized through application of conservation measures that are part of the project description. Additional plants that may be found in pre-construction surveys will be avoided.

- Indirect effects, specifically disturbance from ORVs and the spread of weeds resulting from the increase in access to the action area are expected to be very low because of the BMPs that will be employed. Disturbance to soil structure and compaction of soil may affect recruitment of new plants in the future, especially in areas with existing plants or in areas of suitable habitat. However, because of implementation of the conservation measures, the amount of occupied or suitable habitat that may be disturbed by the project is expected to be very low.

- Population growth enabled by this project may lead to cumulative effects, especially increased recreational use, including ORV use within the area. Continued monitoring of population centers will be important to determine if there is an increase in impacts to Mesa Verde cactus from increased ORV traffic.

Because Mesa Verde cactus occurs almost completely on either Indian lands or Federal lands managed by the BLM, a very high proportion of the activities that might affect the cactus are subject to section 7 consultation, and this process has contributed measurably to conservation of the species. Given that conservation efforts for the species have been effective, that the population can sustain some losses of individuals without detriment to the species as a whole, and that monitoring indicates populations are beginning to increase, the Service concludes that the potential loss of up to 3 Mesa Verde cactus plants from the proposed Navajo-Gallup Water Supply Project would not be likely to jeopardize the continued existence of the species. As noted above, when the NEPA analysis is completed for this project, if the analysis indicates that project related future development would occur within cactus habitat and adversely affect the species, this consultation must be reinitiated.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act 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 actions that create the likelihood of injury to listed species 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), take that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such take is in compliance with the terms and conditions of an incidental take statement. Our incidental take statement is specific to a particular life stage and that stage only. For example, the following incidental take statement is specific to larval fish. We make no assumptions about how many adult fish these larval fish may produce and do not predict the number of juvenile or adult fish lost based on the larval number taken.

The measures described below are non-discretionary, and must be undertaken by Reclamation so that they become binding conditions of any grant or permit issued to any applicants, as appropriate, for the exemption in section 7(o)(2) to apply. Reclamation has a continuing duty to regulate the activity covered by this incidental take statement. If Reclamation (1) fails to assume and implement the terms and conditions, or (2) fails to require applicants to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, Reclamation must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement. [50 CFR §402.14(i)(3)]

Amount or Extent of Take

The Service anticipates that take in the form of direct take of larvae during the spawning season and harm will occur in association with the water depletion and entrainment.

Depletion

Because the proposed 5,271 af/year depletion does not impact the ability for the San Juan River Flow Recommendations to be met, it is expected that key habitats for the endangered fish will continue to be created, maintained and maximized and the proposed diversion will not have a adverse affect on pikeminnow or razorback sucker critical habitat. Any amount of net depletion above 5,271 af/year would result in incidental take.

Entrainment

Colorado pikeminnow

Based on the best available information concerning the habitat needs of this species, the project description, and information furnished by Reclamation, the Service anticipates that pikeminnow larvae will be taken as a result of this proposed action. This incidental take is expected to be in the form of harm, harass, and kill as the result of entrainment of larvae during the spawning season.

Based on capture of larval pikeminnow in the San Juan River, larvae typically enter the drift from mid-July to early-August (Brandenburg and Farrington 2008) and drift passively for 3 to 6 days after emergence (Dudley and Platania 2000). Therefore, larval pikeminnow spawned above the diversion would be subject to loss into the diversion for about 30 days. Flows during peak pikeminnow larvae drift average about 1,500 cfs at the Farmington gage (1993-2003; USGS 2003). The proposed intake will divert about 4 percent (59 cfs) of the total river flow during peak pikeminnow drift. Pikeminnow exit the drift at 14 mm (0.55 in). Larval pikeminnow will not be excluded by a 3/32 inch screen. Thus, we estimate a loss of about 4 percent of larvae spawned above the intake. Because only 25 percent or less of the spawn is expected above the diversion, the net loss is expected to be approximately 1 percent of all pikeminnow larvae produced in the San Juan River.

The implementation of the SJRRIP is intended to minimize impacts of water depletions and therefore, implementation of the SJRRIP will serve as reasonable and prudent measures for minimizing the take that result from the withdrawal of 59 cfs of river flow. Any amount of water withdrawal above this level during larval drift would exceed the anticipated level of incidental take.

Razorback sucker

Based on the best available information concerning the habitat needs of this species, the project description, and information furnished by Reclamation, the Service anticipates that razorback sucker larvae will be taken as a result of this proposed action. This incidental take is expected to be in the form of harm, harass, and kill as the result of entrainment of larvae during the spawning season.

Spawning typically occurs on the ascending limb of the hydrograph during May (Brandenburg et al. 2004). With an assumed potential spawning range from RM 100 to RM 180 and a uniform distribution of spawning adults in the future, about 16 percent of the larval drift would occur above the diversion. During May the flow averages about 4,100 cfs of which 59 cfs or 1.4 percent enters the NGWSP diversion. Therefore, not more than 0.2 percent of drifting larvae would be subject to entrainment in the diversion in the San Juan River on any given year.

Because of the nature of the larvae life history stage and the variation in population sizes from year to year, it is difficult to estimate the number of individuals that will be taken with implementation of this project. Based upon the proposed project, it is estimated that a maximum 59 cfs of the occupied habitat (total river flow) will be taken during peak razorback sucker drift.

The implementation of the SJRRIP is intended to minimize impacts of water depletions and therefore, implementation of the SJRRIP will also serve as the reasonable and prudent measure for minimizing the take that result from the withdrawal of 59 cfs of river flow. Any amount of water withdrawal above this level during larval drift would exceed the anticipated level of incidental take.

Mesa Verde cactus

Sections 7(b)(4) and 7(o)(2) of the ESA generally do not apply to listed plant species. However, limited protection of plants from take is provided to the extent that the ESA prohibits the removal and reduction to possession of federally endangered plants or the malicious damage of such plants on areas under Federal jurisdiction, or the destruction of endangered plants on non-Federal areas in violation of State law or regulation or in the course of any violation of a State criminal trespass law.

EFFECT OF THE TAKE

In the accompanying BO, the Service determined that the level of anticipated take is not likely to result in jeopardy to the razorback sucker and pikeminnow or result in the destruction or adverse modification of their critical habitat.

REASONABLE AND PRUDENT MEASURES

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize impacts of incidental take of the razorback sucker and pikeminnow:

1. Reclamation will continue to support and participate in the implementation of the SJRRIP.

2. Through the SJRBRIP, Reclamation shall implement measures to create and maintain habitat complexity and to minimize loss and long-term degradation of habitat for the endangered fishes within the San Juan River.

3. To project future flow regimes in the San Juan River, through the SJRBRIP Reclamation will be responsible for the maintenance and application of the San Juan Hydrology Model to evaluate proposed projects on the San Juan River.

TERMS AND CONDITIONS

Compliance with the following terms and conditions must be achieved in order to be exempt from the prohibitions of section 9 of the ESA. The terms and conditions implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. The terms and conditions are non-discretionary.

The following term and condition is established to implement Reasonable and Prudent Measure Number 1:

1.1) Reclamation will continue to seek and provide funding, as authorized, for the implementation of the SJRRIP.

The following term and condition is established to implement Reasonable and Prudent Measure Number 2:

2.1) To create and maintain complex habitat, Reclamation through the SJRRIP will:

a. Investigate the use of habitat manipulation such as nonnative vegetation removal, mechanically opening the mouths of secondary channels, or reconnecting the river with the floodplain in appropriate sites to augment the function of high flows. Any appropriate options should be implemented and funded through the SJRRIP.

b. Continue to monitor habitat response to the Flow Recommendations.

c. Monitor the response of actions taken to increase habitat complexity.

The following term and condition is established to implement Reasonable and Prudent Measure Number 3:

3.1) To track potential climate changes and how these changes may affect the pikeminnow and razorback sucker and their designated critical habitats, Reclamation in cooperation with the SJRRIP, will begin monitoring to:

a. Determine changes in the timing of runoff.

b. Determine if average annual runoff is decreasing and a timeframe in which a change may affect the ability of the Flow Recommendations to be met.

c. If, from the monitoring activities completed in 3.1(a) & (b), it is determined that climate change is affecting water availability in the San Juan River, this would be considered as new information that may affect listed species or designated critical habitat. Reclamation would reinitiate consultation with the Service, consistent with Section 7.0 D (2) of the "Principles for Conducting Endangered Species Act Section 7 Consultations on Water Development and Water Management Activities Affecting Endangered Fish Species in the San Juan River Basin" adopted by the Recovery Program on June 19, 2001. Reclamation in consultation with the Service would evaluate the changes in water availability and determine if the changes would have an adverse effect on listed species and if the SJRRIP is sufficient to serve as the reasonable and prudent alternative or measure.

3.2) To ensure the integrity, consistency, and scientific rigor in regards to water project depletions, Reclamation working through the SJRRIP will:

a. Continue maintenance and upgrades of the San Juan Hydrology Model using the best available science.

b. Conduct project analysis for water depletion projects on the San Juan River as needed.

Conservation Recommendations

Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the ESA 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 recommendations provided here relate only to the proposed action and do not necessarily represent complete fulfillment of the agency's section 7(a)(1) responsibility for these species. In order for the Service to be kept informed of actions that either minimize or avoid adverse effects or that benefit listed species and their habitats, we request notification of the implementation of the conservation recommendations. We suggest the following conservation recommendations be implemented:

1. Any collection of Mesa Verde cacti within the action area should be reported to the Service.

2. We recommend that Reclamation participate in the development, approval and management of the Mesa Verde Cactus Conservation Areas.

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

Reporting Requirements

Documentation and reporting on the implementation of the conservation measures and terms and conditions will occur within six months after completion of the project and annually thereafter for a period of five years. The nearest Service Law Enforcement Office must be notified within 24 hours in writing should any listed species be found dead, injured, or sick. Notification must include the date, time, and location of the carcass, cause of injury or death (if known), and any pertinent information. Care should be taken in handling sick or injured individuals and in the preservation of specimens in the best possible state for later analysis of cause of death. In conjunction with the care of sick or injured endangered species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed. If necessary, the Service will provide a protocol for the handling of dead or injured listed animals. In the event Reclamation suspects that a species has been taken in violation of Federal, State, or local law, all relevant information should be reported in writing within 24 hours to the Service's New Mexico Law Enforcement Office (505/883-7814) or the New Mexico Ecological Services Field Office (505/346-2525).

REINITIATION NOTICE

This concludes formal consultation on the proposed Navajo-Gallup Water Supply Project. As required by 50 FR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: 1) The amount or extent of incidental take is exceeded. See section on Amount or Extent of Take; 2) new information reveals effects of the agency action that may impact listed species or critical habitat in a manner or to an extent not considered in this opinion; 3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion; 4) a new species is listed or critical habitat designated that may be affected by the action; or 5) if the SJRRIP ceases to exist or if funding levels are reduced so that critical deadlines for specified recovery actions are not met.

The SJRRIP is expected to result in a positive population response for the pikeminnow and razorback sucker in the San Juan River. If a positive population response for both species is not realized, as measured by the criteria developed by Reclamation dated July 6, 2001, this would be considered new information that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion. Therefore, reinitiation of section 7 consultation would be required for all projects dependent on the Recovery Program, including the subject action. If reinitiation is required, the Service will follow the procedures regarding reinitiation of consultation pursuant to the "Principles for Conducting Endangered Species Act Section 7 Consultations on Water Development and Water Management Activities Affecting Endangered Fish Species in the San Juan River Basin".

In future communications regarding this project please refer to consultation number 2-22-01-F-532. If you have any questions or would like to discuss any part of this BO, please contact David Campbell of my staff at (505) 761-4745.

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